DOE/CF-0109
Volume 3

# Department of Energy
# FY 2016 Congressional Budget Request

**Energy Efficiency and Renewable Energy**
**Electricity Delivery and Energy Reliability**
**Nuclear Energy**
**Fossil Energy Research and Development**
**Naval Petroleum and Oil Shale Reserves**
**Strategic Petroleum Reserve**
**Northeast Home Heating Oil Reserve**
**Elk Hills School Lands Fund**
**Clean Coal Technology**
**Advanced Tech. Vehicles Manufacturing Loan Program**
**Title 17 Innovative Tech. Loan Guarantee Program**
**Tribal Indian Energy Loan Guarantee Program**
**Office of Indian Energy Policy and Programs**
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**Table of Contents**

## FUNDING BY APPROPRIATION

(Discretionary dollars in thousands)

| | FY 2014 Enacted | FY 2014 Current | FY 2015 Enacted | FY 2016 Request | FY 2016 vs. FY 2015 $ | FY 2016 vs. FY 2015 % |
|---|---|---|---|---|---|---|
| **Department of Energy Budget by Appropriation** | | | | | | |
| **Energy and Water Development, and Related Agencies** | | | | | | |
| **Energy Programs** | | | | | | |
| Energy Efficiency and Renewable Energy | 1,900,641 | 1,824,876 | 1,914,195 | 2,722,987 | +808,792 | +42.3% |
| Electricity Delivery and Energy Reliability | 147,242 | 144,205 | 146,975 | 270,100 | +123,125 | +83.8% |
| Nuclear Energy | 888,376 | 877,620 | 833,379 | 907,574 | +74,195 | +8.9% |
| **Fossil Energy Programs** | | | | | | |
| Clean Coal Technology | 0 | 0 | -6,600 | 0 | +6,600 | +100.0% |
| Fossil Energy Research and Development | 561,931 | 550,630 | 560,587 | 560,000 | -587 | -0.1% |
| Naval Petroleum and Oil Shale Reserves | 19,999 | 22,457 | 19,950 | 17,500 | -2,450 | -12.3% |
| Elk Hills School Lands Fund | 0 | 0 | 15,580 | 0 | -15,580 | -100.0% |
| Strategic Petroleum Reserve | 189,360 | 189,360 | 200,000 | 257,000 | +57,000 | +28.5% |
| Northeast Home Heating Oil Reserve | 8,000 | 8,000 | 1,600 | 7,600 | +6,000 | +375.0% |
| **Total, Fossil Energy Programs** | **779,290** | **770,447** | **791,117** | **842,100** | **+50,983** | **+6.4%** |
| Uranium Enrichment Decontamination and Decommissioning Fund | 598,574 | 598,574 | 625,000 | 542,289 | -82,711 | -13.2% |
| Energy Information Administration | 116,999 | 116,999 | 117,000 | 131,000 | +14,000 | +12.0% |
| Non-Defense Environmental Cleanup | 231,741 | 231,782 | 246,000 | 220,185 | -25,815 | -10.5% |
| Science | 5,066,372 | 5,131,038 | 5,067,738 | 5,339,794 | +272,056 | +5.4% |
| Advanced Research Projects Agency - Energy | 280,000 | 280,000 | 279,982 | 325,000 | +45,018 | +16.1% |
| Departmental Administration | 126,449 | 126,449 | 125,130 | 153,511 | +28,381 | +22.7% |
| Indian Energy Programs | 0 | 0 | 0 | 20,000 | +20,000 | N/A |
| Office of the Inspector General | 42,120 | 42,120 | 40,500 | 46,424 | +5,924 | +14.6% |
| Title 17 - Innovative Technology | | | | | | |
| Loan Guarantee Program | 20,000 | 7,857 | 17,000 | 0 | -17,000 | -100.0% |
| Advanced Technology Vehicles Manufacturing Loan Program | 6,000 | 6,000 | 4,000 | 6,000 | +2,000 | +50.0% |
| Tribal Indian Energy Loan Guarantee Program | 0 | 0 | 0 | 11,000 | +11,000 | N/A |
| **Total, Energy Programs** | **10,203,804** | **10,157,967** | **10,208,016** | **11,537,964** | **+1,329,948** | **+13.0%** |
| **Atomic Energy Defense Activities** | | | | | | |
| **National Nuclear Security Administration** | | | | | | |
| Weapons Activities | 7,781,000 | 7,790,197 | 8,180,359 | 8,846,948 | +666,589 | +8.1% |
| Defense Nuclear Nonproliferation | 1,954,000 | 1,941,983 | 1,615,248 | 1,940,302 | +325,054 | +20.1% |
| Naval Reactors | 1,095,000 | 1,101,500 | 1,233,840 | 1,375,496 | +141,656 | +11.5% |
| Office of the Administrator | 377,000 | 370,500 | 0 | 0 | 0 | N/A |
| Federal Salaries and Expenses | 0 | 0 | 369,587 | 402,654 | +33,067 | +8.9% |
| **Total, National Nuclear Security Administration** | **11,207,000** | **11,204,180** | **11,399,034** | **12,565,400** | **+1,166,366** | **+10.2%** |
| **Environmental and Other Defense Activities** | | | | | | |
| Defense Environmental Cleanup | 5,000,000 | 4,999,293 | 5,453,017 | 5,527,347 | +74,330 | +1.4% |
| Other Defense Activities | 755,000 | 755,000 | 753,449 | 774,425 | +20,976 | +2.8% |
| **Total, Environmental and Other Defense Activities** | **5,755,000** | **5,754,293** | **6,206,466** | **6,301,772** | **+95,306** | **+1.5%** |
| **Total, Atomic Energy Defense Activities** | **16,962,000** | **16,958,473** | **17,605,500** | **18,867,172** | **+1,261,672** | **+7.2%** |
| **Power Marketing Administrations** | | | | | | |
| Southeastern Power Administration | 0 | 0 | 0 | 0 | 0 | N/A |
| Southwestern Power Administration | 11,892 | 11,892 | 11,400 | 11,400 | 0 | 0 |
| Western Area Power Administration | 95,930 | 95,930 | 91,740 | 93,372 | +1,632 | +1.8% |
| Falcon and Amistad Operating and Maintenance Fund | 420 | 420 | 228 | 228 | 0 | 0 |
| Colorado River Basins Power Marketing Fund | -23,000 | -23,000 | -23,000 | -23,000 | 0 | 0 |
| **Total, Power Marketing Administrations** | **85,242** | **85,242** | **80,368** | **82,000** | **+1,632** | **+2.0%** |
| Federal Energy Regulatory Commission | 0 | 0 | 0 | 0 | 0 | N/A |
| **Subtotal, Energy and Water Development and Related Agencies** | **27,251,046** | **27,201,682** | **27,893,884** | **30,487,136** | **+2,593,252** | **+9.3%** |
| Uranium Enrichment Decontamination and Decommissioning Fund | | | | | | |
| Discretionary Payments | 0 | 0 | -463,000 | -471,797 | -8,797 | -1.9% |
| Excess Fees and Recoveries, FERC | -26,236 | -19,686 | -28,485 | -23,587 | +4,898 | +17.2% |
| Title XVII Loan Guarantee Program Section 1703 Negative Credit Subsidy Receipt | 0 | 0 | 0 | -68,000 | -68,000 | N/A |
| **Total, Discretionary Funding by Appropriation** | **27,224,810** | **27,181,996** | **27,402,399** | **29,923,752** | **+2,521,353** | **+9.2%** |

# Energy Efficiency and Renewable Energy

# Energy Efficiency and Renewable Energy

**Energy Efficiency and Renewable Energy**

**Table of Contents**

**Energy Efficiency and Renewable Energy**
**Proposed Appropriation Language**

For the Department of Energy expenses including the purchase, construction, and acquisition of plant and capital equipment, and other expenses necessary for energy efficiency and renewable energy activities in carrying out the purposes of the Department of Energy Organization Act (42 U.S.C. 7101 et seq.), including the acquisition or condemnation of any real property or any facility or for plant or facility acquisition, construction, or expansion, [$1,936,999,858] *$2,722,987,000* to remain available until expended: *Provided*, That [$160,000,000] *$165,330,000* shall be available until September 30, [2016] *2017* for program direction: *Provided further*, That, of the amount provided under this heading, the Secretary may transfer up to $45,000,000 to the Defense Production Act Fund for activities of the Department of Energy pursuant to the Defense Production Act of 1950 (50 U.S.C. App. 2061, et seq.): [*Provided further*, That $13,064,858 from unobligated balances available from prior year appropriations provided under this heading is hereby rescinded, of which $145,204 is from Public Law 111–8 and $696,654 is from Public Law 111–85: Provided *further*, That no amounts may be rescinded from amounts that were designated by the Congress as an emergency requirement pursuant to a concurrent resolution on the budget or the Balanced Budget and Emergency Deficit Control Act of 1985.*] Provided further, That of the amount provided under this heading, $15,000,000 shall be available for weatherization assistance for State level demonstrations of financing methods for low-income multi-family units, including technical assistance for recipients, and shall be awarded on a competitive basis, notwithstanding the requirements of Part A of Title IV of the Energy Conservation and Production Act (42 U.S.C. 6861 et seq.): Provided further, That, of the amount provided under this heading, $20,000,000 shall be available for a program to support municipal and county government energy program and project planning, development and implementation through technical assistance and grants awarded on a competitive basis, notwithstanding the requirements of Part D of Title III of the Energy Policy and Conservation Act (42 U.S.C. 6321 et seq.).*

**Explanation of Changes**

Deleted language referencing the rescission of prior year balances included in the FY 2015 Appropriations Bill.

In support of the Weatherization Assistance and Intergovernmental Programs budget request:

- Included language to authorize competitive funding for low-income multi-family units within the Weatherization Assistance Program.
- Included language to authorize funding for a program to support local governments and community agencies through competitive grants and technical assistance for the new Local Technical Assistance Program.

**Public Law Authorizations**

P.L. 93-275, “Federal Energy Administration Act” (1974)
P.L. 93-410, “Geothermal Energy Research, Development, and Demonstration Act” (1974)
P.L. 93-577, “Federal Non-Nuclear Energy Research and Development Act” (1974)
P.L. 94-163, “Energy Policy and Conservation Act” (EPCA) (1975)
P.L. 94-385, “Energy Conservation and Production Act” (ECPA) (1976)
P.L. 94-413, “Electric and Hybrid Vehicle Research, Development and Demonstration Act” (1976)
P.L. 95-91, “Department of Energy Organization Act” (1977)
P.L. 95-618, “Energy Tax Act” (1978)
P.L. 95-619, “National Energy Conservation Policy Act” (NECPA) (1978)
P.L. 95 620, “Power Plant and Industrial Fuel Use Act” (1978)
P.L. 95-238, Title III – “Automotive Propulsion Research and Development Act” (1978)
P.L. 96-512, “Methane Transportation Research, Development and Demonstration Act” (1980)
P.L. 96-294, “Energy Security Act” (1980)
P.L. 100-12, “National Appliance Energy Conservation Act” (1987)
P.L. 100-357, “National Appliance Energy Conservation Amendments” (1988)
P.L. 100-494, “Alternative Motor Fuels Act” (1988)
P.L. 100-615, “Federal Energy Management Improvement Act” (1988)
P.L. 101-218, “Renewable Energy and Energy Efficiency Technology Competitiveness Act” (1989)
P.L. 101-566, “Spark M. Matsunaga Hydrogen Research, Development, and Demonstration Act of 1990”
P.L. 101-575, “Solar, Wind, Waste, and Geothermal Power Production Incentives Act” (1990)
P.L. 102-486, “Energy Policy Act of 1992”

P.L. 104-271, “Hydrogen Future Act of 1996”
P.L. 106-224, “Biomass Research and Development Act” (2000)
P.L. 109-58, “Energy Policy Act of 2005”
P.L. 110-140, “Energy Independence and Security Act of 2007”
P.L. 110-234, “The Food, Conservation, and Energy Act of 2008”
P.L. 111-5, “American Recovery and Reinvestment Act of 2009”

## Energy Efficiency and Renewable Energy

**($K)**

| FY 2014 Enacted[1] | FY 2014 Current[2] | FY 2015 Enacted | FY 2016 Request |
|---|---|---|---|
| 1,900,641 | 1,824,876 | 1,914,195 | 2,722,987 |

**Overview**

The Office of Energy Efficiency and Renewable Energy (EERE) is the U.S. Government's primary clean energy technology organization. EERE works with many of America's best innovators and businesses to support high-impact applied research, development, demonstration, and deployment (RDD&D) activities in sustainable transportation, renewable power, and end-use energy efficiency. EERE implements a range of strategies aimed at reducing U.S. reliance on oil, saving American families and businesses money, creating jobs, and reducing pollution. EERE works to ensure that the clean energy technologies of today and tomorrow are not only invented in America, but also manufactured in America.

EERE's work parallels fundamental national interests—expanding prosperity, increasing energy affordability, ensuring environmental responsibility, enhancing energy security, and offering all Americans a broader range of energy choices. After four decades of investments in American innovation, a wide array of technologies—from solar power, wind power, and plug-in electric vehicles, to solid-state lighting and cellulosic biofuels—are showing a clear path to cost competitiveness compared to conventional forms of energy, bringing a number of these technologies to the edge of widespread market adoption. We have the opportunity to further accelerate the adoption of these technologies and a number of other clean energy technologies, while also providing our Nation an opportunity to win one of the most important global economic races of the 21st century.

EERE's investment strategies focus on investing in only the highest-impact activities to achieve its mission and maximize the value it delivers to the American taxpayer. Impact evaluations using best-practice, peer-reviewed methods are critical to understanding the return to the taxpayer of past investments and making continuous improvements in EERE's investment strategy going forward. The results of EERE's investments are documented through independent evaluations of EERE's portfolio, which are performed on an ongoing basis, and quantify the return on investment across EERE. To date, third party evaluators have completed five evaluations covering research and development (R&D) investments in photovoltaic energy systems, wind energy, vehicle combustion engines, geothermal technologies, and advanced battery technologies for electric-drive vehicles. Investments over the period from 1976 to 2008, roughly one third of EERE's portfolio (by amount invested), have been formally evaluated. The total EERE taxpayer investment for the portion evaluated was $15 billion, and evaluations documented an estimated economic benefit to the United States of $388 billion, a net return on investment of over 24 to 1.[3]

In FY 2016, EERE will continue to inform its investments through insights from the above retrospective analyses, as well as through internal and independent economic analyses and assessments of potential technology impacts on energy usage, energy emissions, American oil imports, and U.S. manufacturing competitiveness. This approach focuses efforts on the most promising opportunities across a full spectrum of sectors and maturation timeframes to ensure a full pipeline of efficiency and renewable technologies in both the near and longer term.

EERE works with industry, academia, National Laboratories, and other partners to create technology-specific roadmaps—evaluating the future market potential and public benefits of clean energy technologies by incorporating in-house expertise, market awareness, and knowledge of private investment. Once technology roadmaps and RD&D support strategies are established, EERE investment for these activities falls under three primary areas:

[1] FY 2014 Enacted and FY 2014 Current reflect the contractor foreign travel rescission of $1,045,000.

[2] Funding reflects the transfer for SBIR/STTR to the Office of Science.

[3] Preliminary aggregate net benefits calculation by EERE Office of Strategic Programs, combining cost-benefit impact results from formal evaluation studies conducted for the Solar, Geothermal, Wind, Vehicles, and Advanced Manufacturing programs.

- Early stage research and development (R&D) to enable cost reduction and performance improvement, working to accelerate the development and commercialization of technologies through applied R&D on components or whole technology systems;
- Technology validation and risk reduction activities to catalyze the wide-scale adoption of clean energy technologies and solutions by demonstrating the performance of technologies at increasing scales in controlled-laboratory and under real-world conditions, providing benchmarks for performance and durability to provide feedback into our research and development roadmaps, and reducing technology uncertainty to unlock private sector investment; and
- Reducing market barriers to the adoption of new technologies that are market ready—such as a lack of reliable information, inconsistent regulatory environments, and workforce training gaps—through activities that include providing best practice information, stakeholder outreach, sustaining and enhancing the clean energy workforce, and providing reliable, objective data.

While EERE strategically plans and evaluates its support of research, development and demonstration (RD&D) activities according to these technology roadmaps, EERE also recognizes how dynamic innovators in the clean energy economy constantly integrate new ideas and discoveries to create competitive advantages. This effort was first implemented in FY 2014 and in FY 2016 EERE will continue its practice to include a small fraction of its annual funding for "Incubator" programs within each of its technology offices. Focusing on technologies and solutions that are not currently significantly represented within EERE's RD&D portfolio and roadmaps. Incubator programs will allow EERE to develop, assess, and screen new "off-roadmap" technologies and solutions for their potential to be "on-ramped" into future program plans, roadmaps, and project portfolios. This incubator effort will be coordinated with ARPA-E as needed to ensure that there is no duplication of effort between the two program offices.

**Highlights and Major Changes in the FY 2016 Budget Request**

In FY 2016, EERE will invest $2.7 billion toward continuing its focus on growing the domestic clean energy industry, increasing energy productivity for American businesses, and expanding access to renewable power and alternative vehicles EERE will also sustain efforts to streamline and enhance its operations, conduct rigorous evaluations of its portfolios, and achieve the greatest possible efficiency and outcomes in each of its three sectors (Sustainable Transportation, Renewable Power, and Energy Efficiency) and its key organization-wide initiatives.

- Sustainable Transportation ($793 million)
  - Vehicle Technologies: The Budget provides $444 million in FY 2016 to support RDD&D of efficient and alternative fuel vehicle technologies. One major initiative, the EV Everywhere Grand Challenge, aims to reduce the combined battery and electric drive system costs of plug-in electric vehicles by up to 50 percent by 2022 from a 2012 baseline. FY 2016 funding supports a significant new SuperTruck II initiative to achieve improved freight-hauling efficiency goals, as well as work to eliminate technical barriers to increased transportation use of alternative and renewable fuels, with a focus on natural gas and drop-in biofuels. Vehicle Technologies will also support a crosscutting initiative to drive significant improvements in the strength, formability, corrosion resistance, and cost of magnesium sheet alloys. A cross-cutting fuels and vehicle systems optima initiative will seek to optimize engine efficiency with low-carbon fuel properties. Major funding changes are the result of enhanced support for these activities, in particular, increased investment in vehicle electrification and grid infrastructure, SuperTruck II, on-board natural gas storage, magnesium sheet, co-optimization of fuels and engines, and partnerships to build high-impact community-scale demonstrations of alternative fuel vehicles.
  - Bioenergy Technologies: The Budget provides $246 million in FY 2016, with an emphasis on the development of innovative processes to convert cellulosic and algal-based feedstocks to bio-based gasoline, diesel, and jet fuel at a target cost of $3.00 per gallon of gasoline equivalent. Emphasis will be on RD&D of "drop-in" hydrocarbon biofuels that can be used interchangeably with petroleum-based fuels. In collaboration with the U.S. Departments of Navy and Agriculture, the program will demonstrate commercial-scale biorefineries to produce military-specification fuels. Additionally, in FY 2016, funds will support R&D to advance new technologies from the lab bench to the commercial market. Major funding changes are the result of increased investment in the algae program and increased funding targeted at greater emphasis on products through R&D to overcome barriers to additional pathways for the integrated production of fuels. Funding will also fully support up to three pilot projects or one demonstration project for advanced biofuels technologies through cost-shared partnerships.
  - Hydrogen and Fuel Cell Technologies: The Budget provides $103 million in FY 2016 to supports the goal to reduce the cost and increase the durability of fuel cell systems, with a targeted cost of $40/kW and durability of 5,000 hours, which is equivalent to 150,000 miles, by 2020. In addition, EERE will invest in R&D for technologies that can

bring the cost of hydrogen from renewable resources to less than $4.00 per gallon of gasoline equivalent—dispensed and untaxed—by 2020. In FY 2016, Fuel Cell R&D will emphasize areas such as stack component R&D, systems, and balance of plant components. Hydrogen Fuel R&D will focus on technologies and materials that will reduce hydrogen production, compression, transport, and storage costs. Funding will also provide resources to rapidly advance the development of quality control tools for the manufacturing of fuel cell components and systems.

- Renewable Power ($645 million)
  - Solar Energy: The Budget provides $337 million in FY 2016 to support the DOE SunShot Initiative's goal of making solar power cost-competitive without subsidies by 2020, equivalent to a cost of solar power of $.06/kWh. FY 2016 funding will support an effort to reduce "soft costs" of solar installation, including new efforts focused on commercial-scale solar to reduce barriers for businesses to choose solar energy. SunShot will also support DOE's Clean Energy Manufacturing Initiative by developing and demonstrating innovative manufacturing technologies to increase U.S. competitiveness. Additionally, funding will be used to focus on improved controls, sensors, power electronics and connection to energy storage as part of the Grid Modernization crosscut.
  - Wind Energy: The Budget provides $146 million in FY 2016, including funding for three advanced offshore wind demonstration projects, planned to be in operation by FY 2017, to address technology and deployment challenges unique to U.S. waters in order to tap into America's offshore wind resources; an Atmosphere to Electrons Initiative focused on optimizing entire wind farms as a system to lower the cost of land-based and offshore wind energy; and activities related to DOE's Grid Modernization Crosscut efforts. FY 2016 funding also expands the program's ongoing efforts to address the impacts of expanded wind development on wildlife.
  - Water Power: The Budget provides $67 million in FY 2016 to support innovative technologies for generating electricity from water resources. The HydroNEXT initiative aims to improve the performance, flexibility, and environmental sustainability of technologies applicable to existing hydropower facilities, while also developing and demonstrating technologies that will enable new, low-impact, fish-friendly hydropower development. HydroNEXT emphasizes modular, "drop-in" systems that will minimize capital costs and environmental impact and maximize ease of manufacture. FY 2016 funding also supports RD&D of marine and hydrokinetic technologies, including front end engineering and design for a grid-connected open-water test facility.
  - Geothermal Technologies: The Budget provides $96 million in FY 2016, supporting full implementation of the Subsurface Technology and Engineering RD&D crosscut. The crosscut is a critical effort for advancing innovative RD&D under the Hydrothermal subprogram to reduce the cost and risk of geothermal development, by targeting opportunities to leverage advances in other subsurface sectors. FY 2016 funding also includes moving the Frontier Observatory for Research in Geothermal Energy (FORGE) toward field operations. FORGE is a dedicated site focused on creating an accelerated commercial pathway to large-scale EGS power generation in the U.S. Additionally, FY 2016 funding will target validation activities for the program's "Play Fairway Analysis," which assesses exploration risk and the probability of finding new geothermal resources on a regional scale, resulting in maps and studies that reduce the industry's drilling and development risks. Major changes are the result of funding full implementation of the Subsurface Technology and Engineering RD&D crosscut and Phase 3 of FORGE.

- Energy Efficiency ($1,030 million)
  - Advanced Manufacturing: The Budget provides $404 million in FY 2016 to enable the research, development, demonstration and deployment of industrial efficiency and crosscutting clean energy manufacturing technologies. This funding supports high-impact R&D focused on advanced manufacturing , working with U.S. manufacturers to realize significant gains in energy productivity, environmental performance, and product yield. As part of the President's vision for a larger multi-agency network aimed at bringing together universities, companies, and the government to improve U.S. manufacturing competitiveness, the funding fully supports the deployment of two additional Clean Energy Manufacturing Innovation Institutes, along with continued support of four existing institutes. FY 2016, funding will also support the deployment of energy efficient manufacturing technologies and practices, including strategic energy management and combined heat and power, across American industry through training programs, site assessments, and standards development.
  - Federal Energy Management Program (FEMP): The Budget provides $43 million in FY 2016 to continue FEMP's core activities to assist and enable Federal agencies to meet energy-related goals and provide Federal energy leadership to the country. Areas of focus in FY 2016 will include efforts to standardize the collection, calculation, and reporting of energy savings data across the Federal Government, and the establishment of a streamlined process for small Federal facilities to install energy conservation measures. FY 2016 funds will also support a challenge to

improve U.S. data center efficiency by 20 percent over ten years through the Better Buildings Data Center Challenge. Major funding changes are a result of a $15 million investment to assist agencies to invest in priority projects for efficiency and renewables with the greatest impact.

- Building Technologies: The Budget provides $264 million, which supports an increased emphasis on emerging technologies R&D in key technology areas such as lighting, heating and cooling and building envelope, needed to support the reduction of the Nation's energy use by 50%. FY 2016 funding also supports a new area of research in building energy efficiency advanced materials R&D focused on the advanced, high-throughput materials development. In addition to R&D activities funds will be used to pursue market-focused initiatives in both the Commercial and Residential Buildings Integration subprograms to overcome market barriers to widespread adoption of cost-effective energy efficiency technologies and solutions. Investments will continue to support building to grid integration activities focused on improving the efficiency and resiliency of the electric grid, including connected buildings and building systems. Equipment and Buildings Standards will continue to generate cost-effective energy savings through the development of national appliance and equipment standards and building energy codes. Funding will support rulemaking and standards certification and enforcement in both commercial and industrial products, as well as providing technical assistance to state and local jurisdictions regarding building energy code compliance. Energy conservation standards and test procedures directly support national energy policy objectives, such as increasing energy savings and energy productivity, and reducing carbon emissions.
- Weatherization and Intergovernmental Program: The Budget provides $318 million in FY 2016, including $228 million to support the Weatherization Assistance Program, which provides access to home weatherization services for low-income households across the country to reduce the comparatively large percentage of available income that they spend on energy. The State Energy Program will continue to disseminate best practices with a goal of helping government facilities and operations reduce annual energy use by 2 percent by 2020 and focus on energy planning and analysis. FY 2016 also establishes a new local program that will provide competitive grants and technical assistance to local governments, creating partnerships to catalyze investments in the advancement of the U.S. clean energy economy.

**EERE Key Initiatives**

- Clean energy manufacturing represents an important opportunity to strengthen U.S. Energy security, grow the American economy, and accelerate innovation in clean energy. The Clean Energy Manufacturing Initiative is a Department-wide approach to increase U.S. competitiveness in clean energy manufacturing while advancing progress toward the nation's energy goals. The DOE Clean Energy Manufacturing Initiative supports research, development, and addressing market barriers that will help companies competitively manufacture clean energy technologies in the U.S., and help companies across the manufacturing sector become more competitive by leveraging energy efficiency measures to increase their energy productivity.

  In EERE, the Advanced Manufacturing Office will establish two Clean Energy Manufacturing Innovation Institutes; and will lead the Department in research, development, and technical assistance on advanced manufacturing of materials and technologies. Energy technology programs across EERE will carry out targeted manufacturing R&D to address specific clean energy technology needs. Examples include fuel cell manufacturing process R&D and supply chain development in the Fuel Cell Technologies Program, advanced solar manufacturing technology development by the Solar Energy Technology Program, and development of new fabrication methods for vehicle lightweighting in the Vehicles Technologies Program.

  Building on this foundation, EERE offices will collaborate in joint efforts across the Department to apply advanced manufacturing technologies across specific energy needs and to carry out advanced materials manufacturing R&D. Advanced manufacturing technologies have enabled the fabrication of products with new capabilities and higher performance while advanced materials are core to several energy technologies. Collaboration across DOE in advanced materials manufacturing R&D will use high performance computing and high throughput combinatorial experimentation to develop validated models of materials systems capturing the effects of manufacturing processes and end-use to accelerate the development of materials from the point of discovery to qualification. This approach also supports the Administration's Materials Genome Initiative, and will be carried out in robust public-private partnership that could form the basis of a new approach to materials process development. Initial focus includes materials for solar energy conversion, non-vapor-compression refrigeration systems and building envelopes, non-platinum group metal catalysts, and vehicle lightweighting.

- EERE is developing and implementing a coordinated strategy of uniform policies and pilot programs aimed at significantly increasing meaningful interactions between the clean energy sector and DOE National Laboratories to help commercialize EERE technologies and strengthen clean energy R&D at the labs. The strategy focuses on increasing and enhancing lab-private sector relationships; increasing and streamlining access to National Laboratory capabilities, as appropriate; and evaluating and communicating lab developed technologies. The DOE National Laboratory infrastructure is a world-leading scientific enterprise. Since their founding in the mid- 20th century, the National Laboratories have been integral in DOE's mission to ensure America's security and prosperity by addressing its energy, environmental, and nuclear challenges through transformative science and technology solutions. Today, the U.S. faces an increasingly competitive landscape in which countries competing for leadership in the global clean energy economy are investing billions of dollars in their own clean energy industries. America's aptitude for technological innovation and competitiveness remains vital to our continued economic growth and energy security. An enduring role for the National Laboratories to advance scientific and technical clean energy solutions is imperative to ensure our continued leadership.

**DOE Crosscutting Initiatives**

The Department is organized into three Under Secretariats—Science and Energy, Nuclear Security, and Management and Performance—which recognize the complex interrelationship among DOE Program Offices. The FY 2016 Budget continues crosscutting programs which coordinate across the Department and seek to tap DOE's full capability to effectively and efficiently address the U.S.'s energy, environmental, and national security challenges. These crosscutting initiatives will be discussed further within the programs in which the crosscuts are funded. The FY 2016 Request for EERE contains the following crosscuts:

**Grid Modernization**: U.S. prosperity and energy innovation in a global clean energy economy depends on the modernization of the National Electric Grid. To support this transformation, DOE's Grid Modernization Initiative will create tools and technologies that measure, analyze, predict, and control the grid of the future; focus on key policy questions related to regulatory practices, market designs, and business models; ensure the development of a secure and resilient grid; and collaborate with stakeholders to test and demonstrate combinations of promising new technologies.

**Supercritical CO2**: The supercritical carbon dioxide (sCO2) based power generation effort is a technology-focused crosscutting initiative that will facilitate industry's transition to realize power cycles based on sCO2 as the working fluid. Building on industry outreach and focused R&D efforts in FY 2015, the major thrusts of the crosscut in FY 2016 are a coordinated R&D effort in high temperature technology development/component validation, and the Supercritical Transformational Electric Power Generation (STEP) initiative to design, construct and operate a 10-MW pilot test bed. Demonstrating and developing this power cycle has the potential to revolutionize electric power generation for fossil, concentrating solar, geothermal, nuclear and waste heat recovery applications in a way that is cleaner and more efficient, and which reduces cost.

**Subsurface Engineering**: Over 80 percent of our total energy supply comes from the subsurface, and this importance is magnified by the ability to also use the subsurface to store and sequester fluids and waste products. The subsurface crosscut, SubTER, will address identified challenges in the subsurface through highly focused and coordinated research in Wellbore Integrity, Stress State and Induced Seismicity, Permeability Manipulation, and New Subsurface Signals to ensure enhanced energy security, material impact on climate change via CO2 sequestration, and significantly mitigated environmental impacts from energy-related activities and operations.

**Energy-Water Nexus**: The energy-water nexus crosscut is an integrated set of cross-program collaborations designed to accelerate the Nation's transition to more resilient energy and coupled energy-water systems. The crosscut supports: (1) an advanced, integrated data, modeling, and analysis platform to improve understanding and inform decision-making for a broad range of users and at multiple scales; (2) investments in targeted technology research opportunities within the system of water-energy flows that offer the greatest potential for positive impact; and (3) policy analysis and stakeholder engagement designed to build from and strengthen the two preceding areas while motivating more rapid community involvement and response.

**Cybersecurity**: DOE is engaged in three categories of cyber-related activities: protecting the DOE enterprise from a range of cyber threats that can adversely impact mission capabilities; bolstering the U.S. Government's capabilities to address cyber threats; and, improving cybersecurity in the electric power subsector and the oil and natural gas subsector. The cybersecurity crosscut supports central coordination of the strategic and operational aspects of cybersecurity and facilitates cooperative efforts such as the Joint Cybersecurity Coordination Center for incident response and the implementation of Department-wide Identity Credential and Access Management.

**FY 2016 Crosscuts ($K)**

| | Grid Modernization | sCO2 | Subsurface Engineering | Energy-Water Nexus | Cyber Security | Total |
|---|---|---|---|---|---|---|
| **Vehicle Technologies** | 18,000 | 0 | 0 | 0 | 0 | **18,000** |
| **Hydrogen and Fuel Cell Technologies** | 8,500 | 0 | 0 | 0 | 0 | **8,500** |
| **Solar Energy** | 60,000 | 0 | 0 | 0 | 0 | **60,000** |
| **Wind Energy** | 12,027 | 0 | 0 | 0 | 0 | **12,027** |
| **Water Power** | 0 | 0 | 0 | 1,000 | 0 | **1,000** |
| **Geothermal Technologies** | 0 | 500 | 71,000 | 3,750 | 0 | **75,250** |
| **Advanced Manufacturing** | 0 | 0 | 0 | 4,300 | 0 | **4,300** |
| **Building Technologies** | 18,000 | 0 | 0 | 0 | 0 | **18,000** |
| **Facilities and Infrastructure** | 36,000 | 0 | 0 | 0 | 2,190 | **38,190** |
| **Total, Crosscuts** | **152,527** | **500** | **71,000** | **9,050** | **2,190** | **235,267** |

**Energy Efficiency and Renewable Energy**
**Funding by Congressional Control ($K)**

| | FY 2014 Enacted | FY 2014 Current[1] | FY 2015 Enacted | FY 2016 Request | FY 2016 vs FY 2015 |
|---|---|---|---|---|---|
| **Vehicle Technologies** | 289,737 | 282,201 | 280,000 | 444,000 | +164,000 |
| **Bioenergy Technologies** | 232,290 | 182,327 | 225,000 | 246,000 | +21,000 |
| **Hydrogen and Fuel Cell Technologies** | 92,928 | 89,518 | 97,000 | 103,000 | +6,000 |
| **Solar Energy** | 257,058 | 254,305 | 233,000 | 336,700 | +103,700 |
| **Wind Energy** | 88,126 | 87,035 | 107,000 | 145,500 | +38,500 |
| **Water Power** | 58,565 | 57,834 | 61,000 | 67,000 | +6,000 |
| **Geothermal Technologies** | 45,775 | 44,802 | 55,000 | 96,000 | +41,000 |
| **Advanced Manufacturing** | 180,471 | 175,400 | 200,000 | 404,000 | +204,000 |
| **Federal Energy Management Program** | 28,248 | 28,248 | 27,000 | 43,088 | +16,088 |
| **Building Technologies** | 177,868 | 173,631 | 172,000 | 264,000 | +92,000 |
| **Weatherization and Intergovernmental Program** | | | | | |
| Weatherization Assistance Program | | | | | |
| Weatherization Assistance [2] | 170,898 | 170,898 | 189,600 | 223,999 | +34,399 |
| Training and Technical Assistance | 2,998 | 2,998 | 3,000 | 4,000 | +1,000 |
| NREL Site-Wide Facility Support | 0 | 0 | 400 | 400 | 0 |
| Total, Weatherization Assistance Program | 173,896 | 173,896 | 193,000 | 228,399 | +35,399 |
| State Energy Program[3] | 49,970 | 49,970 | 50,000 | 70,100 | +20,100 |
| Local Energy Program[4] | 0 | 0 | 0 | 20,000 | +20,000 |
| Tribal Energy Program[5] | 6,996 | 6,996 | 0 | 0 | 0 |
| **Total, Weatherization and Intergovernmental Program** | **230,862** | **230,862** | **243,000** | **318,499** | **+75,499** |
| **Program Direction** | 162,000 | 162,000 | 160,000 | 165,330 | +5,330 |
| **Strategic Programs** | 23,540 | 23,540 | 21,000 | 27,870 | +6,870 |
| **Facilities and Infrastructure** | 45,973 | 45,973 | 56,000 | 62,000 | +6,000 |
| **Subtotal, Energy Efficiency and Renewable Energy** | **1,913,441** | **1,837,676** | **1,937,000** | **2,722,987** | **+785,987** |
| Use of Prior Year Balances | -2,382[6] | -2,382[5] | 0 | 0 | 0 |

[1] Funding reflects the transfer of SBIR/STTR to the Office of Science and $45 million to the Department of Defense for the Defense Production Act
[2] The FY 2016 Weatherization Assistance request is for $208,999 in formula grants and $15,000 in competitive financial assistance
[3] The FY 2016 State Energy request is for $45,000 in formula grants, $15,000 in competitive financial assistance, and $10,100 in technical assistance
[4] The FY 2016 Local Energy request is for $16,000 in competitive financial assistance and $4,000 in technical assistance.
[5] In the FY 2015 Budget Request, the Tribal Energy Program (TEP) was transferred to DOE's Office of Indian Energy Policy and Programs
[6] Reflects the use of prior-year unobligated balances ($2,382,000) in FY 2014

| | FY 2014 Enacted | FY 2014 Current[1] | FY 2015 Enacted | FY 2016 Request | FY 2016 vs FY 2015 |
|---|---|---|---|---|---|
| Rescission of Prior Year Balances | -10,418 | -10,418 | -22,805 | 0 | -22,805 |
| **Total, Energy Efficiency and Renewable Energy** | **1,900,641** | **1,824,876** | **1,914,195** | **2,722,987** | **+808,792** |
| **Federal FTEs** | **679** | **679** | **697** | **719** | **22** |

SBIR/STTR:

- FY 2014 Transferred: SBIR $27,404; STTR: $3,361
- FY 2015 Enacted: SBIR: $24,168; STTR: $3,333
- FY 2016 Request: SBIR: $38,690; STTR: $5,805

## Vehicle Technologies

### Overview

The U.S. transportation sector accounts for two-thirds of U.S. petroleum use and on-road vehicles are responsible for 80 percent of that amount. U.S. dependence on oil for transportation affects the national economy and its potential for future growth–the U.S. sends more than half-billion dollars a day overseas for oil (this amount has been well over $1 billion in recent years) and the average U.S. household spends nearly one-fifth of its total family expenditures on transportation, making it the second-most expensive spending category after housing. Oil price volatility also affects the national economy and household budgets. Over the past ten years, U.S. regular conventional retail gasoline prices have fluctuated from below $1.50 to over $4, squeezing annual household budgets by as much as $1,500 per average passenger car. In addition, the U.S. transportation sector accounts for approximately one-third of U.S. energy-related carbon pollution, and, despite recent progress in reducing other emissions, remains a significant source of air pollution as well.[1] To address these pressing challenges and help Americans reduce their transportation energy costs, there are two key solution pathways: (1) replace conventional fuels with cost-competitive domestically-produced alternatives and (2) use conventional fuels more efficiently. Public investment in the development of advanced transportation technologies that enable both of these pathways will improve the Nation's energy security, reduce greenhouse gas emissions, and strengthen U.S. global economic competiveness.

Aligning with the President's Climate Action Plan and all-of-the-above approach to American energy, the Vehicle Technologies Program supports a broad technology portfolio; adheres to a comprehensive and analysis-based strategy of research, development, demonstration, and deployment activities; and creates strategic public-private partnerships to develop new technologies and move them from the laboratory onto the road.

- Research and development (R&D) activities focus on reducing the cost, minimizing emissions, and improving the energy-related performance of a mix of medium- and long-term vehicle technologies including advanced batteries, electric drive technologies, lightweight and propulsion materials, advanced combustion engines, advanced fuels and lubricants, and other enabling transportation technologies.
- Modeling, evaluation, and demonstration activities provide objective publicly-available data to identify the most appropriate Federal investments and pathways for technology improvements and lessons learned for cost-effective future deployment.
- Outreach and deployment activities provide technical assistance, tools, and resources to help local communities and regions in the U.S. accelerate alternative fuel vehicle and infrastructure market growth and help consumers and fleets understand their options for saving money and reducing their environmental impact.
- Strategic public-private research partnerships with industry (e.g., U.S. DRIVE and 21st Century Truck Partnerships) leverage technical expertise, prevent duplication, ensure public funding remains focused on the most critical barriers to technology commercialization, and accelerate progress. Strategic public-private partnerships with end-users and other key stakeholders (e.g., Clean Cities, National Clean Fleets Partnership, and Workplace Charging Challenge) focus on overcoming market barriers and catalyzing private sector action to enable the widespread use of advanced technology vehicles – at no additional cost to the Government.

Close planning and coordination with other programs in EERE and across the DOE complex–National Laboratories, DOE's Office of Science, Office of Electricity Delivery and Energy Reliability, and the Advanced Research Projects Agency-Energy–accelerates and broadens the scope and productivity of Vehicle Technologies R&D investments ensuring the effective use of resources while avoiding duplication. This coordination enables program leadership of the EV Everywhere Grand Challenge; supports the vehicle-related components of cross-cutting EERE and DOE initiatives; and facilitates the transfer of successful technologies across the R&D continuum. In FY 2016, Vehicle Technologies will continue its strong collaboration with EERE's Hydrogen and Fuel Cell Technologies and Bioenergy Technologies Programs as part of a coordinated and comprehensive strategy under EERE's new Deputy Assistant Secretary for Transportation to achieve the EERE goal of expanding the adoption of sustainable, domestically-powered transportation alternatives.

[1] Transportation sector pollutants account for more than half of all carbon monoxide and NOx emissions, almost a quarter of all volatile organic compounds, and two to six percent of particulate matter emissions. See Transportation Energy Data Book 32nd Edition, ORNL, 2012. http://info.ornl.gov/sites/publications/files/Pub44660.pdf.

**Highlights of the FY 2016 Budget Request**

The Vehicle Technologies Budget Request supports several key efforts that contribute to achieving its high-level goals:

- The EV Everywhere Grand Challenge ($253 million), a bold DOE-wide initiative, seeks to enable the U.S. to produce a wide array of plug-in electric vehicle (PEV) models, including plug-in hybrids and all-electric vehicles, that are as affordable and convenient as gasoline powered vehicles by 2022. Developed with key stakeholder input, the EV Everywhere Grand Challenge technology performance and cost targets will guide DOE investments to reduce the combined battery and electric drive system costs of a PEV by up to 50 percent (by 2022, from a 2012 baseline). Specific technical targets include:
  - Cutting battery costs from $300/kWh in 2014 to $125/kWh by 2022;
  - Eliminating almost 30 percent of vehicle weight through light weighting by 2022, compared to a 2002 baseline; and
  - Reducing the cost of electric drive systems from $16/kW in 2013 to $8/kW by 2022.
- Vehicle Technologies will support new awards for a "SuperTruck II" ($40 million) initiative to research, develop, and demonstrate a suite of technologies with the goal to improve the freight hauling efficiency of heavy-duty Class 8 long-haul vehicles by 100 percent by 2020 with respect to comparable 2009 vehicles, and to demonstrate applicability of these technologies to heavy-duty Class 8 regional-haul vehicles as well. The use of regional-haul trucks is expected to increase in the future as more container ships begin to arrive on the East Coast due to the widening of the Panama Canal. Improving the efficiency of regional haul trucks is becoming more important as fleets shift to daycabs to accommodate shorter hauls. Projects will include RD&D of technologies that improve engine efficiency and emission control, advanced transmissions and hybridization, waste energy recovery, aerodynamic drag of the tractor and trailer, tire rolling resistance, lightweight materials, and auxiliary power units to reduce engine idling, along with other technologies as needed to meet the goal.
- To more rapidly deploy lightweight materials and manufacturing processes for automotive use, Vehicle Technologies will issue a $30 million funding opportunity announcement (FOA) in support of the Administration's Materials Genome Initiative and as part of DOE's Clean Energy Manufacturing Initiative. The focus will be advanced materials manufacturing R&D, which includes the use of high-performance computing and high-throughput materials experimentation, to capture the effects of processing and end use and to dramatically accelerate the development of high strength, high formability, corrosion resistant, and low cost magnesium sheet alloys for vehicle light weighting from discovery through qualification. Vehicle Technologies efforts in this area will emphasize the use of integrated computational and experimental techniques along with the unique computational resources available at the DOE National Laboratories to rapidly address industry challenges and automotive technology barriers associated with lightweight magnesium sheet alloys.
- Building on prior-year and ongoing fuel properties and advanced combustion activities, Vehicle Technologies (through the Fuel and Lubricant Technologies and Advanced Combustion Engine R&D subprograms) will use $17 million to support a "New Fuels and Vehicle Systems Optima" effort, in coordination with the Bioenergy Technologies Program. Establishing a link across fuels and engines early in the R&D cycle will enable a new, synergistic and complete systems-based approach to creating optimized powertrains. Work will involve studying the "optima" for fuel properties/formulation and engine efficiency, as well as techno-economic criteria.
- Vehicle Technologies will also expand its focus on natural gas R&D in the transportation sector, with additional emphasis on advanced low-cost, high-energy density on-board storage ($10 million). To the extent possible, work will be coordinated with and leverage work in the Hydrogen and Fuel Cells Program related to onboard vehicle storage of gaseous fuels.
- A Vehicle Technologies Program "Incubator" funding opportunity will invest 5 percent of Vehicle Technologies funding toward new off-roadmap innovative technologies and solutions that can help meet existing goals but are not represented in a significant way in the current portfolio or technology roadmaps. Successful Incubator projects will reduce the risk associated with potentially breakthrough approaches and technologies so they may be "on-ramped" to future program roadmaps and the program portfolio.

Throughout its efforts, the Vehicle Technologies Program supports the Department's Clean Energy Manufacturing Initiative. The Clean Energy Manufacturing Initiative is a Department-wide approach to increase U.S. competitiveness in clean energy manufacturing while advancing progress toward the nation's energy goals. The DOE Clean Energy Manufacturing Initiative supports research, development, and addressing market barriers that will help companies competitively manufacture clean energy technologies in the U.S., and help companies across the manufacturing sector become more competitive by leveraging energy efficiency measures to increase their energy productivity. Clean Energy Manufacturing efforts in the Vehicle

Technologies Program include research and development to enable scale-up of manufacturing technologies needed to enable market entry of next-generation battery materials and cell components, materials and processes for manufacturing innovative advanced power electronics, development of materials and processes for low rare earth content electric drive systems, and development of new manufacturing methods for carbon fiber production using lower cost precursors. In addition, in alignment with the Administration's Materials Genome Initiative, the Program will support materials manufacturing R&D, focusing on lightweight materials for vehicle applications. This approach will be carried out through public-private partnership and will include the use of high-performance computing and high-throughput materials experimentation to capture the effects of processing and end use and to dramatically accelerate the development of high strength, high formability, corrosion resistant, and low cost magnesium sheet alloys for vehicle light weighting from the point of discovery through qualification and implementation.

Within the FY 2016 Budget Request, the Vehicle Technologies Program supports the Departmental Grid Modernization Crosscut. U.S. prosperity and energy innovation in a global clean energy economy depend on the modernization of the National electric grid. To support this transformation, the DOE's Grid Modernization crosscut will create tools and technologies that measure, analyze, predict, and control the grid of the future; focus on key policy questions related to regulatory practices, market designs, and business models; and collaborate with stakeholders to test and demonstrate combinations of promising new technologies. The Vehicle Technologies Program will support PEV-specific aspects of vehicle/grid integration, with a focus on technologies needed to fully integrate PEVs into the distribution system in a safe, reliable, and cost-effective manner. In addition, Vehicle Technologies will continue to identify what valuable services PEVs may provide to the electric grid and quantify the multiple value streams associated with these services when fully integrated with distributed solar generation, building energy management systems, and other smart grid technologies. The program will also support the development and demonstration of new devices (e.g. low-cost communications-capable energy meters), systems, and algorithms to enable advanced control of PEVs across the electricity distribution system. Vehicle Technologies will also collaborate with other EERE programs to demonstrate the potential of PEVs integrated into a larger transactional energy ecosystem.

**FY 2016 Crosscuts ($K)**

| | Grid Modernization | Total |
|---|---|---|
| **Vehicle Technologies** | **18,000** | **18,000** |

## Vehicle Technologies
## Funding ($K)

| | FY 2014 Enacted[1] | FY 2014 Current[2] | FY 2015 Enacted | FY 2016 Request | FY 2016 vs FY 2015 |
|---|---|---|---|---|---|
| **Vehicle Technologies** | | | | | |
| **Batteries and Electric Drive Technologies** | | | | | |
| Battery Technology R&D | 84,949 | 82,231 | 82,701 | 105,400 | +22,699 |
| Electric Drive Technologies R&D | 23,986 | 23,218 | 21,000 | 39,000 | +18,000 |
| **Total, Batteries and Electric Drive Technologies** | **108,935** | **105,449** | **103,701** | **144,400** | **+40,699** |
| **Vehicle Systems (formerly Vehicle and Systems Simulation and Testing)** | **43,474** | **42,848** | **40,393** | **68,100** | **+27,707** |
| **Advanced Combustion Engine R&D** | **49,970** | **48,371** | **49,000** | **64,500** | **+15,500** |
| **Materials Technology** | | | | | |
| Lightweight Materials Technology | 28,982 | 28,055 | 28,533 | 62,500 | +33,967 |
| Propulsion Materials Technology | 9,155 | 8,862 | 7,069 | 8,000 | +931 |
| **Total, Materials Technology** | **38,137** | **36,917** | **35,602** | **70,500** | **+34,898** |
| **Fuel and Lubricant Technologies** | **15,990** | **15,478** | **20,000** | **37,000** | **+17,000** |
| **Outreach, Deployment, and Analysis** | | | | | |
| Vehicle Technologies Deployment | 23,985 | 23,985 | 24,000 | 49,000 | +25,000 |
| Advanced Vehicle Competitions | 1,999 | 1,999 | 2,500 | 2,500 | +0 |
| Legacy Fleet Improvement | 2,898 | 2,805 | 0 | 0 | +0 |
| Legislative and Rulemaking | 1,899 | 1,899 | 1,804 | 2,000 | +196 |
| Biennial Peer Reviews | 450 | 450 | 0 | 0 | +0 |
| Analysis | 0 | 0 | 0 | 3,000 | +3,000 |
| **Total, Outreach, Deployment, and Analysis** | **31,231** | **31,138** | **28,304** | **56,500** | **+28,196** |
| **NREL Site-Wide Facility Support** | **2,000** | **2,000** | **3,000** | **3,000** | **+0** |
| **Total, Vehicle Technologies** | **289,737** | **282,201** | **280,000** | **444,000** | **+164,000** |

SBIR/STTR:

- FY 2014 Transferred: SBIR $6,594,000; STTR $942,000
- FY 2015 Enacted: SBIR $6,568,000; STTR $906,000
- FY 2016 Request: SBIR $10,411,000; STTR $1,562,000

[1] FY 2014 Enacted funding reflected the contractor foreign travel rescission of $172,937.
[2] Funding reflected the transfer of SBIR/STTR to the Office of Science.

**Vehicle Technologies**
**Explanation of Major Changes ($K)**

| | FY 2016 vs FY 2015 |
|---|---|
| **Batteries and Electric Drive Technologies:** Funding is increased for the EV Everywhere Grand Challenge, including advanced battery materials, advanced battery development, work with industry battery developers, and advanced processing focused on achieving cost reduction and performance goals; wide bandgap power electronics, rare earth-free advanced motor technology designs, and integrated traction drive systems focused on achieving cost reduction and improved reliability and performance goals. Additional funding for Battery Technology R&D will support competitively-awarded projects focused on (1) mitigating issues that impact performance and life of very high energy density lithium ion electrochemistries and (2) technologies that extend cycle life for high voltage cathodes and for alloy and lithium metal anodes. Additional funding for Electric Drive Technology Research will support new competitively-awarded research activities focused on advanced high-temperature low-cost materials, devices, and components, including next-generation wide bandgap power electronics technology. Increased funding will also support new competitively-awarded projects to develop advanced integrated electric drive components and systems, such as enhanced power semiconductor packaging and improved magnetics, with a focus on cost reduction, reliability, and high-temperature operation and meeting system performance targets. | **+40,699** |
| **Vehicle Systems (formerly Vehicle and Systems Simulation and Testing):** The new subprogram title, "Vehicle Systems," more accurately reflects the breadth of activity in this subprogram; the title change has no effect on subprogram content or activities. Funding supports specific high priority activities in Vehicle Modeling and Simulation, Codes and Standards, and Vehicle Technology Evaluations. Efforts to develop climate control efficiency solutions will be reduced as technologies supported in competitively-awarded projects in FY 2013 and FY 2014 are nearing commercialization. Emphasis is increased in Vehicle Systems Efficiency Improvements to support the development of enabling technologies and solutions to reduce vehicle energy requirements. The Department's Grid Modernization crosscut is supported in this subprogram. Vehicle Systems work in the Grid Modernization area includes improved modeling and planning tools for analysis of PEVs, charging infrastructure, and associated electricity consumption and flow characteristics to better inform utilities, fleet owners, and other stakeholders of potential issues and benefits of PEVs on the grid, and includes a new transactive energy ecosystem demonstration. Many of these activities also support the EV Everywhere Grand Challenge. Following the great successes of SuperTruck I, the Vehicle Technologies Program will initiate SuperTruck II in FY 2016 partially supported out of this subprogram. SuperTruck II will continue dramatic improvements in the freight efficiency of heavy-duty Class 8 long-haul vehicles through system-level improvements, such as hybridization and more efficient idling and high efficiency HVAC technologies, and by demonstrating applicability of these technologies to regional-haul vehicles. | **+27,707** |

| | FY 2016 vs FY 2015 |
|---|---|
| **Advanced Combustion Engine R&D:** Funding is increased to support the SuperTruck II program with industry to improve heavy-duty engine efficiency by 30 percent and truck-level freight hauling efficiency of heavy-duty Class 8 long-haul vehicles by 100 percent by 2020, with respect to comparable 2009 vehicles, as well as to demonstrate applicability of the developed SuperTruck II technologies to regional-haul vehicles. Improving the efficiency of regional-haul trucks is becoming more important as fleets shift to daycabs to accommodate shorter hauls. Building on prior year efforts, funding is also increased for New Fuels and Vehicle Systems Optima activities to develop advanced new engine technologies that can effectively utilize new advanced fuels for maximum efficiency improvement and emissions reduction. Research and development of predictive computer models for fuel spray, combustion, and emissions formation using high-performance computing will be pursued to optimize engines and fuels. | **+15,500** |
| **Materials Technology:** Funds are increased to support efforts in the application of computational, high throughput experimental, synthesis, and characterization tools for lightweight materials and manufacturing process R&D as a part of DOE's Clean Energy Manufacturing Initiative. The Program will award new, cost-shared projects for advanced materials manufacturing R&D focused on the use of high-performance computing and high-throughput materials development, to develop models capturing the effects of processing and end-use performance, to dramatically reduce cost and improve U.S. manufacturing competitiveness in magnesium sheet alloys for lightweight vehicles. The activities under Lightweight Materials also support the EV Everywhere Grand Challenge. Propulsion materials efforts will target SuperTruck II powertrain materials requirements to enable increased peak cylinder pressure, reduced friction, and increased system efficiency. | **+34,898** |
| **Fuel and Lubricant Technologies:** Research and development on high performance low-carbon fuels will be continued and emphasized with increased funding for the "New Fuels and Vehicle Systems Optima" effort, including R&D on advanced/drop-in renewable octane sources to be undertaken in cooperation with EERE's Bioenergy Technologies Program. In this collaboration, Vehicle Technologies will focus on end-use aspects of renewable and other low-carbon fuels, in engines and consumer acceptance while Bioenergy Technologies will focus on the production of biofuels designed for advanced engines and fuel systems. Funding is also increased to support R&D on advanced natural gas storage technologies, to be coordinated, as appropriate, with related onboard vehicle storage activities in the Hydrogen and Fuel Cells Program. | **+17,000** |

| | |
|---|---|
| **Outreach, Deployment, and Analysis**: Additional funding is requested for an Alternative Fuel Vehicle Community Partner funding opportunity to accelerate widespread introduction and adoption of commercially-available advanced vehicle technologies to reduce U.S. dependence on petroleum, increase local fuel diversification, and catalyze adoption of clean transportation technologies. No funding is requested for Legacy Fleet Improvement activities. A new key activity, Analysis, has been added to the Outreach, Deployment, and Analysis subprogram to provide additional budget clarity and consolidate cross-cutting Vehicle Technologies analysis activities. Analysis will support the planning, execution, and communication of technology, societal, economic, and interdisciplinary analyses to inform program planning and technology investment decisions. | **+28,196** |
| **Total, Vehicle Technologies** | **+164,000** |

**Description**

The Batteries and Electric Drive Technologies subprogram addresses the development of low-cost, high-energy batteries and R&D of low-cost efficient electric drive systems needed for the widespread adoption of plug-in electric vehicles (PEVs, including all-electric vehicles and plug-in hybrid electric vehicles).

Battery Technology R&D ($105 million)

The focus of the Battery R&D activity is to develop the technologies necessary to reduce modeled high-volume battery costs from $300/kWh in 2014 to $125/kWh by 2022, a nearly 60 percent reduction.

Key additional details include:

- Cost target is based on useable energy and a manufacturing volume of 100,000 battery packs per year.
- Batteries must meet the power, energy, extended life, weight, and volume requirements of the vehicle.
- Batteries must meet the safety and abuse tolerance requirements of the vehicle.

The Battery Technology R&D activity seeks to accomplish these technical objectives by funding research programs with partners in academia, at National Laboratories, and in industry. The activity is focused on the development of high-energy and high-power battery materials and battery systems that promise to significantly reduce the cost, weight, and volume of PEV batteries. The activity supports the development of lower-cost materials and processing technologies to achieve significant cost reductions. R&D focus areas are described below.

Advanced battery materials efforts ($42 million) will focus on key materials (cathode, anode, and electrolyte), which account for 40-70 percent of PEV battery cost. The specific focus of this work will be on the development of new materials and electrode couples that offer a significant improvement in either energy or power over today's technologies. Technologies of interest include, but are not limited to, 2nd generation lithium ion batteries that contain high-voltage (5V) and/or high-capacity (>300mAh/g) cathode materials; 3rd generation lithium ion batteries that contain advanced metal alloy and composite anodes, such as silicon carbon, that offer 2-4 times the capacity of today's graphite anodes; and advanced electrolytes. In FY 2016, the subprogram will expand research into lithium metal batteries and other chemistries and configurations beyond lithium ion technologies. Additional funding will support competitive awards for research focused on technologies for both high-energy and high-voltage cathodes, and for alloy-based and lithium metal anodes. These surface films will be designed to enhance cell life and safety. Major activities will include (1) first principles calculations of surface film interactions with active materials (both anode and cathode) and electrolytes; (2) design and coating of multiple lab-scale, high-energy anode and cathode materials; and (3) detailed diagnostics investigation of the surface films' behavior in electrochemical cells.

Advanced battery development activities ($31 million) will continue to develop advanced PEV batteries in cooperation with industry through projects awarded under a competitive process and cost-shared by developers. The focus of this work will be on the development of robust prototype cells that contain new materials and electrodes and the development of advanced fabrication processes that offer a significant reduction in battery cost over existing technologies. Pack-level innovations will focus on the development of technology that will (1) reduce the weight and the cost of thermal management systems, structural and safety components, and electronics; (2) incorporate fast-charge capability into the design and build process; and (3) utilize robust safety technology, devices, and functionality including technology to minimize damaged battery hazards for first responders. The subprogram will also support development of computer aided design tools for battery engineering. This work will result in batteries that meet PEV cost and performance goals.

Advanced processing and enabling cell chemistry activities will accelerate advanced battery market entry by supporting processing innovation and materials discovery. Processing R&D activities will support the development and scale-up of manufacturing technologies needed to enable market entry of next-generation battery materials and cell components. This effort will emphasize disruptive materials and electrode production technologies that could significantly reduce cost and environmental impact while increasing yield and process control relative to existing production technologies. New batteries using novel cell chemistries are enabled by investigating operational interactions among all cell components (cathode, anode, electrolyte, binders, conductive additives, and separator) and mitigating factors that negatively impact cell

performance and life. Additional funding will support competitively awarded projects focused on the optimizing next generation, high-energy lithium-ion electrochemistries that incorporate new battery materials.

Electric Drive Technologies R&D ($39 million)

The focus of the Electric Drive Technologies R&D activity is to develop technologies and designs to reduce the cost, improve the performance, and increase the reliability of power electronics, electric motors, and other electric propulsion components. Activities also include R&D of advanced thermal management technologies and R&D of advanced materials and manufacturing processes for electric drive technologies. The electric drive cost target for FY 2016 is $12/kW ($660/system), a 25 percent reduction from the 2012 cost of $16/kW ($880/system).

Key additional details include:

- Long-term electric drive system (motor and inverter) goal: 50 percent cost reduction (compared to FY 2013 baseline) by FY 2022 to $8/kW ($440/system).
- Reduce electric drive weight and volume, while meeting stringent performance, efficiency, and reliability requirements.
- Testing, modeling, and analysis confirm the state-of-the-art, remaining barriers, and continued R&D priorities.
- Supports the EV Everywhere Grand Challenge and is coordinated with the EERE Advanced Manufacturing Program's Critical Materials Institute to accelerate development of materials and processes for low rare earth content electric drive systems (especially motors) for electric vehicles.

The Electric Drive Technologies R&D activity seeks to accomplish its technical objectives working closely with academia, National Laboratories, and industry. R&D efforts focus on power electronics, electric motors, and thermal management technologies utilizing advanced, low-cost materials, technologies, and topologies compatible with the high-volume manufacturing of motors, inverters, chargers, and DC/DC converters for electric drive vehicles. In FY 2016, the subprogram will continue subcomponent R&D of high-temperature capacitors, wide bandgap (WBG) semiconductors, advanced magnets, and materials and designs for high-temperature packaging.

To achieve its 2022 goals, the program will conduct Electric Drive Technologies R&D through a combination of competitive funding opportunities for competitively-awarded R&D teams and R&D efforts that leverage the core capabilities of the National Laboratories.

Work is focused on the following:

Advanced electric drive technology research will focus on key materials and components of power electronics and motors to reduce the cost of electric drive technologies by 50 percent by 2022. Specific materials, designs, and technologies of interest include, but are not limited to, high-temperature, low-cost materials and devices to enable utilization of WBG semiconductors in power electronics (inverters, converters, and chargers) and materials and processes to reduce or eliminate the need for rare earth materials in electric motors. Activities include research to develop high-temperature passive devices, interfaces, and interconnects; advanced motor laminations and windings; advanced materials and processes for manufacturing; advanced packaging technologies; and improved heat transfer to enhance thermal performance and reliability. Increased funding for competitively-awarded research efforts will focus on innovative, high-temperature materials, devices, and components to reduce the cost of power electronics and electric motors while improving performance and reliability. Research to develop advanced power electronics and electric motors will enable integration of innovative devices and components for electric drive technologies to significantly improve performance and reliability and reduce cost, weight, and volume. Efforts will focus on achieving the 2022 EV Everywhere power electronics cost target of $3.3/kW, a 49 percent reduction from FY 2013 and the electric motor cost target of $4.7/kW, a 51 percent reduction from FY 2013.

Electric drive technology development will support competitively-awarded projects that are cost-shared by developers. Major technical barriers to closing the gaps between the current status and the targets are the high cost of the materials and components, large volume needed to package these components, additional weight of the components, and high component losses that lead to large thermal management systems that add cost, volume, and weight. The scope of this work will focus on the development of electric drive systems and components including electric motors, inverters, DC/DC converters, and on-board battery chargers. Development efforts will target maturation, scale-up, and manufacturing technologies for critical subcomponents such as power semiconductors and modules, magnetic materials, and capacitors. Additional funding, also through competitively-awarded projects, will focus on electric drive system performance

improvements and cost reduction through the integration of component-level advancements to demonstrate meeting system targets.

In addition, funds may be used to support efforts such as peer reviews, data collection and dissemination, technology assistance, and technology-to-market activities.

**Battery and Electric Drive Technologies**
**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **Battery and Electric Drive Technologies** | | |
| **$103,701,000** | **$144,400,000** | **+$40,699,000** |
| *Battery Technology R&D ($82,701,000)* | *Battery Technology R&D($105,400,000)* | *Battery Technology R&D (+$22,699,000)* |
| • Continue support for up to 20 research projects at National Laboratories to develop 3rd generation lithium ion battery materials and cell R&D focused on advanced metal alloy or silicon composite anode technology. Complete initial R&D to optimize battery cells containing high capacity cathodes and metal alloy or silicon anodes. Continue support for materials research activity focused on beyond lithium ion technologies such as lithium metal and non-lithium battery technologies.<br>• Initiate 6 to 8 new competitively-selected awards to support to develop lower cost production processes that support the scale-up of advanced metal alloy or silicon composite anode materials, new cathode materials, innovative electrolytes, and other battery materials with the potential to significantly reduce battery material cost, electrode production cost, or cell manufacturing cost in support of the Clean Energy Manufacturing Initiative.<br>• Continue support for the development of robust prototype battery cells and modules that incorporate new materials and advanced electrodes that offer a significant reduction in cost. This work will be conducted through 8 to 12 battery development projects supported through the Program's cooperative agreement with the United States Advanced Battery | • Initiate 10 to 15 new competitively-selected awards for advanced battery materials research to develop novel electrolytes and cathodes that will significantly improve the performance, abuse, and cost to enable the commercialization of high-energy, next-generation lithium ion chemistries. Of particular interest are electrolytes that are stable up to 4.8 Volts and high-voltage cathodes including non-intercalation materials that are highly reversible and deliver more than 250 mAh/g of capacity.<br>• Support 3rd generation lithium ion battery materials and cell R&D focused on advanced metal alloy or silicon composite anode technology through projects at National Laboratories.<br>• Continue support for materials research activity focused on beyond lithium ion technologies such as lithium metal and non-lithium battery technologies through projects at National Laboratories.<br>• Support advanced battery development of robust prototype battery cells and modules that incorporate new materials and advanced electrodes that offer a significant reduction in cost. Conduct extensive performance, cycle life, and safety testing of deliverables from battery development efforts with industry. This work will be conducted through 8 to 12 battery development projects under the Program's cooperative agreement with the United States Advanced Battery Consortium.<br>• Support the development of Computer Aided | • Additional funding will support 5 to 10 competitively-awarded advanced battery materials projects for research focused on atomic and molecular level surface film design and engineering for both high energy and high voltage cathodes, and for alloy-based and lithium metal anodes. These surface films will be designed to enhance cell life and safety. Major activities will include (1) first principles calculations of surface film interactions with active materials (both anode and cathode) and electrolytes; (2) design and coating of multiple lab scale high-energy anode and cathode materials; and (3) detailed diagnostics investigation of the surface films' behavior in an electrochemical cells.<br>• Additional funding will support 3 to 5 competitively-awarded advanced processing and enabling cell chemistry projects focused on the optimization of next-generation, high-energy lithium ion electrochemistries that incorporate new battery materials. Emphasis will be on investigating the interaction between all cell components (including the cathode, anode, electrolyte, binders, conductive additives, and separator) and mitigating issues that impact performance and life. |

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| Consortium and will include extensive performance, cycle life, and safety testing of deliverables. | Engineering Battery Design Tools, leveraging the unique capabilities of National Laboratories.<br>• Support 4 to 6 National Laboratory research projects on advanced processing and enabling cell chemistry focused on developing lower-cost production processes for the scale-up of advanced metal alloy or silicon composite anode materials, new cathode materials, innovative electrolytes, and other battery materials with the potential to significantly reduce battery material costs in support of the Clean Energy Manufacturing Initiative. | |
| *Electric Drive Technologies R&D ($21,000,000)*<br>• Support R&D to address critical technical barriers to commercializing advanced electric traction drive components and systems.<br>• Develop non-rare earth magnets and motors with improved thermal management, performance, and reliability through two competitively-awarded projects with industry as well as National Laboratory research.<br>• Support R&D of innovative power electronics designs and packaging to reduce cost and improve performance.<br>• Continue three industry projects to develop low-cost, high-temperature capacitors.<br>• Initiate up to two new competitively-awarded projects to develop Wide Band Gap power modules to enable commercialization and reduce system-level cost with improved performance and reliability. | *Electric Drive Technologies R&D ($39,000,000)*<br>• Through a combination of competitively-awarded projects and National Laboratory efforts, conduct research of high temperature active and passive devices, interfaces, and interconnects to enable innovative power electronics designs; advanced motor materials and configurations to eliminate rare earth materials. Efforts will emphasize materials and processes for manufacturing to reduce cost with improved performance and reliability.<br>• Through up to two new competitively-awarded projects, develop advanced electric drive technologies that incorporate new materials, devices, packaging, and heat transfer technologies to achieve significant cost reductions. In partnership with National Laboratories, increase emphasis on research to reduce the cost and improve the performance of materials, devices and components for advanced power electronic and electric motors. Expand work for electric drive system performance improvement and cost reduction to demonstrate meeting system targets. | *Electric Drive Technologies (+$18,000,000)*<br>• Increased funding will support National Laboratory research efforts focused on cost reduction and performance improvements of materials, devices and components for power electronics and electric motors. Increased funding will support up to two new competitively-awarded projects to develop electric drive components and systems, focused on cost reduction and meeting system targets. |

**Vehicle Technologies**
**Vehicle Systems**
**(formerly Vehicle and Systems Simulation and Testing)**

**Description**

The new subprogram title, "Vehicle Systems," has been changed from "Vehicle and Systems Simulation and Testing" to more accurately reflect the breadth of subprogram activity; the title change has no effect on subprogram content or activities. The Vehicle Systems subprogram supports a broad portfolio of foundational activities to reduce petroleum consumption in the U.S. transportation sector. These activities include:

- The development and use of advanced vehicle modeling tools to identify the most promising technologies for vehicle applications and reduce the cost and time-to-market for developing these technologies;
- Component and vehicle evaluations in both laboratory and on-road environments to validate the modeling tools, prove the long-term reliability and benefits of advanced technologies, and identify critical R&D needs to improve these technologies;
- The development of critical codes and standards to reduce the development time for and costs of plug-in electric vehicles (PEVs, including all-electric vehicles and plug-in hybrid electric vehicles) and components while ensuring real-world interoperability; and
- R&D of enabling technologies to improve overall vehicle efficiencies and reduce energy requirements such as high efficiency heating and cooling systems, drive train hybridization, better aerodynamics, and low rolling resistance technologies.

Vehicle Systems is focused on modeling and simulation projects to develop advanced modeling tools and use these tools to perform simulations and studies of advanced vehicle technology options. In the area of tool development, the subprogram will continue work to expand the capabilities of the Autonomie modeling platform with industry partners, adding new high-fidelity component models of emerging technologies and increasing tool functionality. These resources are made available to the automotive and heavy vehicle industries, where they accelerate development times and reduce the costs of bringing advanced high-efficiency technologies to market. Simulation activities will focus on increasing vehicle efficiency through improved component interactions and conducting predictive modeling to identify optimal configurations and sizing for advanced components.

Work supporting vehicle technology evaluations includes in-depth laboratory testing of advanced vehicles and component interactions; closed track and on-road evaluation of the latest light-duty advanced technology vehicles to evaluate efficiency and high-mileage component reliability; in-fleet evaluation of medium- and heavy-duty advanced vehicle technologies with industry partners; charging equipment evaluations and research in Electric Vehicle Supply Equipment (EVSE) load management; and development and evaluation of vehicle thermal management systems. These efforts provide valuable data to the Vehicle Systems modeling and simulation activity on the operation of advanced vehicles and technologies in laboratory and real-world conditions. In addition, these projects help R&D activities validate performance claims for advanced component technologies and identify potential R&D needs to address technology shortfalls. These projects also use vehicle and charging data trends to guide and facilitate R&D of technologies that can be used to minimize the impact of PEVs on the electricity grid. Closed track and field evaluations of advanced technology vehicles also support the modeling and simulation, laboratory evaluation, and component R&D activities for Vehicle Technologies.

In support of the EV Everywhere Grand Challenge, Vehicle Systems work supporting codes and standards focuses on leading the development and adoption of U.S. PEV standards and working with international organizations to promote the global harmonization of PEV standards. Ensuring that codes and standards are in place for PEV technology directly supports the EV Everywhere Grand Challenge and responds to industry requests for technical assistance in establishing reasonable standards that decrease product development costs and increase investment certainty. Specific standards developments that will be supported include PEV/Grid Communications, Interoperability, Connectivity, Wireless Charging, Vehicle and Component Testing Protocols, and Green Racing Protocols. Each of these efforts is coordinated and consistent with the Smart Grid Implementation Plan and being harmonized with European countries. This activity also directly supports the Grid Modernization crosscut by developing the standards and protocols that govern the PEV/grid interface, enabling plug-in vehicles to communicate and interact with the utility.

The subprogram will also support vehicle systems efficiency improvements that increase overall vehicle operational efficiency by reducing parasitic energy losses as well as system-level solutions that enable reductions in vehicle energy requirements. Projects will focus on reducing the aerodynamic drag of heavy-duty trucks and tractor-trailer combinations; advanced HVAC R&D to improve PEV range; energy management strategies to improve vehicle efficiencies; and R&D of advanced vehicle charging solutions such as wireless, smart fast-charging, low-power DC charging, and recharging from renewable sources. While each of the technologies being investigated can improve PEV efficiency, several of them, including the aerodynamic and advanced HVAC projects, are also applicable to vehicles with conventional drivetrains and potentially could be retrofitted onto legacy fleet vehicles. In FY 2016, the subprogram will complete existing SuperTruck I awards and initiate SuperTruck II projects, including R&D on drive train hybridization, more efficient idling, and high efficiency HVAC technologies. The subprogram will also demonstrate applicability of these technologies to heavy-duty Class 8 regional-haul vehicles.

As part of the greater DOE Grid Modernization crosscut, the Vehicle Systems subprogram will identify and address challenges associated with the large-scale deployment of plug-in vehicles on the electric grid, and maximize the opportunities that PEVs represent when integrated with other distributed clean energy resources. Work in this area includes improved modeling and planning tools for analysis of PEVs, charging infrastructure, and associated electricity consumption and flow characteristics to better inform utilities, fleet owners, and other stakeholders of potential issues (e.g., compromised distribution transformer life due to geographic clustering of PEVs) and benefits (e.g., increasing hosting capacity of variable renewable generation) of PEVs on the grid. Vehicle Technologies will continue to identify what services PEVs may provide to the electric grid, and quantify the multiple value streams associated with these services when fully integrated with distributed solar generation, building energy management systems, and other smart grid technologies. Additionally, this activity supports the development and demonstration of new devices (e.g., low-cost communications-capable energy meters), systems, and algorithms to enable advanced control of PEVs across the electricity distribution system. Vehicle Technologies will also collaborate with other EERE programs to demonstrate the potential of PEVs integrated into a larger transactional energy ecosystem.

The rapidly-moving trend toward connected and autonomous driving is expected to have important implications for the core DOE mission, such as the potential impact on transportation energy use. Building upon the FY 2015 analytical study to assess how consumer and driver behavior in these areas would affect energy consumption, Vehicle Systems will support R&D of enabling technologies for breakthrough advances in fuel consumption reduction through connected and automated driving solutions.

In addition, funds may be used to support efforts such as peer reviews, data collection and dissemination, technology assistance, and technology-to-market activities.

**Vehicle Systems**
**(formerly Vehicle and Systems Simulation and Testing)**
**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **Vehicle Systems $40,393,000** | **$68,100,000** | **+$27,707,000** |
| • Use ongoing vehicle modeling and laboratory testing results to provide a systems-level perspective and quantify the benefits of component technologies developed through Vehicle Technologies R&D activities and identify additional areas for energy efficiency improvements, including evaluation of autonomous vehicle technologies.<br>• Continue support of remaining SuperTruck projects awarded through a previous competitive funding opportunity to demonstrate a 50 percent improvement in Class 8 line-haul truck freight efficiency over a 2009 baseline through systems-level improvements.<br>• Through a competitive funding opportunity, initiate industry effort to develop a distributed vehicle charging system to manage load across numerous PEVs under varying grid conditions.<br>• Initiate multi-National Laboratory Efficiency Analysis of Autonomous Vehicles effort to quantify the potential efficiency and fuel consumption reduction benefits of various autonomous vehicle technologies.<br>• Continue National Laboratory efforts to integrate PEVs, buildings, and distributed electricity generation by implementing findings of an FY 2014 EV/Smart Grid Requirements Study. | • Provide a vehicle systems context in support of Vehicle Technologies' component-level R&D activities. Enhance advanced vehicle models and simulation capabilities by incorporating new features into the Autonomie simulation platform and developing and validating higher-fidelity models based on test data from the Advanced Powertrain Research Facility.<br>• Conduct laboratory and field testing of six new emerging advanced electric-drive vehicle models by incorporating them into the Advanced Vehicle Testing & Evaluation (AVTE) fleet.<br>• Provide technical support for PEV standards development, and promote international harmonization of vehicle codes and standards through participation in key standards development organizations.<br>• Complete final SuperTruck I projects and initiate up to two new SuperTruck II projects to develop energy-efficient powertrain technologies that will improve commercial vehicle freight hauling efficiency of heavy-duty Class 8 long-haul vehicles by 100 percent in 2020, compared to a 2009 baseline, through systems-level improvements and to demonstrate applicability of these technologies to heavy-duty Class 8 regional-haul vehicles as well.<br>• Expand vehicle/grid integration R&D efforts by implementing recommendations of the Grid Modernization Laboratory Consortium, coordinated with other EERE and DOE offices to | • Increase support for component, sub-system, and powertrain hardware-in-the-loop simulations. Focus on developing higher-fidelity vehicle component and sub-system models for integration into Autonomie.<br>• Eliminate activities to collect and analyze real-world data from ARRA-funded demonstration projects. Reduce efforts to develop climate control efficiency solutions as technologies supported from four competitively-awarded projects in FY 2013 and FY 2014 are nearing commercialization.<br>• Support international efforts to harmonize U.S. PEV codes and standards with those of China and other Asian countries. Increase engagement with other agencies and standards development bodies involved with global EV charging standards.<br>• Initiate support of up to two new competitively-awarded SuperTruck II projects. Initiate industry-led R&D on systems-level efficiency solutions and develop enabling technologies for plug-in electric vehicles.<br>• Increase Vehicle Technologies support for vehicle/grid integration through National Laboratory work and competitively-awarded industry projects, coordinated with grid integration efforts as part of the DOE Grid Modernization crosscut.<br>• Shift focus from analytical work for connected and autonomous vehicles to R&D for technology |

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| | ensure synergy and optimal integrated impact.<br>• Support the development of enabling technologies, including up to two competitively-awarded projects for the development of high-power wireless charging technologies, as well as National Laboratory efforts to reduce vehicle energy consumption through connected driving. | solutions to enable energy efficiency benefits from the use of vehicle connectivity and automation.<br>• Initiate up to two new competitively-awarded projects for technologies enabling wireless charging. |

## Vehicle Technologies
## Advanced Combustion Engine R&D

**Description**

The Advanced Combustion Engine R&D subprogram focuses on researching and developing cutting-edge new technologies to enable the commercialization of high-efficiency advanced internal combustion engines for passenger and commercial vehicles. Increasing the efficiency of internal combustion engines is one of the most cost-effective approaches to reducing petroleum consumption and associated greenhouse gas emissions of the Nation's vehicle fleet in the near- to mid-term. A 2013 National Academies review of Vehicle Technologies research efforts stated that internal combustion engines "are going to be the dominant automotive technology for decades, whether in conventional vehicles, hybrid vehicles, PHEVs, biofueled or natural gas vehicles."[1]

In FY 2016, the subprogram will support research to accelerate the development of high-efficiency advanced combustion engines while reducing emissions, and develop technologies to use waste energy from engine exhaust to further improve vehicle fuel economy. Targets include the following:

- In 2020, increase passenger vehicle engine efficiency to improve gasoline vehicle fuel economy by 35% and diesel vehicle fuel economy by 50% compared to 2009 gasoline vehicles; and
- In 2020, increase SuperTruck vehicle engine efficiency by 30% compared to a 2009 baseline.

The subprogram will seek to improve the thermal efficiency of passenger and commercial vehicle engines by investigating emerging and innovative combustion processes related to high efficiency new engine technologies, including homogeneous charge compression ignition (HCCI) and other modes of low-temperature combustion (LTC), lean-burn gasoline, clean diesel, and multi-fuel operation while also reducing engine-out emissions of nitrogen oxides (NOx) and particulate matter (PM) to near-zero levels. Using the unique capabilities at National Laboratories, the subprogram will conduct laser and X-ray based diagnostics to increase the fundamental understanding of in-cylinder combustion and emissions formation processes. Since all future high-efficiency engines will employ direct injection, high energy X-ray and neutron-based diagnostics will be utilized to visualize fuel injection spray formation and how it affects combustion in these engines. Computer simulations of combustion, including spray models, intake and exhaust flows, heat transfer, chemical kinetics mechanisms of the fuel, and motion of internal engine components will be further refined using high-performance computing facilities at the National Laboratories. The subprogram will also initiate new competitively-awarded research projects with universities to augment fundamental research at the National Laboratories. Prior successful DOE investments in combustion research have yielded a 70:1 return on investment in fuel savings and associated health benefits.[2]

Meeting anticipated future emission standards will be challenging for high-efficiency diesel and lean-burn gasoline engines. To address this challenge, the Advanced Combustion Engine R&D (ACE) subprogram will also conduct research and development of innovative emission control strategies to enable the successful development of these high-efficiency engine types through projects led by the National Laboratories, industry, and universities designed to reduce costs and increase the performance and durability of NOx-reduction and PM-oxidation systems. In FY 2016, ACE will continue research at the National Laboratories in areas including low-cost base metal catalysts (to replace expensive platinum group metals), catalysts that operate at lower exhaust temperatures, lighter and more compact multifunctional emission control components, and new control strategies. The subprogram will also initiate new competitively-awarded research projects with universities to augment fundamental research at the National Laboratories. A workshop conducted in FY 2013 with industry, universities, and National Laboratories pointed to the need for research on catalysts to reduce emissions at low exhaust temperatures of 150°C.[3] The subprogram will support the development and characterization of 150°C catalysts in combination with hydrocarbon and NOx traps to enable low-temperature combustion engines to meet EPA Tier 3 standards

[1] *Review of the Research Program of the U.S. DRIVE Partnership: 4th Report,* NRC 2013.

[2] Valued in inflation adjusted 2008 dollars; "Retrospective Benefit-Cost Evaluation of U.S. DOE Vehicle Combustion Engine R&D Investments: Impacts of a Cluster of Energy Technologies," U.S. DOE, May 2010. The investment of $931,000,000 includes some funds from the Office of Science.

[3] Future Automotive After treatment Solutions: The 150°C Challenge Workshop Report (Nov 2012).

with low energy penalty. Also, ACE will develop and validate particulate filters to enable efficient direct-injection gasoline engines to meet future particulate standards without negatively impacting fuel economy.

In FY 2016, Vehicle Technologies will competitively award new cost-shared projects with industry under the SuperTruck II Initiative to develop technologies to improve the freight hauling efficiency of heavy-duty Class 8 long-haul vehicles by 100 percent in 2020, compared to a 2009 baseline vehicle. These efficiency technologies will also be applicable to heavy-duty Class 8 regional-haul vehicles. The use of regional-haul trucks is expected to increase in the future as more container ships begin to arrive on the East Coast due to the widening of the Panama Canal. Improving the efficiency of regional-haul trucks is becoming more important as fleets shift to daycabs to accommodate shorter hauls. SuperTruck II industry teams will develop engine technologies to improve engine efficiency by 30 percent, achieve 55 percent brake thermal efficiency while meeting EPA emission standards, and provide vehicle demonstrations of the goals at the completion of the initiative.

Technologies to improve engine efficiency may include, but are not limited to, higher in-cylinder and fuel injection pressures, air boosting systems capable of higher pressure ratios and flow rates over a broad operating range, waste heat recovery systems, advanced low temperature combustion regimes with thermal barrier coating to reduce heat transfer, friction and pumping work reduction, multi-fuel operation, emission control systems effective at lower exhaust temperatures, and alternate engine architectures. Teams will also investigate technologies that further improve advanced transmissions and hybridization, aerodynamic drag of the tractor and trailer, tire rolling resistance, lightweight materials, and auxiliary power units to reduce engine idling along with other advanced technologies as needed to meet the goal. For this comprehensive approach to improving vehicle efficiency, in addition to Advanced Combustion Engine R&D, funds from across Vehicle Technologies will support SuperTruck II project activities related to vehicle systems, lightweight materials, fuels and propulsion materials improvements. In addition, the subprogram will provide funding to successfully complete the final SuperTruck I project that will demonstrate a 20 percent improvement in engine efficiency, compared to a 2009 baseline.

The Advanced Combustion Engine R&D subprogram will support competitively-awarded, cost-shared projects with industry to develop enabling technologies for light- and heavy-duty engine and powertrain systems and support the achievement of breakthrough thermal efficiencies while meeting or reducing emissions below U.S. Environmental Protection Agency's standards. Enabling technologies to be considered include, but are not limited to, components for waste heat recovery systems such as Organic Rankine Cycle, including heat exchangers, control valves, expanders and working fluids; advanced components for exhaust gas recirculation systems, including heat exchangers and valves; variable compression ratio and variable displacement mechanisms; variable valve actuation and timing mechanisms; reduced friction approaches; low heat rejection and thermal management approaches; advanced fuel injectors; advanced ignition systems; intake air management systems; and turbomachinery.

In collaboration with the Fuel and Lubricant Technologies subprogram and building on prior year efforts, Advanced Combustion Engine R&D will support the "New Fuels and Vehicle Systems Optima" effort by further investigating the impact of fuel properties on engine performance and how they can be optimized to achieve higher efficiency and lower emissions. Co-development of engines and fuels as an integrated system will allow future engines to operate at peak efficiency for a higher portion of drive cycles. In support of this effort, the subprogram will develop chemical kinetics models of petroleum and bio-based fuels and various fuel additives to allow screening of numerous fuels without the need for conducting engine experiments, saving time and cost in the development cycle. Data used for the chemical kinetics models will be gathered from detailed experiments in rapid compression machines, shock tubes, and ignition quality testers. Modeling will guide the co-development of optimal fuels and engines that will be tested to assess their impact.

The Advanced Combustion Engine R&D subprogram will also support competitively-awarded, cost-shared projects for fundamental research at universities that will complement research at the National Laboratories to increase the efficiency of engines while reducing emissions. Research may include modeling of fuel sprays and other processes, development of kinetic mechanisms for fuels and combustion, and characterization of catalyst for emissions reduction at low temperatures.

In addition, funds may be used to support efforts such as peer reviews, data collection and dissemination, technology assistance, and technology-to-market activities.

**Advanced Combustion Engine R&D**
**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **Advanced Combustion Engine R&D $49,000,000** | **$64,500,000** | **+$15,500,000** |
| • Demonstrate fuel economy improvements of 25 percent for passenger cars and 20 percent for commercial vehicles compared to 2009 baselines.<br>• Continue development of engine technologies to increase fuel economy of passenger cars by 35 percent in 2020 compared to a 2009 baseline.<br>• Initiate 2 to 3 new competitively-awarded projects to develop enabling technologies for engine systems that have the potential to increase commercial vehicle engine efficiency by 30 percent.<br>• Complete characterization of particulate matter from direct injection gasoline engines to enable design optimization of particulate filters.<br>• Conduct experimental validation of fuel injector spray models developed using high performance computers and provide to industry.<br>• Develop atomistic-scale design and scalable synthesis of multi-functional catalyst for emissions reduction at low exhaust temperatures. | • Develop computer simulations of combustion and emission control processes that utilize the high performance computing capabilities at the National Laboratories.<br>• Support laser- and X-Ray-based research of advanced combustion concepts and fuel injection systems to improve engine efficiency.<br>• Continue to develop chemical kinetic models of fuels to optimize combustion and reduce emissions.<br>• Continue to develop emission control systems to reduce NOx from lean-burn gasoline and other advanced engines that have low exhaust temperatures.<br>• Support development and characterization of 150$^{o}$C catalysts in combination with hydrocarbon and NOx traps to enable low-temperature combustion engines to meet EPA Tier 3 standards with low energy penalty.<br>• Develop and validate performance of gasoline particulate filters to enable efficient direct-injection engines to meet future particulate standards.<br>• Initiate up to two new competitively-awarded SuperTruck II projects to develop energy efficient powertrain technologies that will improve commercial vehicle engine efficiency by 30 percent and freight hauling efficiency of heavy-duty Class 8 long-haul vehicles by 100 percent in 2020, compared to a 2009 baseline vehicle, and demonstrate applicability of these technologies to heavy-duty Class 8 regional-haul vehicles. | • Increase funding to support up to two new competitively-awarded SuperTruck II projects with industry for advanced technologies to improve engine efficiency by 30 percent and freight hauling efficiency of heavy-duty Class 8 long-haul vehicles by 100 percent, with respect to comparable 2009 vehicles, while demonstrating applicability of these technologies to heavy-duty Class 8 regional-haul vehicles.<br>• Increase funding to further investigate the co-optimization of engine technologies and fuels formulation for maximum efficiency improvement in support of the “New Fuels and Vehicle Systems Optima” effort.<br>• Increase funding for fundamental combustion and emission control research at the National Laboratories and universities. |

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes<br>FY 2016 vs FY 2015 |
|---|---|---|
| | • Complete final SuperTruck I project.<br>• Initiate 3 to 5 new competitively-awarded projects to develop enabling technologies for engine and powertrain systems to support the achievement of breakthrough thermal efficiencies while meeting emissions standards.<br>• Further investigate the fundamental impact of fuel properties on engine performance and how they can be optimized to achieve higher efficiency and lower emissions in support of the "New Fuels and Vehicle Systems Optima" effort.<br>• Initiate new competitively-awarded projects for fundamental combustion and emission control research at universities that will complement research at the National Laboratories to increase the efficiency of engines while reducing their emissions. | |

**Description**

The Materials Technology subprogram supports vehicle light weighting and improved propulsion efficiency through the discovery, development, and utilization of materials and enabling technologies for light- and heavy-duty vehicles. The Materials Technology subprogram seeks to accomplish its technical objectives through research programs with academia, National Laboratories, and industry. Weight reduction activities emphasize all vehicle systems including the body, chassis, interior, and powertrain. The full breadth of lightweight materials technologies are considered, such as advanced high strength steels, aluminum alloys, magnesium alloys, carbon fiber composites, and hybrid materials. Propulsion materials activities develop high-performance materials to withstand the aggressive conditions of high-efficiency combustion and the demands of improved electric vehicle drive trains.

Subprogram activities focus on the following key areas with cost and performance targets:

- By 2017, validate a 25% improvement in component strength relative to components made with 2010 baseline cast Al alloys (A319 or A356) for improved efficiency light-duty engines.
- By 2018, validate a 25% improvement in component strength relative to components made with 2010 baseline A842 (Cast Iron) for improved efficiency heavy-duty engines.
- By 2019, validate material technology enabling 35% weight reduction in a light-duty vehicle body versus a 2002 baseline, meeting target $4.32 per pound removed on a lifecycle basis.

Lightweight Materials Technology ($62.5 million)

Reducing the weight of a vehicle by 10 percent yields a 6-8 percent fuel economy improvement for an internal combustion engine vehicle and also increases the electric range or decreases the necessary battery size of an electric vehicle. However, the integration of lightweight materials into vehicle structures is limited by cost, performance, and manufacturing barriers as well as a lack of adequate design tools. The Lightweight Materials Technology activity addresses these barriers by developing and demonstrating advanced steels, aluminum (Al) alloys, magnesium (Mg) alloys, carbon fiber composites, and multi-material systems with performance and manufacturability that greatly exceed today's technologies. Materials and manufacturing challenges spanning from extraction to assembly are addressed with an emphasis on establishing tools, capabilities, and material standards for light- and heavy-duty vehicles.

In FY 2016, the Lightweight Materials Technology activity will continue to emphasize and support low-cost carbon fiber and low-cost carbon fiber composites, in coordination with manufacturing activities across EERE and the Department. Areas of emphasis will include low-cost precursors for carbon fiber that meet or exceed automotive industry mechanical property requirements while also meeting industry requirements for material and process cost. The Lightweight Materials Technology activity will also support weight reduction and fleet efficiency improvements for heavy-duty vehicles under SuperTruck II. The Lightweight Materials Technology activity will also support a new advanced materials manufacturing effort that will dramatically accelerate performance improvements and cost reduction of automotive Mg sheet and improve U.S. competitiveness in the manufacturing of Mg sheet structures for vehicles. Aligned with the Administration's Materials Genome Initiative and as part of the Department's Clean Energy Manufacturing Initiative, this effort will be carried out through public-private partnership and will use high-performance computing and high-throughput experimentation to accelerate material development from discovery through qualification, capturing the effects of processing and end-use performance. The Lightweight Materials Technology activity will also support technology development and demonstration that addresses technology gaps in dissimilar material joining and assembly.

Propulsion Materials Technology ($8 million)

This activity supports developing and demonstrating materials for vehicle powertrains with greatly improved properties compared to the state-of-the-art. Advanced combustion research can yield more efficient combustion regimes, but advanced engines are limited by existing material capabilities—new materials with improved strength, toughness, and high-temperature performance are required to enable greater efficiency. In FY 2016, the Propulsion Materials activity will support SuperTruck II through the development of materials to enable downsized, high-efficiency engines that provide the greatest opportunity for weight reductions and improvements in overall powertrain efficiency. This activity addresses new materials for components such as crankshafts, pistons, connecting rods, turbocharger wheels, engine valves, gaskets, and

bearings that improve efficiency by reducing mechanical/thermal losses and enabling higher peak cylinder pressures. This activity will complement work in the Electric Drive Technologies R&D activity by developing multi-material bonding techniques for induction motor components that enable higher current capabilities and improved dimensional stability.

In addition, funds may be used to support efforts such as peer reviews, data collection and dissemination, technology assistance, and technology-to-market activities.

**Materials Technology**
**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **Materials Technology $35,602,000** | **$70,500,000** | **+$34,898,000** |
| *Lightweight Materials Technology ($28,533,000)*<br>• Initiate new competitively-selected project to support vehicle lightweighting through the discovery, development, and utilization of integrated computational materials engineering tools for composites made from low-cost carbon fiber; development of lightweight materials that are compatible with existing infrastructure; and validation of the Mach I design for the multi-material prototype vehicle.<br>• Initiate 2 to 5 competitively-awarded projects to demonstrate the full performance and cost capabilities of advanced lightweight materials and manufacturing technologies through the design, construction, and testing of ultra-lightweight vehicle sub-structures.<br>• Initiate 2 to 5 competitively-awarded projects emphasizing improved properties, manufacturability, computational materials science, multi-material joining, and enabling technologies for carbon fiber composites, advanced high strength steels, aluminum alloys, and magnesium alloys. | *Lightweight Materials Technology ($62,500,000)*<br>• Through a combination of competitively-awarded projects and National Laboratory work, support vehicle weight reduction across all vehicle classes through development of precursors and processes for low-cost carbon fiber composites.<br>• Support up to two new competitively-awarded projects to develop and demonstrate weight reduction technologies (including materials and manufacturing processes) for SuperTruck II, emphasizing improvements in freight efficiency of heavy-duty vehicles.<br>• Initiate 1 to 5 competitively-awarded projects for an advanced materials manufacturing R&D effort that will use high-performance computing and high-throughput experimentation to accelerate the development of high strength, highly formable, corrosion resistant automotive magnesium sheet alloys, in support of the Administration's Materials Genome and DOE's Clean Energy Manufacturing Initiative. The goal of this work is to demonstrate significant acceleration in deploying magnesium sheet production, forming, joining, and corrosion protection technologies into the vehicle manufacturing supply chain.<br>• Through a combination of competitively-awarded projects and National Laboratory work, emphasize dissimilar material joining and | *Lightweight Materials Technology (+$33,967,000)*<br>• Initiate 1 to 5 competitively-awarded projects to support an advanced materials manufacturing R&D effort that will focus on the use of high-performance computing and high-throughput materials experimentation to accelerate the development of high strength, highly formable, corrosion resistant automotive magnesium sheet alloys, aligned with the Administration's Materials Genome Initiative and as a part of DOE's Clean Energy Manufacturing Initiative.<br>• Increase emphasis on sponsoring enabling technologies that address technology gaps identified in the prior-year's multi-material lightweight vehicle (MMLV) program.<br>• Increase emphasis and support for heavy duty truck weight reduction technologies to support improved freight efficiency (SuperTruck II).<br>• Support increased adoption of aluminum alloys and carbon fiber composites by addressing significant technology barriers through the use of computational materials science and engineering. |

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| | assembly technologies that enable the use of various lightweight materials as best suited for particular applications.<br>• Through a combination of competitively-awarded projects and National Laboratory work, develop and implement computational materials science and engineering tools to address automotive industry challenges in lightweight materials.<br>• Initiate 2 to 5 new competitively-awarded projects to develop aluminum alloys and manufacturing processes which reduce implementation cost and improve structural performance.<br>• Initiate 2 to 5 new competitively-awarded projects to design non-petroleum precursors for low-cost carbon fiber using an integrated computational materials engineering approach. | |
| *Propulsion Materials Technologies ($7,069,000)*<br>• Develop enabling materials in support of Advanced Combustion Engine R&D 2020 targets of 35 percent improvement in conventional passenger car fuel economy and 30 percent improvement in heavy-duty engine efficiency.<br>• Continue work on cast metals for engine blocks, cast steel processing for rotating components, and low temperature catalysts. | *Propulsion Materials Technologies ($8,000,000)*<br>• Develop materials and manufacturing processes for up to two new competitively-awarded SuperTruck II projects, targeting freight efficiency improvements via materials enabled powertrain efficiency increases and weight reductions through increased power density. | *Propulsion Materials Technologies (+$931,000)*<br>• Shift focus of Propulsion Materials activities to support up to two new competitively-awarded SuperTruck II projects – specifically, focus on powertrain materials requirements to enable increased peak cylinder pressure, reduced friction, and increased system efficiency. |

## Vehicle Technologies
## Fuel and Lubricant Technologies

**Description**

The Fuel and Lubricant Technologies subprogram develops technologies that reduce petroleum consumption through vehicle powertrain efficiency improvements and alternative fuels petroleum displacement. The subprogram's activities fall into three main categories: (1) alternative and renewable fuels, such as natural gas-derived fuels, drop-in biofuels, and other renewable fuels; (2) the use of unique non-conventional fuel properties to improve efficiency; and (3) lubricant technologies that can reduce friction losses in new and legacy vehicles to improve fuel economy.

In support of alternative and renewable fuels, the Fuel and Lubricant Technologies subprogram focuses on overcoming technical barriers to the implementation of petroleum-displacing fuels. Fuels such as natural gas, drop-in biofuels, and higher alcohols (e.g., butanol) frequently have technical barriers that prevent their implementation in traditional equipment and infrastructure designed for petroleum and petroleum-based products. Work to overcome these barriers will include support for new alternative-fuel engine offerings, testing and evaluation of refueling infrastructure, and evaluation of the emissions impact of novel alternative fuels.

A major focus of the FY 2016 Budget Request is the development of on-board natural gas storage technologies for light- and heavy-duty natural gas vehicles ($10 million). Overall goals for this effort include increasing the energy density of storage by 25 percent and reducing tank cost to enable a two-year system payback (relative to conventional fuel). Potential emerging approaches include, but are not limited to, conformable tanks, advanced adsorbent technology, and implementation of more-efficient fueling for increased effective storage.

Subprogram activities focus on achieving the following targets:

- In 2020, demonstrate fuel properties that enable an increase in the operating range of advanced combustion regimes to 90 percent coverage of non-idling portions of the city (UDDS) and highway (HWFET) light-duty Federal drive cycles.
- In 2020, demonstrate improved natural gas refueling technology for light-duty vehicles to increase vehicle range by 25 percent, compared to a 2010 baseline with equivalent-sized 3,600 psi tanks.
- In 2020, demonstrate novel engine oil additives compatible with new and legacy vehicles to achieve at least a 4 percent fuel economy improvement compared to 2010 state-of-the-art synthetic 10W-30 engine oil on standard ASTM tests.

In FY 2016, the subprogram will increase emphasis on fuel properties R&D in support of the "New Fuels and Vehicle Systems Optima" effort, in coordination with EERE's Bioenergy Technologies Program and the Vehicle Technologies Advanced Combustion Engine (ACE) subprogram. Within Vehicle Technologies, the ACE subprogram will primarily focus on R&D of the mechanical aspects of engine design that take advantage of specific fuel properties. Building on prior-year activities in this area, the Fuel and Lubricants subprogram will perform R&D emphasizing how changes in fuel properties and fuel design can improve system efficiency. The ultimate goal of the effort is cost-effective, lower-carbon fuels for high-performance efficient engines. These systems will deliver up to 60 percent lower greenhouse gas emissions than conventional engines using conventional fuel on a lifecycle basis. Through a combination of competitively-awarded projects and work with National Laboratories, activities will be structured to apply to a wide range of current and potential future lower-carbon fuels. A key component of this effort is knock mitigation. By differentiating fuel property effects, such as chemical octane, and physical effects, such as evaporation (each of which contribute to knock mitigation and differ independently among different fuel components), engine knock will become more predictable, enabling operation closer to the knock limit and, therefore, at higher efficiency. Correlating these fuel property variations for new fuel components and candidate lower-carbon fuels in modern engines will directly help engine designers better understand fuel-engine design interplay and create high-efficiency engines optimized for use with those fuels. Fuel property effects R&D for both low-temperature combustion regimes and advanced conventional spark-ignition and compression ignition engines will continue. Co-development of engines and fuels as an integrated system will enable better control of future engines operating on future fuel formulations and allow them to operate at peak efficiency for a higher portion of drive cycles. Development of improved metrics for fuel quality will enhance the consistency and predictability of fuel behavior under a variety of combustion conditions, including under advanced and conventional combustion.

In addition, the Fuel and Lubricant Technologies subprogram will focus on developing advanced lubricants that are compatible with future and legacy vehicles to reduce friction loss in engines, transmissions, and axles. This includes R&D and evaluation of candidate additives for friction- and wear-reduction needed to accelerate the movement of these additives from small start-ups to mainstream suppliers—filling a gap in higher-risk, long-term research. When applied across the legacy fleet, the gains from advanced lubricants are significant. The 2-6 percent fuel economy improvement that advanced lubricants can potentially provide is immediately applicable to the over 240 million light-duty vehicles and 2 million heavy-duty vehicles on the road today. Achieving a 4 percent fuel economy improvement by 2020 could save almost 8 billion gallons/year and more than 80 billion gallons by 2030—a significant addition to the petroleum reductions achieved through new technology adoption.

In FY 2016, a prototype system of drivetrain lubricants capable of cost-effectively attaining a 3 percent improvement in fuel economy (relative to state-of-the-art 10W-30 synthetic engine oil and state of the art axle lubricants) will be designed through a combination of experimental work and simulation. In addition, the subprogram will support the study of engine lubrication requirements of high octane fuels, in coordination with the high octane fuel study described above.

In addition, funds may be used to support efforts such as peer reviews, data collection and dissemination, technology assistance, and technology-to-market activities.

**Fuel and Lubricant Technologies**
**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **Fuel and Lubricant Technologies $20,000,000** | **$37,000,000** | **+$17,000,000** |
| • Demonstrate an increase in the operating range of advanced combustion engines due to the use of renewable fuel properties, allowing 62 percent coverage of non-idling portions of the city (UDDS) and highway (HWFET) light-duty Federal drive cycles.<br>• Initiate 2 to 3 new competitively-awarded projects to develop dual-fuel natural gas heavy-duty engine enabling technologies capable of improving efficiency to achieve a smaller-than 5 percent penalty relative to a comparable diesel engine.<br>• In cooperation with EERE's Bioenergy Technologies Program, and leveraging the unique capabilities of National Laboratories, expand R&D of drop-in biofuel compatibility with existing and future infrastructure, fuel, and engine systems. Continue R&D to develop and evaluate novel materials as lubricant additives and base-oil blendstocks for reduced friction and improved engine and transmission efficiency. Demonstrate via dynamometer testing powertrain friction reduction that would deliver a 3 percent benefit in light-duty vehicle fuel economy relative to SAE 5W-30 engine oil. | • Initiate 3 to 5 new competitively-awarded projects to develop advanced on-board natural gas storage for light- and heavy-duty natural gas vehicles, with a focus on increasing the energy density of storage by reducing tank size for constant range, reducing weight, and, especially, reducing tank cost.<br>• In collaboration with the Bioenergy Technologies Program and Vehicle Technologies Advanced Combustion Engine R&D subprogram, and building on prior-year activities, support the "New Fuels and Vehicle Systems Optima" effort, with a focus on cost-effective, bio-derived, high-octane fuels for high-performance, efficient engines, as well as fuel quality metrics.<br>• Design prototype system of drivetrain lubricants capable of cost-effectively delivering a 3 percent fuel economy benefit relative to SAE 5W-30 engine oil in vehicle testing. | • Initiate 3 to 5 new competitively-awarded projects to develop advanced on-board natural gas storage for light- and heavy-duty vehicles.<br>• Increase coordinated fuel properties R&D activities with the Advanced Combustion Engine R&D subprogram and Bioenergy Technologies Program under the "New Fuels and Vehicle Systems Optima" effort, with an initial focus on fuel property impacts on ignition and knock mitigation.<br>• Develop prototype formulation of powertrain lubricant system to cost-effectively deliver a 3 percent fuel economy benefit in light-duty vehicles relative to SAE 5W-30 engine oil and demonstrate in a vehicle. |

## Vehicle Technologies
## Outreach, Deployment, and Analysis

**Description**

The Outreach, Deployment, and Analysis subprogram includes a portfolio of activities to catalyze the widespread adoption of advanced vehicle technologies. These include the Vehicle Technologies Deployment activity, which enables and works with a nationwide network of local public/private partnerships (Clean Cities coalitions), bringing together key stakeholders to help accelerate the use of alternative fuel and energy-efficient vehicle technologies. The Vehicle Technologies Deployment activity also supports the annual DOE/EPA Fuel Economy Guide publication and associated website, www.fueleconomy.gov, as well as the development and dissemination of related data (required by law) to the public. The Advanced Vehicle Competitions activity encourages university student engineers to participate in advanced technology development—helping to address the need for more highly-trained engineers in advanced vehicle technologies to overcome barriers in the marketplace. The Legislative and Rulemaking activity focuses on a variety of DOE statutory responsibilities established in the Energy Policy Act (EPAct) of 2005 and other statutes and legislation, primarily related to requirements for state and alternative fuel providers to operate alternative fuel vehicle fleets. In addition, a new Analysis key activity has been added to the Outreach, Deployment, and Analysis subprogram to provide additional budget clarity and consolidate cross-cutting Vehicle Technologies analysis activities. The Analysis activity supports the planning, execution, and communication of technology, societal, economic, and interdisciplinary analyses to inform overall Vehicle Technologies Program planning as well as key technology investment decisions.

Vehicle Technologies Deployment ($49 million)

This activity, primarily through Clean Cities, supports four main focus areas: (1) helping to convene key community and business leaders to develop and implement projects and policies, leverage resources, and address local barriers; (2) developing tools and information to help consumers save money on fuel costs and help fleets understand their options for cost-effective alternatives to gasoline and diesel fuel; (3) providing technical assistance to help local leaders address permitting and safety issues, technology shortfalls, and other project implementation barriers; and (4) providing competitive financial assistance awards that encourage initial private sector match and long-term investment in alternative fuel and advanced technology vehicle deployment initiatives($25 million).

Advanced Vehicle Competitions ($2.5 million)

In FY 2016, this activity will develop and execute a four-year collegiate engineering competition, EcoCAR 3, which provides hands-on, real-world experience to demonstrate a variety of advanced vehicle technologies and designs and develops a workforce trained in advanced vehicle technologies.

Legislative and Rulemaking ($2 million)

This activity focuses on implementing the State and Alternative Fuel Provider Regulatory program (10 CFR Part 490); alternative fuel designations; the Private and Local Government Fleet Regulatory Program; and other EPAct 2005 requirements including reports and rulemaking, analyses of impacts of other regulatory and pending legislative activities, and the implementation of legislative changes to the EPAct fleet activities as they occur.

Analysis ($3 million)

This activity supports the planning, execution, and communication of technology, societal, economic, and interdisciplinary analyses to inform program planning and technology investment decisions. Specifically, three main focus areas: (1) a strong foundation of data, (2) a robust toolbox of relevant and up-to-date analytical models, and (3) integrated analysis (leveraging data and tools)—will inform technology cost and performance projections, market dynamics estimations, and policy insights. This work supports the development of resources used widely across the transportation community, including the Transportation Energy Data Book and Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation (GREET) model. Vehicle Technologies Analysis activities are coordinated closely with related work in EERE's Fuel Cell Technologies and Bioenergy Technologies Programs.

In addition, funds may be used to support efforts such as peer reviews, data collection and dissemination, technology assistance, and technology-to-market activities.

**Outreach, Deployment and Analysis**
**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **Outreach, Deployment and Analysis $28,304,000** | **$56,500,000** | **+$28,196,000** |
| *Vehicle Technologies Deployment ($24,000,000)*<br>• Displace petroleum use through public/private partnerships to catalyze the widespread adoption of advanced vehicle technologies, publishing annual DOE/EPA Fuel Economy Guide publication and www.fueleconomy.gov, conducting advanced vehicle competitions, implementing statutory responsibilities placed on DOE by EPAct 2005 and other statutes and legislation, and improving the legacy vehicle fleet energy use.<br>• Exceed Clean Cities' petroleum reduction goal of 950 million gallons per year.<br>• Implement 5 to 10 competitively-awarded Alternative Fuel Vehicle (AFV) Deployment Initiative projects to support alternative fuel vehicle use via hands-on driver/fleet experiences, safety-related training, and use of AFVs in regional emergency preparedness plans.<br>• Initiate 1 to 2 competitively-awarded projects to support an aggregated purchasing and procurement strategy to facilitate increased alternative fuel vehicle deployments.<br>• Expand work with the Natural Gas Vehicle Technologies Forum to identify near-term barriers to vehicle deployment.<br>• Expand participation in the National Clean Fleets Partnership and support member fleets' implementation of petroleum reduction strategies.<br>• Complete data gathering from earlier AFV community planning projects, analyze data, and hold public forum to present findings. | *Vehicle Technologies Deployment ($49,000,000)*<br>• Document petroleum reduction impact of Clean Cities activities of at least 1.15 billion gallons per year.<br>• Expand technical and problem solving assistance to key stakeholders to help in overcoming specific market and technical barriers.<br>• Plan, execute, and communicate technology, societal, economic, and interdisciplinary analyses to inform program planning and technology investment decisions.<br>• Initiate Alternative Fuel Vehicle Community Partner projects. These projects will accelerate widespread introduction and adoption of commercially-available advanced vehicle technologies to reduce U.S. dependence on petroleum, increase local fuel diversification, and catalyze adoption of clean transportation technologies. Up to 5 projects will be awarded with federal funding leveraged by a minimum 50 percent cost share from private sector partners. | *Vehicle Technologies Deployment (+$25,000,000)*<br>• Initiate Alternative Fuel Vehicle Community Partner projects to accelerate widespread introduction and adoption of commercially-available advanced vehicle technologies to reduce U.S. dependence on petroleum, increase local fuel diversification, and catalyze adoption of clean transportation technologies. Up to 5 projects will be awarded with federal funding leveraged by a minimum 50 percent cost share from private sector partners. |

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| *Advanced Vehicle Competitions ($2,500,000)*<br>• Plan and begin Year 1 of a four-year collegiate engineering competition, EcoCAR 3. | *Advanced Vehicle Competitions ($2,500,000)*<br>• Year 2 of a four-year collegiate engineering competition, EcoCAR 3. | *Advanced Vehicle Competitions ($0)*<br>• Incorporate increased emphasis on workforce development and technology innovation within student competitions. |
| *Legislative and Rulemaking ($1,804,000)*<br>• Review and process petitions to designate new alternative fuels under EPAct 2005. Implement legislative changes to the EPAct 2005 fleet activities, as needed. | *Legislative and Rulemaking ($2,000,000)*<br>• Review and process petitions to designate new alternative fuels under EPAct 2005. Implement legislative changes to the EPAct 2005 fleet activities, as needed. | *Legislative and Rulemaking (+$196,000)*<br>• Slight increase for Legislative and Rulemaking. |
| | *Analysis ($3,000,000)*<br>• Leveraging the unique analytical capabilities of National Laboratories and in cooperation with university partners, this activity supports the planning, execution, and communication of technology, societal, economic, and interdisciplinary analyses to inform program planning and technology investment decisions. | *Analysis (+$3,000,000)*<br>• A new activity has been added to the Outreach, Deployment and Analysis subprogram to provide additional budget clarity and consolidate cross-cutting Vehicle Technologies analysis activities. Previously, Vehicle Technologies Analysis activities were funded within individual subprograms. This change will bring transparency to Vehicle Technologies analysis activities and result in stronger alignment across EERE transportation programs. |

## Vehicle Technologies
## NREL Site-Wide Facility Support

**Description**

In FY 2016, EERE programs will continue to directly fund NREL site-wide facility costs that are not included in the Facilities and Infrastructure budget rather than fund those costs as laboratory overhead. This approach is consistent with Generally Accepted Accounting Practices and DOE management at other National Laboratories. EERE began this practice in FY 2014 to effectively control NREL's labor rate multiplier. One outcome has been reducing the cost of accessing unique NREL capabilities (such as facilities and staff expertise) by industry and academia. This practice also makes site operating costs more transparent in order to facilitate cost control and planning. In FY 2014, this practice resulted in a reduction in the lab-wide direct labor multiplier of approximately 15 percent compared to FY 2013. The proposed FY 2016 budget continues the approach applied in 2014 and 2015

This subprogram funding supports research programs by providing basic site services, functions, and infrastructure for site operations, which includes: management, building operations, building and grounds maintenance, fire and emergency response, engineering and construction support, minor construction projects, electrical safety program, utilities, and facilities planning support; and activities within the Sustainability and Environmental Health and Safety (EHS) portfolios. These activities and their costs are relatively fixed and only vary significantly based upon variations in commodities, construction activity, emergencies, weather patterns, etc. They are considered to be the core functions for site operations, safety, environmental compliance, and sustainability at NREL. In FY 2016, this funding will continue to support more than 60 FTEs that manage and provide support for these core functions. It will also fund site-wide subcontracts such as janitorial services, refuse and recycling, and subcontracts for minor construction. Additionally, this funding will support site-wide costs associated with maintaining NREL's leadership position, such as: maintaining International Organization for Standardization, American Association for Laboratory Accreditation, and other lab-wide accreditations, managing facilities to enable mission goals, improving sustainability, pollution prevention, waste minimization, improving energy efficiency, reducing water use, and maintaining an effective emergency management system.

The FY 2016 budget allocation remains consistent with the method EERE developed in FY 2015. This approach is a more precise, equitable, and economically neutral method that ensures a predictable net-zero impact on programs' funding. For each program, the contribution to direct funding for site-wide facility support is equivalent to the estimated contribution the program otherwise would have made through overhead charges. This method is based upon each program's level of funding to NREL, adjusted to account for anomalies from large capital expenditures and major subcontracts.

**NREL Site-Wide Facility Support**
**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **NREL Site-Wide Facility Support $3,000,000** | **$3,000,000** | **$0** |
| • Directly fund NREL Site-Wide Facility support costs that are not included in the Facilities and Infrastructure budget rather than continue to fund these costs in the laboratory overhead rate. | • Directly fund NREL Site-Wide Facility support costs that are not included in the Facilities and Infrastructure budget rather than continue to fund these costs in the laboratory overhead rate. | • No change. |

**Vehicle Technologies**
**Performance Measures**

In accordance with the GPRA Modernization Act of 2010, the Department sets targets for, and tracks progress toward, achieving performance goals for each program.

| | FY 2014 | FY 2015 | FY 2016 |
|---|---|---|---|
| Performance Goal (Measure) | **Batteries - Reduce the modeled cost of energy storage for Electric Vehicles (EVs). ($/kWh)**<br>**2014: Measure for modeled production cost of a high power battery for a Plug-In Hybrid Electric Vehicle Battery capable of a 40 mile all electric range**. | | |
| Target | 300 | 275 | 250 |
| Result | Exceeded - 289 | Not Applicable | Not Applicable |
| Endpoint Target | $125/kWh by 2022 | | |

## Bioenergy Technologies

### Overview

The Bioenergy Technologies Program catalyzes the development of cost-effective technologies that reduce our dependence on imported petroleum, while lowering greenhouse gas emissions, through the use of domestically produced non-food biomass resources that enable the U.S. to be competitive in emerging renewable energy markets. Use of advanced biofuels in the transportation sector has significant potential to address U.S. energy competitive advantage, transportation-related greenhouse gas (GHG) emissions, and U.S. job growth. The potential exists to sustainably produce at least 1 billion dry tons of non-food biomass resources by 2030.[1] This is a sufficient quantity that, if used completely for transportation fuel, could displace approximately 30 percent of the country's present petroleum consumption without impacting food or feed needs and have a significant positive impact on the environment by reducing GHG emissions[1].

To realize the promise of advanced biofuels and bioenergy technologies, the program is working to produce cost-competitive ($3/gallon of gasoline equivalent) advanced biofuels that reduce greenhouse gas emissions by 50% or more versus petroleum based alternatives. The program conducts research, development, demonstration, and market transformation activities on sustainable feedstock supply and logistics systems, cost-competitive conversion processes, and cost-shared scale-up and construction of pilot- and demonstration-scale integrated biorefineries that will reduce the risk of this “first-of-a-kind” technology to enable further private investment critical to scale-up and market penetration. The program activities are outlined in the Bioenergy Technology Program’s Multi-Year Program Plan (MYPP)[2], and are supported by cost shared partnerships with the private sector to enable the development of technologies that transform the robust, renewable biomass resources of the U. S. into commercially viable high-performance biofuels, bioproducts, and biopower. Research is targeted primarily on fuels that have the potential to enter the market and compete directly with petroleum, both in terms of cost and performance - while exceeding performance in terms sustainability.

To measure performance and to support program objectives, the program is pursuing several technology pathways (i.e. feedstock/conversion approaches) to reduce the cost of converting biomass feedstocks to hydrocarbon biofuels, including, thermochemical, biochemical, and hybrid pathways to enable the optimal deployment of bioenergy solutions to take advantage of the large diversity of feedstocks within the U. S. If the program goal of $3/gasoline gallon equivalent (GGE) drop-in biofuel production cost is met by 2022 with at least 50 percent greenhouse gas emission reduction on a lifecycle basis for one or more of these technology pathways, biofuels will offer a substantial mitigation strategy for highly volatile petroleum prices that are impacted by foreign as well as domestic demand while reducing greenhouse gas emissions as compared to petroleum counterparts. As part of an “all of the above” strategy, bio-based hydrocarbon fuels that directly replace petroleum fuels offer the opportunity to diversify the fuel mix with domestically produced, sustainable feedstocks strengthening the U. S. economy. Additionally, in the same way different crudes are needed to make different fuel blends, a number of technology pathways may ultimately be required to achieve large-scale production of biofuel blendstocks. The availability of different biomass feedstocks at scale in different regions of the country also suggests a range of technologies will be necessary to fully utilize this resource. (See one example in Figure 1.)

### Highlights of the FY 2016 Budget Request

The Bioenergy Technologies Program Budget has several key focus areas in FY 2016:
Feedstocks:

- The Feedstock Supply and Logistics activity continues to work to meet 2017 biomass feedstock cost targets for delivered biomass to the bioenergy conversion plant (from $115/Dry Matter Ton (DMT) in FY 2015 to $95/DMT in FY 2016 and then $80/DMT in FY 2017). Research areas focus on advanced technologies for woody and herbaceous feedstock including advanced harvesting (such as single-pass technologies), preprocessing (i.e. high moisture densification), and blending techniques).
- The Algae and Advanced Feedstocks activity will focus on research to address yield, productivity, and integration of downstream logistics at the pre-pilot scale. This will support validating the potential for algae supply and logistics

[1] http://www1.eere.energy.gov/bioenergy/pdfs/billion_ton_update.pdf.

[2] http://www.energy.gov/sites/prod/files/2015/01/f19/mypp_beto_november_2014_0.pdf.

systems to produce 5,200 gallons of oil (or equivalent biofuel intermediate) per acre of cultivation per year by 2022. This will also achieve a modeled nth plant minimum selling price of $3.27/gge (2011) of raw biofuel intermediate by FY 2022 that will enable the final fuel production price of $3/gge.

Conversion:

- The subprogram will select at least two pathways for validation at DOE's National Laboratories integrated bench and/or pilot scale in FY 2016 with the final validation completed in FY 2017 to provide real data that when used in program models demonstrates that nth-plant cost reductions can be achieved reducing the risk for private sector investment in first of a kind projects. The program will fund research consortia to further the integration of bio-oils into petroleum refineries, for the development of biological and chemical catalysts and clean sugar production, for the resolution of gasification and gas to liquids issues identified in FY 2014 workshops. The program will also continue to fund Incubator, carbon fiber, and other renewable chemicals activities.

Demonstration and Market Transformation:

- The Demonstration and Market Transformation subprogram (formerly "Demonstration and Deployment") will focus on scale up of drop-in hydrocarbon production. Research and development activities to support enhancing markets for advanced biofuels will be considered, including co-designing next-generation engines to better utilize biofuels through the Fuel and Vehicle Systems Optima collaboration with the Vehicle Technologies Program. Support of commercial demonstration of military-specification jet fuel in collaboration with the Departments of Defense and Agriculture through the Defense Production Act will continue.
- A Bioenergy Technologies Program 'Incubator' funding opportunity will invest 5 percent of Bioenergy Technologies funding toward new off-roadmap innovative technologies and solutions that can help meet existing goals but are not represented in a significant way in the current portfolio or technology roadmaps. Successful Incubator projects will reduce the risk associated with potentially breakthrough approaches and technologies so they may be 'on-ramped' to future program roadmaps and the program portfolio.

Program performance goals are as follows:

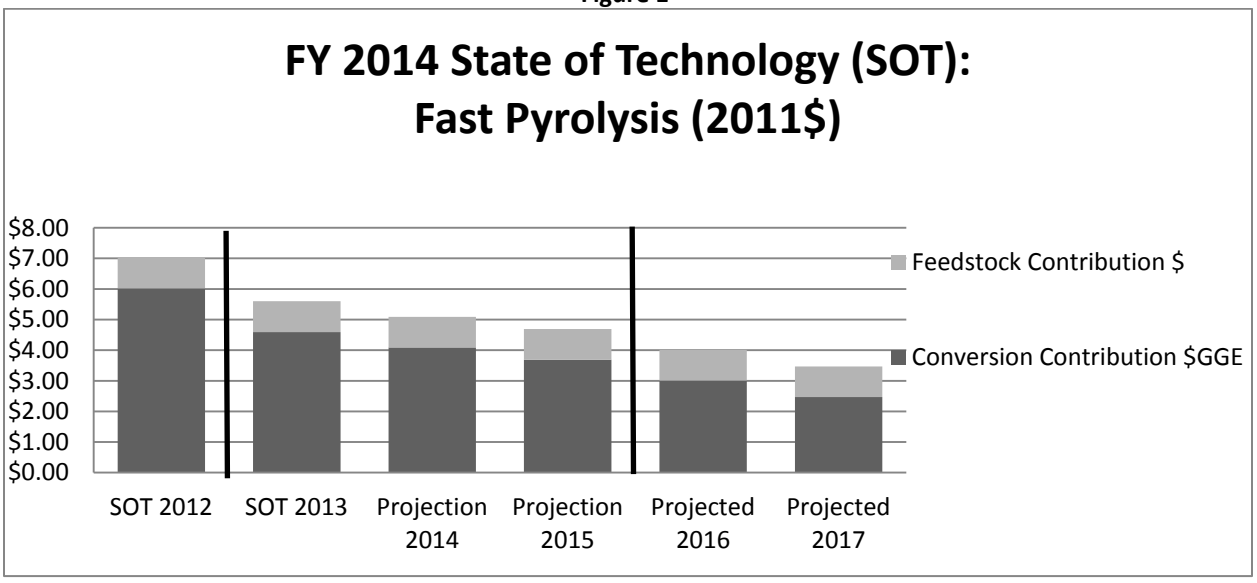
- Through RDD&D, make drop-in hydrocarbon fuels competitive with petroleum-based fuels at a modeled price of mature technology of $3/gge (2011), with GHG emissions reduction of 50 percent or more compared to petroleum-derived fuel, based on EIA projected gasoline wholesale prices in 2017.
- By 2017 validate a mature technology plant model price of ethanol production, based on actual IBR project plant performance data and compared to the target of $2.15/gallon ethanol (2007)

Several key challenges must be addressed in order for the bioenergy sector to continue to increase its contribution to our national goals of reducing oil dependency, and decreasing GHG emissions from the transportation sector:

- Scalability – Significant quantities of biomass feedstock exist today as agricultural and forestry residues and as urban wastes. However, it is difficult to cost-effectively collect and haul these materials to central processing facilities because they have intrinsically lower bulk and energy densities than crude oil, coal, and corn grain. In addition, first-of-a-kind facilities carry the large risks associated with scaling technologies from bench to fully integrated commercial scale. Furthermore, all components of the bioenergy supply chain must be developed in a manner that is environmentally, socially, and economically sustainable.
- Cost of Production – The cost of the processing steps required to convert biomass to hydrocarbon fuels that are indistinguishable from petroleum fuels must continue to decrease for this technology to be economically competitive. Figure 1 represents the current State of Technology (SOT) for one of the program's leading biomass-derived drop-in hydrocarbon technology pathways: fast pyrolysis and upgrading pathways2. The SOT reflects inclusion of the newest data from the previous year's efforts run through the models to indicate progress towards cost reduction goals of modeled mature costs. Fast pyrolysis and upgrading involves the conversion of biomass to biocrude through the use of high heat and pressure then upgrading to final fuel products.
- Private-sector investments — In order to support the emerging advanced biofuels industry through its early development and commercialization, the industry needs to demonstrate the technology thus reducing risk in order to attract future private sector investment in subsequent commercial facilities. For example, continued government support, in partnership with the private sector, to build specialized, first-of-a-kind facilities will help validate

performance and economics at a scale necessary to enable confidence from the financial markets for commercializing a robust biofuels industry.

**Figure 1**[1]




| | SOT 2012 | SOT 2013 | Projection 2014 | Projection 2015 | Projection 2016 | Projection 2017 |
|---|---|---|---|---|---|---|
| **Conversion Contribution $GGE** | $6.00 | $4.60 | $4.10 | $3.70 | $3.00 | $2.50 |
| **Feedstock Contribution $** | $1.00 | $1.00 | $1.00 | $1.00 | $1.00 | $1.00 |
| **Minimum Fuel Selling Price $GGE** | $7.00 | $5.60 | $5.10 | $4.70 | $4.00 | $3.40 |

[1] Jones, SB and LJ Snowden-Swan. *Production of Gasoline and Diesel from Biomass via Fast Pyrolysis, Hydrotreating and Hydrocracking: 2012 State of Technology and Projections to 2017*. PNNL-22684. Richland, Washington. Pacific Northwest National Laboratory, 2013.

**Bioenergy Technologies**
**Funding ($K)**

| | FY 2014 Enacted[1] | FY 2014 Current[2] | FY 2015 Enacted | FY 2016 Request | FY 2016 vs FY 2015 |
|---|---|---|---|---|---|
| **Bioenergy** | | | | | |
| Feedstocks | 46,972 | 45,500 | 32,000 | 38,800 | +6,800 |
| Conversion Technologies | 101,384 | 98,248 | 95,800 | 99,186 | +3,386 |
| Demonstration and Market Transformation (formerly Demonstration and Deployment) | 64,790 | 19,790 | 79,700 | 87,514 | +7,814 |
| Strategic Analysis and Cross-Cutting Sustainability | 12,146 | 11,849 | 11,000 | 14,000 | +3,000 |
| Biopower/Cookstoves | 1,998 | 1,940 | 0 | 0 | 0 |
| NREL Site-Wide Facility Support | 5,000 | 5,000 | 6,500 | 6,500 | 0 |
| **Total, Bioenergy** | **232,290** | **182,327** | **225,000** | **246,000** | **+21,000** |

SBIR/ STTR:

- FY 2014 Transferred: SBIR $4,343,000; STTR $620,000
- FY 2015 Enacted: SBIR $3,590,000; STTR $495,000
- FY 2016 Request: SBIR $3,984,000; STTR $598,000

[1] FY 2014 Enacted funding reflected the contractor foreign travel rescission of $139,000.
[2] Funding reflected the transfer of SBIR/STTR to the Office of Science and $45,000,000 to the Department of Defense for the Defense Production Act.

**Bioenergy Technologies**
**Explanation of Major Changes ($K)**

| | FY 2016 vs FY 2015 |
|---|---|
| **Feedstocks:** Increased funding will be applied to the FY 2016 Algal Biomass Yield Phase 2 FOA for up to three facilities to reduce the risk of scaling up to achieve 2,500 gallon/acre annual average yields of biofuel intermediate oil at the one-acre cultivation equivalent scale. | **+6,800** |
| **Conversion Technologies:** The increase reflects a greater emphasis on preparing to conduct validation activities at a scale above bench scale with process integration to meet the FY 2017 R&D target as technologies reach greater maturity and de-risk the technologies in preparation to release the successful projects to the Demonstration and Market Transformation Program. | **+3,386** |
| **Demonstration and Market Transformation:** Increased funding will be applied for up to three new pilot projects or one new demonstration project that will enable the advancement of a wider array of technology pathways converting biomass feedstocks to hydrocarbon fuels. | **+7,814** |
| **Strategic Analysis and Cross-Cutting Sustainability:** Increase funding for projects focused on improving the environmental and social benefits of bioenergy production while generating critical data on feedstock quality, logistics costs, and lifecycle greenhouse gas emissions. | **+3,000** |
| **Total, Bioenergy Technologies** | **+21,000** |

**Description**

The Feedstocks subprogram includes the Feedstock Supply and Logistics and the Algae and Advanced Feedstocks activities. The primary goal of the Feedstock Supply and Logistics activity is to develop strategies, technologies, and systems that can provide feedstock to the throat of the conversion reactor for a total average cost of $80/dry matter ton by FY 2017 (from $130/DMT in FY 2014), while meeting conversion process specifications. Past accomplishments for this program have included the publication of the *U.S. Billion-Ton Update,*[1] as well as disseminating yield data for several different energy crops from the Regional Feedstock Partnership seven-year field trials ending in FY 2015—including yield density maps and capturing vital variability across the nation—and making this data publicly available for researchers and biorefinery developers in the Bioenergy Knowledge Discovery Framework (KDF).[2] The KDF provides online access to a wide variety of information resources, including biomass production data and decision-support tools. In FY 2013 and FY 2014, five high-tonnage feedstock logistics projects—which included partnerships with original equipment manufacturers—demonstrated significant reduction of costs (e.g., a $13/dry matter ton reduction for corn stover, relative to conventional systems) for integrated systems that are directed at agricultural residues, woody crops, and/or herbaceous and short-rotation woody energy crops. Furthermore, Idaho National Lab (INL) has achieved $10/dry matter ton modeled reduction in feedstock preprocessing costs from improvements in size reduction, densification, and drying. The INL Process Demonstration Unit completed designation as the Biomass Feedstock National User Facility (BFNUF), denoting it as the premier facility in the U.S. for scientific and technical investigation of biomass feedstock energy applications. More than 20 industrial users are in the BFNUF "project pipeline" and several have completed work. The work in scale up and integration of preprocessing systems has positioned partner companies to validate design concepts that are being built into modern biorefineries. The BFNUF houses commercial-scale preprocessing equipment and has an associated Biomass R&D Resources Library that currently has more than 55,000 archived physical samples. The library enables feedstock characterization results to be tracked and accessed and also links samples to INL's extensive analytical capabilities. INL partners with the conversion facilities at Lawrence Berkeley National Laboratory (LBNL), Pacific Northwest National Laboratory (PNNL), and National Renewable Energy Laboratory (NREL) to determine and track the impact of feedstock quality on various conversion processes and products. Determining the range of variability in biomass materials and analyzing both the impacts of preprocessing on feedstock characteristics and the impacts of those characteristics on conversion performance is critical to identifying the most cost-effective way to deliver high-quality, easily convertible biomass to the conversion facility while addressing technical and logistical risks for the national supply chain.

Information from field trials, collected from programs in FY 2015 and FY 2016, will be used to supplement core supply and logistics efforts. Specifically, one FY 2015 effort will focus on the incorporation of energy crops within existing agroforestry systems using principles of landscape design to make the specific field or system even more sustainable, and hence profitable, for the farmer. Feedstock Supply research is critical to meeting the program's cost and performance goals (i.e. $3/GGE by 2017). Activities are focused on identifying and enabling sufficient, sustainable, and affordable, high-quality biomass feedstocks to support the development of the biomass conversion industry. In FY 2016, results obtained from ongoing feedstock trials will be incorporated into core resource assessment efforts and will be used to evaluate progress toward meeting the Billion-Ton "vision," to set technical targets, and to identify research needs. Understanding the variability in feedstocks is vital to reducing risks and driving towards biomass-derived feedstocks as a commodity. The feedstock quality information available in the INL Biomass R&D Resources Library will be expanded and results will be shared publicly via the KDF in alignment with the Presidential Open Data Initiative. The BFNUF will be used to obtain and test feedstocks produced by the USDA National Institute of Food and Agriculture (NIFA)-funded Coordinated Agriculture Projects (CAP), program-funded (and other) integrated biorefineries, and other users in a variety of preprocessing configurations that can mimic commercial operations and allow for data collection at each module and for detailed characterization of the material at any stage towards driving down risks and costs. Results stemming from the Regional Feedstock Partnership will be compiled into a synthesis/summary report to be released in conjunction with the next Billion-Ton Update in FY 2016. Work has already begun on the synthesis report, which will highlight value that the project has

[1] http://www1.eere.energy.gov/bioenergy/pdfs/billion_ton_update.pdf
[2] http://www.bioenergykdf.net

provided the program in support of DOE's mission and building the bioeconomy. Content includes methodology, characterization results, and yield summaries and maps resulting from the Regional Feedstock Partnership, which began in FY 2005. Increased focus on the mixing of sorted, dried municipal solid waste with other feedstocks will continue as the program seeks to identify high-volume sources of biomass while increasing the diversity and reducing the supply risk for national bioenergy feedstocks.

Recognized as a major element in the National Biofuels Action Plan[1], the Bioenergy Technologies Program MYPP, and other analyses, feedstock logistics challenges need to be overcome to build a sustainable national bioenergy and bioproducts industry. Core integrated research for FY 2016 includes harvesting, collection, in-field handling and drying, dry- and wet-storage, preprocessing (including drying, grinding, blending and densification), and transport of biomass feedstocks. Through its biomass depot concept, the program is exploring blending and formulation strategies for utilizing a combination of feedstocks capable of providing large quantities of biomass that meet or exceed quality specifications for a variety of biorefinery conversion processes at a cost not to exceed an average of $80/dry matter ton at the throat of the conversion reactor. These strategies could be regional in nature and vary among different conversion pathways, but could develop to a national biomass commodity market. Parameters included in the testing are ash- and moisture-content, dry matter loss, particle-size and -shape, carbohydrate- and lignin-content, and others. The INL BFNUF will be given base funding with additional funds provided on a cost-share basis with various users, including the private sector, universities, and federal and state agencies. Specific activities in FY 2016 will include validating that Program-supported technology efforts have achieved a sustainable feedstock supply and logistics cost of $95/dry matter ton at conversion reactor throat (including grower payment and logistics cost) for at least one conversion process towards a 2017 goal of $80/dry matter ton. In FY 2017, it is the intent of this subprogram to validate at least two pathways for the production of hydrocarbon fuels (gasoline, diesel, and jet). Data generated from the FY 2017 validation will be used to confirm the projected $3.40/GGE mature biorefinery production conversion cost for at least one subset of high-impact feedstocks.

Blending is one strategy that this subprogram is actively pursuing as a means to mitigate feedstock quality- and quantity-variability (meeting the in-feed specifications required by various conversion processes) while managing feedstock cost, and continuing to hit the $80/dry matter ton target. By mitigating cost and quality, blending will make more biomass resources available for energy production. As a demonstration of progress made in the blending strategy, this subprogram will partner with Conversion to validate one blendstock for thermochemical conversion and one blendstock for biochemical conversion at a scale of 1 ton per day in 2022.

In FY 2013 and FY 2014, the program's five "high-tonnage feedstock logistics" projects—each of which included partnerships with original equipment manufacturers—have demonstrated significant reduction of feedstock logistics costs - associated costs (e.g., $13/dry matter ton cost reduction relative to conventional systems for baled corn stover) for integrated systems that utilize agricultural residues, woody crops, and/or herbaceous and short-rotation energy crops. Cost reductions reported in all five projects have been independently validated by Oak Ridge National Laboratory researchers. In FY 2015, two new projects were initiated to build upon these efforts by lowering the delivered cost of short rotation woody crops and to study how blending feedstocks could play a role in increasing the amount of available feedstock within a given delivery radius.

The Algae and Advanced Feedstocks activity develops cost-effective algal biofuels production and logistics systems to supply a cost competitive finished fuel. The challenges and opportunities to commercializing algal biofuels production systems are broad and complex, requiring the close integration and collaboration of many scientific and engineering disciplines to bring about innovations. The primary advantages of algal biomass, which include its ability to grow quickly, use waste resources, and accumulate ideal fuel precursors (e.g., lipids) are broadly recognized. In recent years, the program has achieved technological advancements that promise to bring about transformational changes, including the ability to predict, breed, and select the best-performing strains; the ability to monitor and control system inputs in a dynamic and integrated fashion; the ability to harvest algae at ever higher throughputs; and the ability to extract and convert more algal biomass components into fuels.

[1] http://www1.eere.energy.gov/bioenergy/pdfs/nbap.pdf

In FY 2016, the Algae and Advanced Feedstocks activity ($38.8 million) will continue algae efforts initiated in FY 2013 and fund the demonstration of improvements in biomass yield, productivity, and integration of downstream logistics, using preexisting facilities and infrastructure. The projects will be selected based on their ability to demonstrate the potential to achieve the production goal of 2,500 gallons of biofuel intermediate per acre, per year by 2020 at one-acre cultivation equivalent capacity (<50,000 Liters, process development unit-scale in an outside facility). This work is critical to achieving the program's $5/GGE modeled production cost goal with up to 20 grams/$m^2$/day productivity targets. This will support the programmatic path towards the 2022 MYPP goal of demonstrating and validating algae supply and logistics systems that can produce 5,000 gallons of oil (or equivalent biofuel intermediate) per acre of cultivation per year (All goals are average annual yields due to seasonal variability). Data resulting from this research and development will help to support a modeled nth plant minimum selling price of $3.27/GGE (2011$) of raw biofuel intermediate by FY 2022 and enable the final fuel production price of $3/GGE by 2030.

In FY 2015, the Algae and Advanced Feedstocks activity issued a new solicitation in September 2014 using FY 2014 and FY 2015 funds (up to $25 million in total funding) aimed at reducing the cost of algal biofuels through non-integrated laboratory and process development scale technology improvements. Projects will consist of both multi-disciplinary consortia to produce valuable algae bioproduct precursors (alongside fuel components) as well as single investigator or small team technology development projects focused on developing crop protection and $CO_2$ utilization technologies to increase biomass yields. The focus for these projects was determined after soliciting input on major barriers to algal biofuel commercialization from industry and academic stakeholders during public workshops held in FY 2014. This input will continue to be used and refined with additional workshops as we complete the go/no go evaluation of the ABY Phase I projects and plan for the Phase 2 Funding Opportunity Announcement.

The Algae and Advanced Feedstocks activity will continue to leverage nation-wide operations at the Algae Testbed Public-Private Partnership (testbeds located in Arizona, Hawaii, California, Georgia, and Florida) and the Regional Algal Feedstock Testbeds (testbeds located in Arizona, Texas, New Mexico, and Washington) to validate the algae strain improvements and cultivation technologies, at the process development unit scale, from the National Laboratories and competitively awarded projects. In addition, the program will continue to invest in small National Laboratory teams (lab consortia) focused on specific research and development barriers, based on their respective areas of core expertise, as well as the development and validation of models for techno-economics, life-cycle greenhouse gas emissions, advanced engineering practices and new research into polycultures and innovative cultivation strategies. Feedstock supply is critical to meeting the program's cost and performance goals (i.e. $5/GGE by 2022). Resource assessment activities were begun in FY 2014 which are focused on producing sufficient, sustainable, affordable, high-quality biomass feedstocks to support the development of the biomass conversion industry. In FY 2016, these efforts will be expanded as a result of engineering cost assessments on cultivation systems that limit sites for open pond cultivation systems. More effort will be focused on integrating photobioreactor systems with open ponds looking at benefits of co-location for improved nutrient use and recycle that are more cost effective.

In addition, funds may be used to support efforts such as peer reviews, data collection and dissemination, technology assistance, and technology-to-market activities.

**Feedstocks**
**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **Feedstocks $32,000,000** | **$38,800,000** | **+$6,800,000** |
| • Biomass supply assessments for crop residues, energy crops, and forest resources will include environmental and quality criteria to meet feedstock quality demands of conversion facilities.<br>• Biomass quality analysis work will continue at the Biomass National User Facility.<br>• Continued public-private partnerships to develop systems at industrial scale to reduce cost and energy associated with biomass drying and densification, such that the feedstocks are compatible with existing, high-capacity handling and transport infrastructure.<br>• Continued research focused toward demonstrating biomass stabilization technologies (e.g., high-moisture pelleting) that preserve feedstock quality during transport and storage, thereby reducing degradation potential and cost.<br>• Increase the longer-term core research targeted at more fundamental understanding of algae ecology, physiology, biochemistry, and genetics; and use new techno-economic models to screen projects and direct more of the longer-term research. | • Update to the *U.S. Billion Ton Study* (last published in FY 2011). A five-year resource analysis effort in collaboration with the Regional Feedstock Partnership will be used to update yield projections.<br>• Develop engineered storage practices to reliably handle variable feedstock moisture content; promote drying in storage to improve stability and reduce preprocessing costs. Includes demonstration of individual advanced system processing components.<br>• The Algae activity will fund competitive research and development project work to achieve programmatic targets for productivity and yield at a 1-acre equivalent scale (up to three projects focused on pre-pilot integration of production and pre-processing).<br>• Targeted research and development along the algal biofuels supply and logistics chain will continue through the National Laboratories. | • The Algae program requires the increase in funding to select more projects from the ABY FOA, Phase I conducted in FY 2013 and Phase II conducted in FY 2016, which provides important technology to achieve FY 2022 targets. |

**Description**

Conversion Technologies develops technologies for converting biomass feedstocks into commercially viable liquid transportation fuels, as well as bioproducts and biopower. After a decade of research, development, and pilot-scale work, technical performance data were generated by the Conversion Technologies subprogram in FY 2012 that validated the potential of biochemical and thermochemical process pathways to produce cellulosic ethanol in a mature commercial biorefinery for approximately $2/gallon. The R&D program is now focused on hydrocarbon fuel production to increase compatibility with existing infrastructure and to displace a larger percentage of petroleum use in more U.S. markets while seeking to aid with price volatility in an "all of the above" solution. This R&D priority also reflects the recent successful commercial deployment of early cellulosic ethanol technologies. Many of the technology breakthroughs that are responsible for achieving the $2/gallon ethanol goal can and will be leveraged for the production of hydrocarbon fuels going forward. The program has set an ultimate target of $3/GGE for hydrocarbon fuels in order to be competitive with projected long-term petroleum fuel prices.

Conversion R&D includes biological, catalytic, thermochemical, and hybrid routes to convert biomass into suitable intermediates, including—but not limited to—sugars, bio-oils, and gases. There are several early adopter market opportunities, including—and also not limited to—renewable heating oil, renewable jet fuel, renewable marine fuel, and numerous renewable chemicals.

In the past, the Conversion Technologies subprogram was divided into two technology pathway areas—Biochemical and Thermochemical (including pyrolysis and gasification). However, an increasing number of high promise technologies have emerged through the Bioenergy Technology Program's activities that do not fit this simple taxonomy. Hybrid processes that are being developed show promise; e.g., the combination of gasification (thermochemical) and fermentation (biochemical) to produce ethanol and the conversion of historically biochemical-derived intermediates (i.e., sugars, acetic acid, lignin, etc.) via direct catalytic conversion to hydrocarbon molecules.

To reflect this, in the FY 2015 Budget Request the Conversion Technologies subprogram was reorganized into more fundamental processing steps, such as deconstruction of the biomass polymers (comprising such techniques as pretreatment/hydrolysis, gasification, pyrolysis, etc.), fractionation, synthesis and upgrading, and integration and process intensification.

The diversity of biomass resources across the nation necessitates the development of multiple conversion technologies that can efficiently deal with a broad range of feedstock materials, as well as their physical and chemical characteristics. In addition, different conversion technologies produce, or have the potential to produce, different mixes of products that may be suitable for application in different fuel (e.g. gasoline, diesel, and jet fuel) or product applications. Each of these potential conversion pathways, however, is at a different level of technical maturity. The Conversion Technologies subprogram will, therefore, seek to develop multiple candidate technologies that can potentially meet the cost goal of $3/GGE using a wide array of feedstocks in the FY 2017 to FY 2022 time frame, and, hence, reduce technical risk.

In FY 2016, core R&D will continue to address interactions between blended feedstock properties and deconstruction processes. The feeding of biomass into the conversion process has been a frequent issue for deconstruction processes of all types. In FY 2014, a survey of feedstock/feeder combinations was conducted and an initial assessment was made of characteristics that have led to successful and unsuccessful combinations. This assessment was expanded in FY 2015 to include the examination of biomass structures, properties, and feeder mechanisms that will minimize problems for multiple possible systems going forward. An expected optimum will be reached that balances costs for feedstock blending and preparation and costs for feeding and conversion. A sufficient quantity of the optimal feedstock will be prepared in FY 2016 for performance of the validation runs in FY 2017. R&D will also be conducted to resolve remaining technical barriers for the most promising deconstruction pathways, as determined by the techno-economic assessments as well as technical

issues that the Demonstration and Market Transformation (formerly known as Demonstration and Deployment) subprogram's projects identify.

Enabling a diverse product slate from a biorefinery, especially by valorizing materials that are currently waste products, can substantially reduce risks associated with early biofuel plants and biorefineries. Some of these potential products may also offer opportunities to replace current fossil-derived products while simultaneously reducing the carbon footprint with bio-derived, functionally equivalent replacements. The Multi-Products for Enabling Generalized Approaches to the BIOeconomy (MEGA-BIO) effort will enable integrated development of deconstruction, separation and upgrading technologies that allow simultaneous optimization of biomass resources and market demand for both petrochemical and fuel replacements. It is envisioned that this will be a collaborative effort requiring diverse expertise and likely partnering between National Laboratories, academia and industry. Based on technical targets established by techno-economic analyses completed in FY 2014, barriers documented in the Conversion Technologies for Advanced Biofuels Workshop report, and workshops held in FY 2014 and FY 2015, a significant aggregate effort will be devoted to R&D to continue the development of biological organisms and chemical catalysts for the conversion of hydrolysis, syngas, and bio-oil intermediates to fuels and products.

Efforts will continue to convert lignin to fuels and products (rather than combusting it for heat and power), as this will be critical to the economics of fuel production within a biorefinery. R&D will also continue on conversion of carbon in the pyrolysis process aqueous phase into useful products including oxygenated carbon molecules and hydrogen in order to drive optimal utilization of biomass derivatives. In FY 2015, based on the results from the analyses as well as R&D results from competitive and DOE National Laboratory activities, a subset of pathways will be identified as being appropriate validation similar to those conducted for cellulosic ethanol production in FY 2012. Also in FY 2015, the program issued a request for information (RFI) seeking industrial entities that have assets suitable for similar technical process validations and that are willing to make validation tests results available to the public. In future years, these capabilities may be employed to track progress in overcoming technical barriers to commercialization such as integration of process steps.

It is the intent of this subprogram in FY 2017 to validate at least two pathways for the production of hydrocarbon fuels (gasoline, diesel, and jet). Data generated from the FY 2017 validation will be used in modeling software (i.e., ASPEN or ChemCad) to confirm the projected $2.50/GGE mature biorefinery production conversion cost ($3.40, including feedstock costs) for at least one subset of high-impact feedstocks. Facility identification and/or modification for the FY 2017 pilot-scale operations for validation of the program cost target will begin by the end of FY 2015, and be completed in FY 2016.

Work will also continue to overcome hurdles to integrate bio-oil and other intermediates in existing petroleum refineries and petrochemical plants. This will include oils production for testing, improved stabilization processes, and finalization of broadly applicable and accepted analysis and characterization methods. Other areas that will be investigated include process intensification, such as combining or eliminating reaction steps to reduce process complexity and biorefinery cost.

At least one additional pathway will be validated in FY 2022. This will be accomplished by incorporating advanced deconstruction methods and new metabolic pathways for hydrocarbon production into organisms; further developing catalysts—both for conversion of sugars and other hydrolysis intermediates—as well as additional pyrolysis and gaseous-derived intermediates, into fuels and chemicals; and improving separation and upgrading technologies.
R&D in a number of enabling technology areas will continue in FY 2016, including advanced modeling in support of reaction and reactor design, systems biology, design, and discovery of novel catalyst systems, and advanced separation concepts. Any promising technologies that demonstrate traction resulting from the incubator funding opportunity conducted in FY 2014 will be further developed as will advances resulting from research conducted by the Basic Energy Sciences (BES), Biological and Environmental Research (BER), and Advanced Research Projects Agency-Energy (ARPA-E) Offices as well as NSF and other agencies. Examples may include methanotroph and lignin utilization technologies. Separation technologies necessary to remove impurities from hydrolysis, oils and gaseous intermediates, and product mixtures also remain a critical R&D focus in FY 2016.

Bioproducts, co-products, and value-added uses for lignin and the aqueous phase resulting from some pyrolysis pathways will also receive increased emphasis. In FY 2016, the Conversion Technologies subprogram will encourage the development

of additional pathways for the integrated production of fuels and chemicals and will conduct R&D required to overcome barriers to fully commercialize the pathways. This will include explorations of functionally-equivalent chemicals and products that have either been identified as problematic (e.g. bio-based replacements for chemicals such as BPA) or that, due to structural similarities, are suited to production from biomass. These projects will assess current and end-state techno-economic and sustainability metrics. Work will include both early-stage and more mature process concepts and may offer an opportunity for early-stage developers to engage additional funding partners upon successful completion of the R&D projects. This is intended to both ensure that the program maximizes the number of potential "wins" in the industry and as a supplement to validations conducted by the program.

In FY 2014, the Conversion Technologies subprogram initiated research and analyses to improve two aspects of methane production/utilization in one waste-to-energy (WTE) pathway and conducted an RFI to identify priority areas and barriers to define a future FOA. In FY 2015, a workshop on opportunities and needs in processing of wet feedstocks (biosolids, food, and wet agricultural waste) will be conducted. Priority areas identified at this point include the need to manage variable feedstocks, assess spatially resolved resources; improve microbial consortia for processing biosolids and other waste streams; and determine opportunities to improve biosolids treatment. In FY 2015, core R&D will continue in analyzing the state of the art, defining resource scale and location, and performing baseline techno-economic analyses to define opportunities and targets. In FY 2016, the Waste to Energy portion of the Conversion Technologies Subprogram ($5 million) will initiate projects to address these R&D targets.

In addition, funds may be used to support efforts such as peer reviews, data collection and dissemination, technology assistance, and technology-to-market activities.

**Conversion Technologies**
**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **Conversion Technologies $95,800,000** | **$99,186,000** | **+$3,386,000** |
| • Finalize selection of conversion pathways for validation in FY 2017 and begin facility modifications as needed. Initiate consortia to further the integration of bio-oils into petroleum refineries; biological and chemical catalyst development and clean sugar production; and other issues identified in FY 2014 workshops. Continue incubator activities. Initiate program supporting products that enable transportation fuels and the Clean Energy Manufacturing Initiative. | • Finalize facility modification for conversion pathways validation in FY 2017. Possible modifications are for pyrolysis and upgrading, biological upgrading or indirect liquefaction.<br>• Continue work to further the integration of bio-oils into petroleum refineries (a conversion topic in the FY 2015 DMT FOA which builds on the FY 2013 BOSC FOA); clean sugar production; and other issues identified in FY 2014 workshops.<br>• Continued R&D on issues such as catalyst lifetime, separations, and carbon efficiency to demonstrate technical performance corresponding to a mature, modeled thermochemical conversion cost $3/GGE of combined blendstock (this does not include a $1/GGE feedstock contribution to the total fuel cost).<br>• Continued R&D on low-temperature conversion routes producing biobased hydrocarbon fuels and chemicals (such as biological and chemical catalyst development) will demonstrate technical performance corresponding to a modeled, mature conversion cost contribution of $5.30/GGE in 2017 on a pathway to a $3/GGE cost in 2022.<br>• Initiate R&D in a diverse set of pathways (MEGA-BIO FOA) that produce renewable chemicals derived from biomass which enable more competitive biofuels and support the DOE Clean Energy Manufacturing Initiative. | • The increase reflects a greater emphasis on products through R&D to overcome barriers to additional pathways for the integrated production of fuels. The funding will help restore the MEGA-BIO FOA (6-8 selections of teams from National Laboratories, Academia and Industry) to its originally planned level and allow selection of an additional project targeting barriers to products that enable biofuels including functionally equivalent chemicals or integration with existing refinery infrastructure. |

## Bioenergy Technologies
## Demonstration and Market Transformation
## (formerly Demonstration and Deployment)

**Description**

Demonstration and Market Transformation (DMT) reduces the risk of bioenergy production technologies through validated proof of performance at the pilot-, demonstration-, and pioneer-scale. This assistance is critical to enabling the confidence of the private sector to invest in facility construction and replication at the commercial scale. Each scale has its own discreet objectives: (1) pilot-scale facilities verify the integrated technical performance of the given suite of technologies and provide the initial detailed financial data for scaling confidence, (2) demonstration-scale facilities validate larger scale performance to provide the process and equipment specifications that are required to design a pioneer or "first-of-a-kind"-commercial scale facility and validate a robust technology process through a long-term run, and (3) pioneer-scale biorefineries prove integrated technical operation and economical production at commercial volumes on a continuous basis. Once performance has been validated at the pioneer scale, the facility can be replicated more readily through equity investment, traditional debt, or project financing.

In calendar year 2014, two pioneer cellulosic ethanol plants began production with assistance from the DMT subprogram. These plants will have a combined annual production capacity of 50 million gallons of cellulosic ethanol that is derived from sustainable agricultural residues, including corn stover and wheat straw. The DMT subprogram manages a diverse portfolio of integrated biorefinery projects, which is focused on the scale-up of biofuels production. In FY 2015, the program managed a portfolio of 28 projects including 2 at pioneer scale (plus three pioneer scale co-managed within DPA), 7 at demonstration scale, 12 at pilot scale, and 4 additional projects selected under at the Innovative Pilot FOA to support aviation and military fuel applications. The conversion pathways addressed include 13 biochemical technologies, 7 thermochemical technologies, and 5 algal technologies. The active portfolio included 13 projects that focused on cellulosic ethanol and 12 projects that focused on renewable hydrocarbons, and one project focused on a renewable intermediate bioproduct chemical. However most of these projects, the majority of which were funded by the American Recovery and Reinvestment Act, will be completed by the end of FY 2015. In FY 2016, only eight projects from the prior portfolio of 28 projects will still be ongoing: two at the pioneer scale producing cellulosic ethanol, an additional three co-managed in DPA producing renewable diesel and jet fuel, and three at a small pilot scale producing renewable hydrocarbons, such as military-specification diesel and aviation fuel.

Numerous barriers must be successfully addressed in the DMT subprogram in order to advance biofuels into high-volume production. These barriers include developing secure and cost-effective feedstock supply chains, ensuring the efficient operation of integrated end-to-end systems, reducing capital and operating costs, testing product qualifications, enabling off-take agreements, and encouraging commercial financing. However, financial barriers are the most challenging hurdle for technology deployment. The DMT subprogram is executing a Lessons Learned/Best Practices communications campaign to educate the private financial and equity investment communities on how its public-private partnerships have achieved measurable risk reduction, thus helping accelerate technology readiness and making it more attractive to investment for the private sector.

With the lack of experience in scaling these advanced energy technologies, along with the significant capital and market risks associated with transportation fuel prices, private industry investment would not occur without government assistance. All of the current, successful, cellulosic ethanol biorefinery developers confirm that they would not have made the investment without the DOE partnership.

In FY 2016, the program continues to support the Defense Production Act (DPA) memorandum of understanding (MOU) that DOE, USDA, and DoD signed in June 2011. Additionally, DOE is requesting $45 million in order to enable the objective of producing advanced biofuels that meet military fuel specifications at a price that is competitive with petroleum. Funds will be administered through the DPA authority to fund additional innovative technologies that are ready for validation at least at the demonstration scale, and are able to produce blended renewable military- and civilian-specification fuels (diesel- and or jet-fuel) that are on the trajectory to being cost competitive with their petroleum counterparts. Prior funding

in combination with this request will help support multiple biorefineries that are in the construction phase and scheduled to begin commercial production of jet and diesel fuels.

There is a need to expand the program's focus on drop-in advanced biofuels that are fully compatible with today's engines, delivery infrastructure, and refueling station equipment installations. Many projects have shown great promise at the R&D scale, but require testing and validation at a larger scale to accelerate commercialization. For FY 2015, DMT initiated a competitive FOA for a definition phase of six to eight new biorefinery projects that will focus on the manufacturing of advanced biofuels at an increasing scale. In FY 2016, the DMT subprogram will fully fund up to three pilot projects or one demonstration project for advanced biofuels technologies through cost-shared partnerships ($32 million). This effort will fully fund the projects upfront as the funds are made available, resulting in no outyear mortgages. The DMT subprogram will review biorefinery facility designs expected to result from FY 2015 funding but open to others as well, support construction and operation of the most promising designs, and validate the technical progress for biofuel manufacturing. Potential projects will include municipal solid waste, advanced anaerobic digestion, and other waste-to-energy (WTE) technologies, as well as advancements for improving the financial viability of biorefineries through the addition of high-value co-products that enable biofuels. Project awards will be cost-shared with industry and other partners, and will include extensive process capability data collection, validation, and analysis to inform technology development and the assessment of commercial viability.

The DMT subprogram will continue using well-defined stage gates and annual comprehensive project reviews to actively manage all projects utilizing government funding. If projects do not meet the specific technical and financial criteria for advancements into the next phase of development, the projects are not allowed to proceed. This gate review process enables active control of projects within the portfolio and has led to projects being discontinued on several occasions in the past.

In FY 2015, the Nation's pioneer cellulosic ethanol plants will approach full capacity of commercial-scale production in Florida, Iowa, and Kansas, while many others have been developing drop-in advanced biofuel technology in States that are as varied as California, Illinois, Michigan, New Mexico, and Ohio. These biofuel manufacturing technologies could add billions of gallons of new renewable fuel to the U.S. fuel supply. They have also created an opportunity for vehicle manufacturers to design future engines that take advantage of unique biofuel properties. An initial analysis that was conducted in FY 2014 suggests there is a significant opportunity to expand the market for biofuels through the development of high-octane and other tailored fuels for use in future engines. Building on prior-year and ongoing activities looking at high octane fuels, the Bioenergy Technologies Program will support the New Fuels and Vehicle Systems Optima effort, in collaboration with the Vehicle Technologies Program. Co-development of fuels and engines has proved successful for controlling criteria pollutants and provides great promise for increasing vehicle efficiency and reducing greenhouse gas emissions. By establishing a link early in the R&D cycle of both fuels and engines, a complete systems-based approach to create optimized solutions can be realized. Work will involve studying the "optima" for fuel properties/formulation and engine efficiency, as well as techno-economic criteria. A major objective in FY 2016 is to leverage biofuel's high-octane levels and other potentially unique fuel properties, in order to enable higher efficiency engines and lower life-cycle GHG emissions associated with renewable fuels. This work will require fuel characterization of cellulosic ethanol and/or other hydrocarbon biofuel blends and the co-development of engine technology components. These blends of biofuel will also be tested for compatibility with existing infrastructure systems, impacts on engine efficiency, tailpipe emissions, and for the development of various codes and standards for certification.

In addition, funds may be used to support efforts such as peer reviews, data collection and dissemination, technology assistance, and technology-to-market activities.

**Demonstration and Market Transformation**
**(formerly Demonstration and Deployment)**
**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **Demonstration and Market Transformation** | | |
| **$79,700,000** | **$87,514,000** | **+$7,814,000** |
| • Select six to eight integrated pilot- and/or demonstration-scale biorefineries for a project definition phase that will focus on the manufacturing of advanced biofuels at an increasing scale.<br>• Down-select and fund commercial biofuel production facilities under the DPA interagency effort with DOE, USDA, and DoD.<br>• In cooperation with Vehicle Technologies, expand R&D on super-renewable premium fuels and drop-in fuels to evaluate compatibility with existing and future infrastructure, fuel, and engine systems. | • Fund up to three biofuel manufacturing pilot scale facilities or one new demonstration scale facility from the pool of projects that are validated and ready for construction through public and private partnerships.<br>• Continue managing commercial biofuel manufacturing facilities under the DPA interagency effort with DOE, USDA, and DoD.<br>• Conduct fuel characterization of cellulosic ethanol and/or other hydrocarbon biofuel blends and work with the Vehicle Technologies Program on the co-development of engine technology components. These biofuel blends will also be tested for compatibility with existing infrastructure systems, impacts on engine efficiency and tailpipe emissions, and for the development of various codes and standards for certification. | • Increased funds will be used to initiate new pilot- and demonstration-scale projects for manufacturing of advanced biofuels and bioproducts at an increasing scale. |

## Bioenergy Technologies
## Strategic Analysis and Cross-Cutting Sustainability

**Description**

The Strategic Analysis and Cross-Cutting Sustainability subprogram plays a vital role in supporting decision making, demonstrating progress toward established goals, and directing research activities. These activities are instrumental in setting the entire biofuel value chain on an environmentally, socially, and economically viable course. The relationships with experts at DOE National Laboratories, universities, and numerous external stakeholders are leveraged to obtain the best qualitative information and quantitative data possible. The maintenance and enhancement of key models and tools for internal and external use ensures that the Bioenergy Technologies Program has the ability to advance the understanding of bioenergy and its related impacts. The program also works with EERE's Strategic Programs to ensure the coordination of analyses within the Sustainable Transportation Sector of EERE.

Through quantification, Strategic Analysis activities provide context and justification for decisions regarding the future direction and scope of the program's research, development, and demonstration work. Cross-Cutting Sustainability activities investigate and develop more sustainable practices with regard to GHG emissions, air quality, land use, water quality, water consumption, soil quality, and biodiversity. This information is critical to the sound management of the program's RDD&MT portfolio, and the establishment, adaptation and fulfillment of its vision in a dynamic context of rapid technological progress and great economic and environmental uncertainty.

Strategic Analysis activities include techno-economic, resource, market, and impact assessments that provide the analytical basis for planning and assessing progress. High-level techno-economic and life-cycle GHG analyses on emerging biofuel pathways provide an understanding of the GHG and cost implications relative to conventional fuel pathways. They also identify areas where process improvements could lead to significant breakthroughs. System-level analyses identify the key drivers and hurdles in industry growth, and advance our understanding of bioenergy and its related impacts. The maintenance of decision support, data management, and analytical tools allow the program to better articulate its vision, identify and validate performance goals, measure progress toward these goals, and plan for the successful fulfillment of its mission in support of national policies and priorities. FY 2016 activities will focus on assessing the environmental, socio-economic, and industry impacts of a growing bioenergy economy. The program will also publish a second annual market assessment that details the state of the industry.

Strategic Analysis supports each individual program and the program as a whole through the provision of critical quantitative measures of progress and future projections. Critical to strategic decisions at both the program and subprogram levels, analysis activities are focused on clearly identifying synergies and addressing potential barriers, while concurrently monitoring progress and validating accomplishments. Cross-Cutting Sustainability Activities focuses on evaluating environmental impacts and developing more sustainable practices with regard to GHG emissions, air quality, land use, water quality, water consumption, soil quality, and biodiversity, as well as developing relevant social aspects of sustainability. Cross-Cutting Sustainability works with research partners to conduct field trials, applied research, capacity building, and analyses to inform sustainable best practices that are integrated across the RD&D portfolio. Sustainability activities also enable the program to engage in critical international dialogues on bioenergy, such as the Global Bioenergy Partnership and the Intergovernmental Panel on Climate Change. In FY 2015, Cross-Cutting Sustainability collaborated with the Feedstocks subprogram to initiate projects that apply landscape design approaches for integrating cellulosic feedstock production into existing agricultural and forestry systems while maintaining or enhancing environmental and socio-economic sustainability including ecosystem services and food, feed, and fiber production. Projects will help overcome barriers and uncertainties surrounding the environmental sustainability of cellulosic feedstocks and challenges for land managers in producing new cellulosic feedstocks in a practical, sustainable, and economically viable manner.

In FY 2016, activities will focus on identifying best practices for improving environmental performance (such as reducing air emissions and water use) based on representative case studies of advanced bioenergy production systems; the development of innovative web-based tools to visualize sustainability performance of bioenergy systems; and an evaluation of field data that is collected on the water quality and environmental impacts of cellulosic energy crops.

To date, accomplishments include the creation of transparent methodologies for evaluating and comparing technologies, practices, and inputs in terms of environmental sustainability. Activities have also developed innovative tools and concepts for increasing biomass and bioenergy production while maintaining or improving environmental performance, such as deploying a geographic information system-based mobile application—the Landscape Environmental Assessment Framework (LEAF). LEAF helps feedstock producers assess the economic and environmental impacts of removing agricultural residue and integrating dedicated energy crops into traditional row crop production systems. For example, LEAF has been applied to several case study fields to show that the strategic residue removal and placement of energy crops within a corn field can increase total farm profitability, increase soil organic carbon, and reduce erosion. FY 2015 activities included initiating a joint FOA with the Feedstocks program (Landscape Design for Sustainable Bioenergy Systems) to support cross-disciplinary R&D projects that achieve an increase in cellulosic biomass production, while maintaining or improving environmental sustainability compared to the existing baseline agricultural or forestry production system. This was measured through sustainability indicators, such as productivity, GHG emissions, water quality, water availability, soil quality, air quality, and biodiversity. These projects are addressing the challenges of quantifying multiple sustainability metrics and proactively designing systems that achieve acceptable outcomes for landowners, industry, and environmental stakeholders. The projects are also evaluating the harvesting, preprocessing, and transport of the introduced feedstocks to understand feedstock availability, quality, and costs as a function of the landscape design. These efforts are critical to achieving large volumes of bioenergy feedstocks in a way that maintains food, feed, and fiber production, as well as natural systems. In addition, FY 2015 activities resulted in updated water footprint and air emissions estimates for advanced biofuels technologies to understand potential impacts and proactively develop RD&D solutions. These critical efforts resulted in publications and data that were made available through the Bioenergy KDF to better inform researchers, policy makers, and private sector stakeholders. For example, estimates of air pollutant emissions from advanced biofuel conversion technologies has provided critical information to R&D partners and the regulatory community on ways to design air emission control systems that can meet regulatory requirements.

In addition, funds may be used to support efforts such as peer reviews, data collection and dissemination, technology assistance, and technology-to-market activities.

**Strategic Analysis and Cross-Cutting Sustainability**
**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **Strategic Analysis and Cross-Cutting Sustainability** | | |
| **$11,000,000** | **$14,000,000** | **+$3,000,000** |
| • Continue key techno-economic, market, resource, and impact analyses to guide R&D prioritization, target development, and assessment of progress toward goals; advance scientific methods to measure and understand the land use, GHG, water, and other environmental effects of bioenergy production; and promote positive social, economic, and environmental effects and reduce negative effects of bioenergy production with a focus on developing practices that increase biomass and bioenergy production while minimizing GHG and air emissions, water use, and water quality impacts. | • Maintain and enhance key models and tools for internal and external use (including the Biomass Scenario Model, GREET, WATER footprint tool, and LEAF).<br>• Assess environmental, socio-economic, and industry impacts of a significantly larger Bioeconomy concept.<br>• Coordinate with logistics and conversion R&D areas to set targets for optimally converging on an ideal economic outcome while minimizing GHG emissions, air pollutants, and water consumption for at least three renewable hydrocarbon pathways.<br>• Initiate projects that improve environmental and social benefits of bioenergy production while providing critical data on feedstock quality, logistics costs, and lifecycle greenhouse gas emissions. | • Cross-Cutting Sustainability requires an increase in funding to initiate projects that focus on improving the environmental and social benefits of bioenergy production. These projects would also provide critical data on feedstock quality, logistics costs, and lifecycle greenhouse gas emissions. |

## Bioenergy Technologies
## NREL Site-Wide Facility Support

**Description**

In FY 2016, EERE programs will continue to directly fund NREL site-wide facility costs that are not included in the Facilities and Infrastructure budget rather than fund those costs as laboratory overhead. This approach is consistent with Generally Accepted Accounting Practices and DOE management at other National Laboratories. EERE began this practice in FY 2014 to effectively control NREL's labor rate multiplier. One outcome has been reducing the cost of accessing unique NREL capabilities (such as facilities and staff expertise) by industry and academia. This practice also makes site operating costs more transparent in order to facilitate cost control and planning. In FY 2014, this practice resulted in a reduction in the lab-wide direct labor multiplier of approximately 15 percent compared to FY 2013. The proposed FY 2016 Budget Request continues the approach applied in 2014 and 2015.

The NREL Site-Wide Facility Support subprogram funding supports research programs by providing basic site services, functions, and infrastructure for site operations, which includes: management, building operations, building and grounds maintenance, fire and emergency response, engineering and construction support, minor construction projects, electrical safety program, utilities, facilities planning support; and activities within the Sustainability and Environmental Health and Safety (EHS) portfolios. These activities and their costs are relatively fixed and only vary significantly based upon variations in commodities, construction activity, emergencies, weather patterns, etc. They are considered to be the core functions for site operations, safety, environmental compliance, and sustainability at NREL. In FY 2016, this funding will continue to support more than 60 full time equivalents that manage and provide support for these core functions. It will also fund site-wide subcontracts such as janitorial services, refuse and recycling, and subcontracts for minor construction. Additionally, this funding will support site-wide costs associated with maintaining NREL's leadership position, such as: maintaining International Organization for Standardization, American Association for Laboratory Accreditation, and other lab-wide accreditations, managing facilities to enable mission goals, improving sustainability, pollution prevention, waste minimization, improving energy efficiency, reducing water use, and maintaining an effective emergency management system.

The FY 2016 Budget Request remains consistent with the method EERE developed in FY 2015. This approach is a more precise, equitable, and economically neutral method that ensures a predictable net-zero impact on programs' funding. For each program, the contribution to direct funding for site-wide facility support is equivalent to the estimated contribution the program otherwise would have made through overhead charges. This method is based upon each program's level of funding to NREL, adjusted to account for anomalies from large capital expenditures and major subcontracts.

**NREL Site-Wide Facility Support**
**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **NREL Site-Wide Facility Support $6,500,000** | **$6,500,000** | **$0** |
| • Directly fund NREL Site-Wide Facility support costs that are not included in the Facilities and Infrastructure budget rather than continue to fund these costs in the laboratory overhead rate. | • Directly fund NREL Site-Wide Facility support costs that are not included in the Facilities and Infrastructure budget rather than continue to fund these costs in the laboratory overhead rate. | • No change. |

In accordance with the GPRA Modernization Act of 2010, the Department sets targets for, and tracks progress toward, achieving performance goals for each program. For more information, refer to the Department's FY 2013 Annual Performance Report.

| | FY 2014 | FY 2015 | FY 2016 |
|---|---|---|---|
| Performance Goal (Measure) | **Thermochemical Conversion - Reduce modeled thermochemical conversion cost of a combined gasoline and diesel production ($/gallons of gasoline equivalent).**<br>**2014: Reduce modeled conversion cost for feedstock to gasoline/diesel by way of liquefaction.**<br>**2013: Reduce modeled conversion cost for feedstock to gasoline/diesel fuel via a bio-oil pathway (including feedstock contribution).** | | |
| Target | $4.10/GGE | $3.70/GGE | $3.00/GGE[1] |
| Result | N/A | N/A | N/A |
| Endpoint Target | $2.47/GGE by 2017[10]<br>Which would enable a modeled mature Minimum Fuel Selling Price of $3.39/GGE with a feedstock cost of $80/dry matter ton in 2017. | | |

[1, 10] FY 2015 target and endpoint target reflect an updated design case and state of technology. Jones, SB and LJ Snowden-Swan, December 2013. *Fast Pyrolysis and Hydrotreating: State of Technology and Projections to 2017 PNL-23294*.

## Hydrogen and Fuel Cell Technologies

### Overview

Hydrogen and fuel cells have the potential to improve energy security and reduce emissions of greenhouse gases, criteria pollutants, and net oil imports by improving energy efficiency, enabling alternative fuel sources, and spurring domestic production of clean energy technologies. Widespread use of hydrogen and fuel cells can have a major impact toward achieving EERE's goals of expanding the adoption of sustainable, domestically powered transportation alternatives; improving the efficiency of energy use; stimulating the growth of domestic clean energy manufacturing; and enabling the integration of clean energy into a reliable, resilient, and more efficient electricity grid. Fuel cells also enable highly efficient use of energy and have the potential to provide zero carbon emissions power when fueled by renewable fuels or hydrogen produced in tandem with carbon capture and storage. Analysis by Oak Ridge National Laboratory indicates that by 2050, the market penetration of fuel cell electric vehicles (FCEVs) could reach 40-60 percent of light-duty vehicle stocks (not just sales) if program targets are met, and the resulting benefits of the Hydrogen and Fuel Cell Technologies Program's efforts could therefore include reductions in national oil consumption of 2-4 million barrels per day and reductions in greenhouse gas (GHG) emissions of 200–450 million metric tons per year.[1]

The Hydrogen and Fuel Cell Technologies Program's focus is on transportation applications. However, stationary fuel cells are a strong first adopter market that will benefit from knowledge spillover and help enable fuel cells for high impact transportation applications by achieving reductions in cost through increased volumes. The successful development of early stationary markets by industry (i.e., backup power or small residential co-generation of heat and power using polymer electrolyte membrane (PEM) fuel cell systems), as well as other early markets such as forklifts and airport/delivery trucks, will help drive down cost, develop a supply base, and provide a strategic pathway to higher volumes and establishing an industry in transportation applications. Other examples aligned with EERE's mission include fuel cells that co-produce power, heat, and hydrogen (tri-generation) and reversible fuel cells that can produce hydrogen in electrolysis mode or power/heat in fuel cell mode. These technologies are aligned with the program's hydrogen production activities, regardless of fuel cell technology, fuel, or temperature, and are focused on life cycle emissions reductions. The scope is technology neutral and fuel flexible with emphasis on low and medium temperature fuel cells applicable to future transportation applications, renewable pathways, and areas of synergy (e.g., biogas, tri-generation, and contaminant clean up). In doing so, the program coordinates efforts with the Office of Fossil Energy (FE). FE focuses on solid oxide fuel cells while the Hydrogen and Fuel Cell Technologies Program focuses on research and development (R&D) on PEMs and other fuel cell technologies.

The program's portfolio focuses on both fuel cell R&D and hydrogen fuel R&D, with an emphasis on renewable production pathways, delivery, and storage of hydrogen, to meet cost and performance goals. Near term efforts in real-world demonstration and validation help to accelerate market growth and provide critical feedback for future R&D. The portfolio also addresses a number of non-technical factors, such as user confidence, ease of financing, the availability of codes and standards, and refueling infrastructure logistics, particularly for FCEVs. Figure 1 shows specific focus areas to enable cost competitive FCEVs on a life cycle basis.

### Highlights of the FY 2016 Budget Request

The Fuel Cell R&D subprogram will focus on R&D of fuel cell stacks and systems for transportation applications. Emphasis will be on stack component R&D (including catalysts, membranes, and membrane electrode assembly (MEA) integration), stack and component operation and performance (including durability, impurities, and mass transport), systems and system integration, balance of plant (BOP) components, testing, technical analysis, and high-throughput combinatorial approaches. Consistent with rigorous peer review processes, competitive selection of projects in topic areas will be determined based on the relative merit, applicability, and potential for R&D progress of the projects through planned funding opportunity announcements (FOAs). Funding will focus on transportation-specific areas of activity with potential impact on other applications (e.g., BOP components or start-stop durability cycling relevant to automotive duty cycles).

[1] Lin, Z., Dong, J., & Greene, D. L. (2013). Hydrogen vehicles: Impacts of DOE technical targets on market acceptance and societal benefits. *International Journal of Hydrogen Energy*, *38*(19), 7973–7985. doi: http://dx.doi.org/10.1016/j.ijhydene.2013.04.120.

The Hydrogen Fuel R&D subprogram's efforts will include emphasis on materials and process development to enable hydrogen production from diverse renewable resources. In FY 2016, these efforts will continue to balance approaches to near-term commercialization while driving advances in longer-term technologies and leveraging investments by other Federal research programs. The Hydrogen Fuel R&D subprogram's hydrogen production and delivery efforts will focus on a two pronged approach: (1) enabling near-term options by lowering the cost of hydrogen delivered and dispensed at the station; and (2) focusing on longer-term renewable options such as direct solar water splitting, including high throughput/combinatorial approaches to enable rapid identification of promising new materials. Further efforts include developing and testing the innovative materials, components, and systems needed to establish the technical and cost feasibility for hydrogen delivery. The emphasis will be on forecourt station technologies such as reliable, cost-effective and energy efficient hydrogen compressors; durable, high pressure dynamic and static seals; and low-cost station and vehicle storage. A Hydrogen and Fuel Cell Technologies Program 'Incubator' funding opportunity will invest 5 percent of Hydrogen and Fuel Cell Technologies funding toward new off-roadmap innovative technologies and solutions that can help meet existing goals but are not represented in a significant way in the current portfolio or technology roadmaps. Successful Incubator projects will reduce the risk associated with potential breakthrough approaches and technologies so they may be 'on-ramped' to future program roadmaps and the program portfolio.

Throughout its efforts, the Fuel Cell Technologies Program supports the Department's Clean Energy Manufacturing Initiative. The Clean Energy Manufacturing Initiative is a Department-wide approach to increase U.S. competitiveness in clean energy manufacturing while advancing progress toward the nation's energy goals. The DOE Clean Energy Manufacturing Initiative supports research, development, and addressing market barriers that will help companies competitively manufacture clean energy technologies in the U.S., and help companies across the manufacturing sector become more competitive by leveraging energy efficiency measures to increase their energy productivity. Clean Energy Manufacturing efforts in the Hydrogen and Fuel Cells program include development of quality control tools for the manufacturing of fuel cell components and systems; development of fabrication processes that lead to low-cost, high-volume manufacturing; support for the development of a domestic supply base; and analysis of global manufacturing competitiveness for hydrogen and fuel cell-related technologies. In addition, in alignment with the Administration's Materials Genome Initiative, the program will collaborate on materials manufacturing R&D, focused on non-platinum group metal (PGM) catalysts, electrodes, and interfaces. This approach will be carried out through public-private partnership and will include the use of high-performance computing and high-throughput process experimentation to develop validated models capturing the effects of manufacturing processes and end use to dramatically accelerate the development of these materials from the point of discovery through qualification and implementation.

To increase the likelihood that R&D efforts lead to successful commercialization, the program pursues a market-acceleration strategy that integrates technology demonstration and validation, codes and standards development, and early market deployments. Demonstration and validation ensure that pre-commercial technologies are ready for the deployment phase and provide critical feedback to R&D efforts, revealing issues that come to light when technologies are operated in complete systems under real-world conditions. Efforts in safety, codes and standards enable development of codes and standards that are necessary for commercial deployments and help reduce permitting times. Early market deployment activities focus on key markets for commercial-ready technologies that will have a catalytic effect on the growth of domestic manufacturing and significant impact on long-term commercialization by reducing costs through economies of scale.

As part of the greater DOE Grid Modernization crosscut in the FY 2016 Budget, the Hydrogen and Fuel Cell Technologies Program will focus on developing controls and associated system architectures needed to manage a diverse set of resources and grid assets, including fuel cell technologies, electrolyzers, and energy storage across the distribution system; investigating how reversible fuel cells can help mitigate variable generation and enable energy from the system to be more easily dispatched over the course of a given day; developing low cost sensors to provide visibility to grid operators on what services reversible fuel cells and electrolyzers can provide to the grid; and determining how reversible fuel cells and electrolyzers can provide flexibility to the grid. The Hydrogen and Fuel Cell Technologies Program will also partner with a National Laboratory consortium to design, simulate and demonstrate a transactional energy ecosystem as the basis for accomplishing grid integration and realizing the full potential of energy and grid related opportunities.

**FY 2016 Crosscuts ($K)**

| | Grid Modernization | Total |
|---|---|---|
| **Hydrogen and Fuel Cell Technologies** | **8,500** | **8,500** |

The fuel cell industry is poised for significant near-term expansion—investing heavily in product development and leading the clean-energy sector in patents, with more than 850 patents issued in 2013.[1] The U.S. has been the world leader in fuel cell patents, with 43 percent of all patents issued from 2002 to 2013, compared to 33 percent issued by Japan during the same time frame. Major government-industry partnerships in several countries abroad have been announced to support hydrogen infrastructure development for FCEVs. Continued support by major industrial players and governments of other countries underscores the global market potential for these technologies and the need for continued Federal investment for domestic industry to remain competitive.

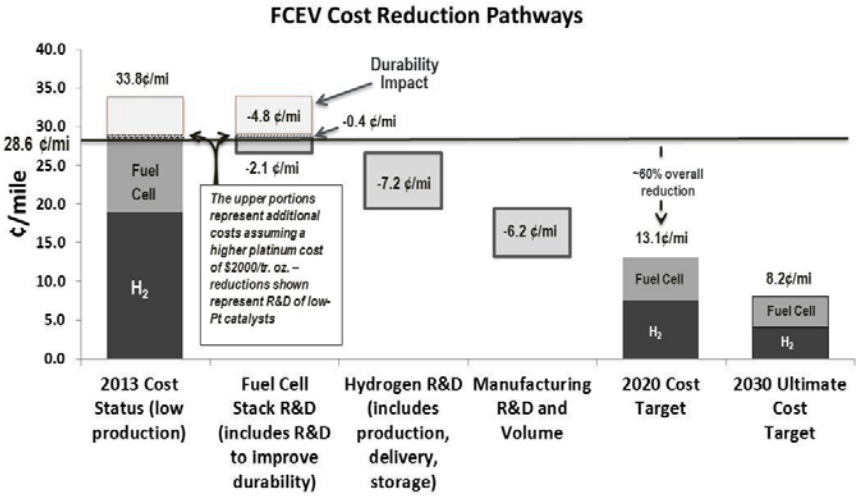



**Figure 1.** The program's goals for reducing FCEV cost are driven by an overarching goal to reduce the hydrogen and fuel cell portion of the life-cycle cost of the vehicle to 13.1¢/mile by 2020, with an ultimate goal of 8.2¢/mile.

[1] Source: http://cepgi.typepad.com/files/cepgi-2013-year-end-wrap-up.pdf

## Hydrogen and Fuel Cell Technologies
### Funding ($K)

| | FY 2014 Enacted[1] | FY 2014 Current[2] | FY 2015 Enacted | FY 2016 Request | FY 2016 vs FY 2015 |
|---|---|---|---|---|---|
| **Hydrogen and Fuel Cell Technologies** | | | | | |
| Fuel Cell R&D | 33,383 | 32,423 | 33,000 | 36,000 | +3,000 |
| Hydrogen Fuel R&D | 36,545 | 34,466 | 35,200 | 41,200 | +6,000 |
| Manufacturing R&D | 3,000 | 2,879 | 3,000 | 4,000 | +1,000 |
| Systems Analysis | 3,000 | 3,000 | 3,000 | 3,000 | 0 |
| Technology Validation | 6,000 | 6,000 | 11,000 | 7,000 | -4,000 |
| Safety, Codes and Standards | 7,000 | 6,909 | 7,000 | 7,000 | 0 |
| Market Transformation | 3,000 | 2,841 | 3,000 | 3,000 | 0 |
| NREL Site Wide Facility Support | 1,000 | 1,000 | 1,800 | 1,800 | 0 |
| **Total, Hydrogen and Fuel Cell Technologies** | **92,928** | **89,518** | **97,000** | **103,000** | **+6,000** |

SBIR/STTR:

- FY 2014 Transferred: SBIR $3,129,000; STTR $281,000
- FY 2015 Enacted: SBIR $1,907,000; STTR $263,000
- FY 2016 Request: SBIR $2,239,000; STTR $336,000

[1] FY 2014 Enacted funding reflected the contractor foreign travel rescission of $55,467.
[2] Funding reflected the transfer of SBIR/STTR to the Office of Science.

**Hydrogen and Fuel Cell Technologies**
**Explanation of Major Changes ($K)**

| | FY 2016 vs FY 2015 |
|---|---|
| **Fuel Cell R&D:** The funding increase will accelerate development of non-platinum group metal catalyst through advanced-materials manufacturing R&D focused on using high performance computing and high throughput combinatorial approaches to accelerate the development of potential catalysts that will enable fuel cell system cost reductions while enhancing durability. | **+3,000** |
| **Hydrogen Fuel R&D**: The funding increase will enable additional long-term R&D in hydrogen production from renewable resources including efforts in high temperature electrolysis and the development of novel hydrogen delivery methodologies. | **+6,000** |
| **Manufacturing R&D:** The funding increase will provide resources to rapidly advance the development of quality control tools for the manufacturing of fuel cell components and systems. | **+1,000** |
| **Technology Validation:** A one-year (FY 2015) funding increase is not requested in FY 2016 for the testing and analysis of fuel cells as industrial-scale energy storage devices using full-scale testing and demonstration. | **-4,000** |
| **Total, Hydrogen and Fuel Cell Technologies** | **+6,000** |

**Description**

The primary objectives of the Fuel Cell R&D subprogram are to improve the durability, reduce the cost, and improve the performance (e.g., power, start-up time, and transient response) of fuel cell systems. The efforts in the Fuel Cell R&D subprogram seek to advance fuel cell technologies that can be used in automotive and other applications. Key goals include reducing the cost of automotive fuel cells to $40/kW and improving fuel cell durability to 5,000 hours (approximately 150,000 miles of driving) for automotive systems by 2020. These goals are consistent with a technology roadmap for enabling FCEVs to start becoming competitive compared to conventional vehicle technologies; in the long term, the fuel cell cost must be reduced to $30/kW to be competitive with future-advanced gasoline engines. This cost target is compared to today's modeled automotive fuel cell cost of approximately $55/kW using state-of-the-art fuel cell technology projected to high manufacturing volumes (500,000 units/year), which represents a more than 30 percent reduction since 2008 and more than 50 percent reduction since 2006.

Since automotive fuel cells are only now becoming commercially available and are produced at very low volumes, the current actual cost based on early market applications is estimated at roughly $1,000/kW, significantly higher than the projected $55/kW as a result of high volume manufacturing processes and economies of scale. To this end, the program plans to continue R&D to address challenges facing fuel cells for automotive applications with potential spillover benefits relevant to near-term applications such as distributed power (primary and backup), Auxiliary Power Units (APUs), material handling equipment, and specialty vehicles which will help drive manufacturing volume. These near term applications will generate market traction for adoption of longer-term applications such as light-duty vehicles, which will have the greatest potential impact for fuel cell technologies on national energy goals and associated metrics, as well as other transportation systems such as APUs that could be applicable for truck, marine, or aircraft applications, and would also provide substantial environmental and energy-security benefits. Advances in fuel cell component and balance of system technologies can provide a range of benefits for all applications. The portfolio is "technology neutral" in the sense that it covers a range of fuel cell technologies, including PEM fuel cells, alkaline fuel cells, direct methanol fuel cells, and medium-temperature fuel cells such as phosphoric acid fuel cells.

In FY 2016, the Fuel Cell R&D subprogram ($36 million) will continue R&D of automotive fuel cells and fuel cell systems. Key areas of emphasis include cell stack component R&D (including catalysts, membranes, and MEA integration), stack and component operation and performance (including durability, impurities, and mass transport), and work on systems and system integration, balance of plant components, testing, technical analysis. In addition, the subprogram will initiate an advanced-materials manufacturing R&D effort focused on using high performance computing and high throughput combinatorial approaches. These approaches will capture the effects of materials processing and end-use performance and will accelerate advanced materials development and implementation. The emphasis on advanced materials manufacturing R&D, in support of the Administration's Materials Genome Initiative and DOE's Clean Energy Manufacturing Initiative, will include a FOA of approximately $8 million to support advanced materials development for non-platinum group metal (PGM) catalysts, electrodes, and interfaces. Platinum is the primary cost driver for current fuel cell technologies. Discovery and development of non-PGM catalysts could dramatically reduce fuel cells stack cost by approximately 40%. Consistent with rigorous peer review processes, competitive selection of projects in topic areas will be determined based on the relative merit, applicability, and potential for R&D progress of the projects through planned funding opportunity announcements.

The subprogram improved the catalyst specific power of fuel cells to 6.0 kW per gram (g) of PGM in 2013, which is more than double the 2008 baseline of 2.8 kW/g and approaching the 2020 target of 8.0 kW/g, reflecting a more than 80 percent reduction in total platinum content in fuel cells since 2005. The subprogram achieved this reduction through breakthrough developments such as nanostructured thin film catalysts and core-shell catalysts (in which platinum coats the outside of a non-platinum-containing core). In FY 2016, the program plans to increase the catalyst power density to 6.9 kW per gram of PGM, to help reduce the high volume, modeled levelized cost per mile from the current cost of $0.34 per mile, toward the 2020 goal of $0.13 per mile. Depending on gasoline price, comparable components (fuel, tank and engine) of the gasoline ICE cars on the road today average a levelized cost per mile of $0.095 to $0.14 cents. These efforts target cost reduction

and an increase in fuel cell stack and system durability. As recommended in a 2008 National Research Council report, [1] the program reallocated funding over the past several years to prioritize and emphasize R&D that addresses the most critical barriers, such as catalysts (low- and non-platinum-group-metal catalysts), electrodes, membranes, MEAs, and modes of operation addressing stack and component durability and performance. There are different technology needs for different types of fuel cells. The program implements a portfolio approach to ensure specific R&D needs are addressed based on the status of the technology compared to application-driven targets, such as fuel cleanup for fuel flexible fuel cells.

In FY 2016, the program will continue to emphasize R&D at the materials and component level, as well as component integration into MEAs and stacks. The program will pursue the acceleration of non-PGM catalyst, electrode and MEA development through the application of high performance computing, high-throughput combinatorial approaches and advanced modeling. The program will continue system BOP component R&D (e.g., for air management) that can lead to lower cost and lower parasitic losses, as well as on component integration in systems for non-automotive applications. The program will also pursue the development of longer-term technologies (e.g., anion-exchange [alkaline] membrane fuel cells), which will provide high-performance and durable, PGM-free technology. Targeted R&D of medium-temperature fuel cell technologies (e.g., phosphoric acid and phosphoric-acid based, molten carbonate fuel cells) will enhance the capability to take advantage of diverse fuels, with a focus on renewables, for highly efficient production of power and heat. In addition, fuel processors integrated with the fuel cell will enable the conversion of fuels—including biomass-derived liquids and waste gas—into hydrogen for fuel cell applications.

Fuel cell system modeling will serve to guide component R&D, help to benchmark complete systems before they are built, and explore alternate system components and configurations. The modeling activity will include cost analysis for multiple applications and evaluation of operation strategies—with the aim of enhancing performance and reducing degradation. Optimizing system controls will improve performance and durability, while lowering cost. Analytical tools and partnerships continue to expand research capabilities. In addition, R&D efforts will leverage outside activities, through coordination with the Office of Science's Basic Energy Sciences Program, ARPA-E, and the National Science Foundation (NSF).

In addition, funds may be used to support efforts such as peer reviews, data collection and dissemination, technical assistance, and technology-to-market activities.

[1] Transitions to Alternative Transportation Technologies—A Focus on Hydrogen, National Research Council of the National Academies, 2008, http://www.nap.edu/catalog/12222/transitions-to-alternative-transportation-technologies--a-focus-on-hydrogen

**Fuel Cell R&D**
**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **Fuel Cell R&D $33,000,000** | **$36,000,000** | **+$3,000,000** |
| • Continue catalyst and MEA component integration R&D projects to demonstrate advanced MEAs to achieve 6.5 kW/g PGM.<br>• Develop membranes for transportation that operate under hot and dry conditions, meeting area specific resistance of 0.02 Ohm $cm^2$ at 120$^oC$ and 40kPa water partial pressure more than a 10 percent improvement with respect to the 2011 baseline (0.023 Ohm $cm^2$).<br>• Develop and demonstrate innovative non-PGM catalysts that achieve 150 milliamps/$cm^3$ at 0.8 V, more than a two-fold improvement compared to the 2011 baseline value of 60 mA/$cm^3$.<br>• Develop higher temperature fuel cell stack components, as well as system and subsystem components to extend fuel cell operational life to 50,000 hours.<br>• Issue catalyst R&D solicitation and competitively select 2 to 6 catalyst projects developing novel catalysts and electrodes to achieve 8 kW/g PGM by 2020.<br>• Issue solicitation which will emphasize teaming using a Consortium approach and competitively select Consortium to increase the understanding of fuel cell performance and durability, with a focus on transportation fuel cells demonstrating a lifetime of 5,000 hours by 2020. | • Develop innovative catalyst and electrode technologies and integrate state-of-the-art components in advanced MEAs to achieve 6.9 kW/g PGM.<br>• Accelerate non-PGM catalyst, electrode and MEA development through the application of high-performance computing, high-throughput combinatorial based approaches and advanced modeling, capturing the effects of processing and end-use performance, to facilitate meeting 2020 and ultimate fuel cell cost target of $40/kW and $30/kW respectively, in support of the Administration's Materials Genome Initiative and DOE's Clean Energy Manufacturing Initiative.<br>• Continue development of higher temperature fuel cell stack components, as well as system and subsystem components and system integration to extend fuel cell operational life beyond 50,000 hours.<br>• Issue Fuel Cell R&D solicitation and select 3 to 6 projects that will help achieve the fuel cell system cost ($40/kW by 2020) and durability (5,000 hours by 2020) metrics. | • The increase funds a next generation advanced materials manufacturing R&D effort focused on high throughput combinatorial approaches capturing the effects of processing and end-use performance to develop non-PGM catalysts and electrodes and interface and MEA optimization, in support of the Administration's Materials Genome Initiative and DOE's Clean Energy Manufacturing Initiative. |

**Description**

The Hydrogen Fuel R&D subprogram supports the program's mission through materials research and technology development to enable low-cost production of hydrogen from renewable sources and address key challenges to hydrogen delivery and storage.

The overarching goal of the Hydrogen Fuel R&D subprogram is to enable several renewable domestic production approaches—at a variety of scales ranging from large, centralized production to small, local (distributed) production—that will achieve a hydrogen cost of less than $4/gge, dispensed and untaxed, by 2020. This cost represents the threshold at which hydrogen for FCEVs will be competitive on a cent-per-mile basis with conventional vehicles. To enable the use of hydrogen produced from highly-efficient centralized facilities, technologies will have to be developed to lower the cost of delivery to the station. There are also costs associated with compression, storage, and dispensing (CSD) at the station that will affect the final cost of hydrogen produced at both central and distributed sites. The program is pursuing advances in existing technologies for hydrogen delivery and station CSD and developing new technologies to reduce costs, with the ultimate goal of reducing the delivery portion of the total hydrogen cost to less than $2/gge by 2020.

The Hydrogen Fuel R&D subprogram is also developing technologies to enable efficient and cost-effective hydrogen storage systems ranging from high-pressure compressed hydrogen storage systems to more advanced technologies, such as cold or cryo-compressed hydrogen and materials-based storage technologies, with potential for significantly improved performance. The overarching goal of the program's hydrogen storage efforts is to enable a driving range of more than 300 miles (~500 km), while meeting the packaging, cost, safety, and performance requirements of current and future vehicle markets. While automakers have demonstrated progress with vehicles that can travel more than 300 miles on a single fill (including one vehicle that was independently validated at 430 miles) with 700 bar compressed hydrogen, advanced storage approaches will be needed to achieve this driving range across all vehicle platforms without compromising passenger and cargo space or performance. The Hydrogen Fuel R&D subprogram has established onboard automotive storage density goals for 2017 of 1.8 kWh/kg (5.5 percent by weight) and 1.3kWh/liter (0.04 kg $H_2$/liter) with a system cost target of $12/kWh. The long-term subprogram light-duty vehicle targets are 2.5 kWh/kg (7 percent by weight) and 2.3 kWh/liter (0.07 kg $H_2$/liter), with a storage system cost target of $8/kWh. While some promising storage materials have been identified, no single material has been identified that meets all storage targets simultaneously. Furthermore, any hydrogen storage material will have to be able to be integrated into a system that meets the cost, safety, and performance requirements of current and future vehicle markets.

The Hydrogen Fuel R&D subprogram ($41.2 million) will continue to pursue reductions in the cost of hydrogen from renewable resources, bio-oil reforming, and continued advances in electrolysis. Opportunities to reduce emissions from hydrogen production will be explored through development of advanced reforming technologies using biogas, pyrolysis oil, or other sustainable resources. While the Program has dramatically reduced the capital cost of electrolyzers – more than 80 percent for the electrolyzer stack since 2002 – the cost of electricity remains a major cost barrier. However, further cost-reduction opportunities exist for electrolyzers through R&D of high temperature electrolysis and reversible fuel cells for Grid Modernization ($3 million), balance of plant components, systems integration, and alternate membranes (e.g., anion-exchange membranes). In addition, significant opportunities exist for near-term utilization of electrolyzers, including: regions with low-cost electricity; larger-scale energy storage; and situations where electrolysis can play a role in additional value streams—e.g., use with stationary fuel cells to provide grid stability; and use of electricity that would otherwise be curtailed, to produce hydrogen for FCEVs or other higher-value applications.

The hydrogen production component of the Hydrogen Fuel R&D subprogram will address materials and process development to enable hydrogen production from renewable sources and will collaborate with other agencies. The efforts will focus on advances in hydrogen production through microbial biomass conversion, direct solar water splitting, and other innovative approaches with emphasis on renewable pathways, including high throughput/combinatorial approaches to enable rapid identification of promising materials as appropriate.

The Hydrogen Fuel R&D subprogram's hydrogen delivery component will focus on developing and testing the innovative materials, components, and systems needed to establish the technical and cost feasibility for hydrogen delivery. The emphasis will be on forecourt station technologies such as reliable, cost-effective, and energy efficient hydrogen compressors; durable, high pressure dynamic and static seals; and low-cost station storage. In addition, synergies between natural gas and hydrogen infrastructures (e.g., transmission and distribution, station technologies and components for compression and storage and dispensing) will be explored and specific opportunities for leveraging will be identified.

The hydrogen storage component of the Hydrogen Fuel R&D subprogram will focus on R&D to lower the cost of near-term physical storage options and to develop longer-term advanced hydrogen storage technologies that meet the full set of onboard system targets and that can enable the widespread commercialization of hydrogen fuel cell systems for automotive and other applications. The near-term focus exploring low-cost carbon fiber composites for high-pressure storage will not only benefit hydrogen fuel cell vehicles but can also generate knowledge spillover benefits relevant to compressed natural gas vehicles. In FY 2016, the Hydrogen Fuel R&D subprogram, in coordination with the Vehicle Technologies Program, will establish complementary, jointly-implemented funding efforts to address common technical barriers to high energy density, onboard gaseous fuel storage for light-duty vehicles. By coordinating R&D the programs will accelerate the pace, minimize duplication, and lower the overall cost of necessary R&D.

In addition, funds may be used to support efforts such as peer reviews, data collection and dissemination, technical assistance, and technology-to-market activities.

**Hydrogen Fuel R&D**
**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **Hydrogen Fuel R&D $35,200,000** | **$41,200,000** | **+$6,000,000** |
| • Continue to develop technologies and materials to lower the cost and improve the efficiency of hydrogen production, delivery, and storage technologies to achieve the 2020 goal of less than $4/gge and to meet the full set of onboard system targets to provide a 300 mile driving range without sacrifice to passenger and cargo space.<br>• Relative to the 2011 baseline of $8.00/gge, reduce hydrogen cost (dispensed and untaxed) to $6.80/gge.<br>• Demonstrate a semiconductor-based photo electrochemical device with a stabilized solar-to-hydrogen conversion efficiency of >15 percent compared to a 2011 baseline of 12 percent.<br>• Demonstrate electrolyzer stack efficiency of 76 percent (lower heating value) and determine the potential to meet a modeled high volume cost of $4/gge for hydrogen production.<br>• Develop technologies to enable a 15 percent cost reduction of 700 bar compressed hydrogen storage systems from the 2013 baseline projection of $17/kWh, on track towards meeting the target of $10/kWh by 2020.<br>• Develop and evaluate a sub-scale hydrogen adsorbent system and compare projected full-scale performance against DOE targets of 40 grams per liter and 5.5 weight percent.<br>• Support approximately 20 new projects and continue support for about nine direct-funded National Laboratory projects. | • Relative to the 2011 baseline of $8.00/gge, reduce the hydrogen cost (dispensed and untaxed) to $6.70/gge.<br>• Demonstrate > 500 hours of $H_2$ production from bio-derived liquids with in-situ $CO_2$ capture and >90 percent pure $H_2$.<br>• Design a mega-watt scale solar thermochemical hydrogen production plant for 100,000 kg/day, and show through modeled performance analysis the capability to meet the $2/gge cost target.<br>• Develop PV-grade wide-band gap thin-film absorbers with photo electrochemical solar photocurrent densities ≥13 mA/cm$^2$ to enable 16 percent solar to hydrogen conversion efficiency.<br>• Demonstrate at least 80 percent isentropic efficiency for forecourt compression, compared to the 2011 baseline of 65 percent, to meet or exceed the 2020 target.<br>• Demonstrate the pilot production of a new high strength (750 KSI), low cost ($6/lb) glass fiber with the potential to replace traditional carbon fiber at half the cost, for 700 bar hydrogen storage systems.<br>• Develop technologies to enable a 25 percent cost reduction of 700 bar compressed hydrogen storage systems from the 2013 baseline projection of $17/kWh, on track towards meeting the target of $10/kWh by 2020.<br>• Continue support for approximately nine direct-funded National Laboratory projects and plan to initiate approximately 13 new projects. | • Additional funds will accelerate R&D in hydrogen production from renewable resources including efforts in high temperature electrolysis and the development of novel hydrogen delivery methodologies.<br>• Initiate a joint R&D effort with the Vehicle Technologies Program to address common technical barriers to high energy density, onboard gaseous fuel storage for light-duty vehicles. |

## Hydrogen and Fuel Cell Technologies
## Manufacturing R&D

**Description**

The Manufacturing R&D subprogram supports the program's mission through the development of advanced fabrication technologies and processes to meet the cost targets of hydrogen and fuel cell technologies. These activities will help reduce fuel cell and hydrogen system costs to be competitive with those of current technologies. The Manufacturing R&D subprogram also supports outreach activities to facilitate development and expansion of the domestic supply chain of hydrogen and fuel cell-related components. A nimble supply chain can help reduce cycle time in production and ensure a constant flow of raw materials.

The Manufacturing R&D subprogram will build upon awards made in FY 2015 and identify specific manufacturing R&D projects as program plans are updated to reflect advancement in technologies and new application requirements. The Manufacturing R&D subprogram coordinates extensively with other organizations within DOE such as the crosscutting Clean Energy Manufacturing Initiative and EERE's Technology Offices including the Advanced Manufacturing Office.

The Manufacturing R&D subprogram ($4 million) will continue its development of fabrication processes that lead to low-cost, high-volume manufacturing, assist the development of a domestic supply base, and carry out global manufacturing competitiveness analysis for hydrogen and fuel cell-related technologies. In FY 2016, the Manufacturing R&D subprogram will continue to develop new diagnostics for quality control in production of hydrogen and fuel cell components and systems, which will help achieve the fuel cell portion of the FCEV levelized cost per mile target of $0.13/mile by 2020. In FY 2014, the Manufacturing R&D subprogram successfully demonstrated quality control diagnostics on membrane material on a web-line at 60 feet/min. In FY 2016, the Manufacturing R&D subprogram will demonstrate its diagnostics for defect detection at domestic hydrogen and fuel cell production facilities. The Manufacturing R&D subprogram will use experiments and modeling to quantify the effect of defects generated during the manufacturing process on fuel cell performance. The Manufacturing R&D subprogram will analyze various approaches to develop and enhance the domestic supply chain for hydrogen and fuel cell components and systems. The Manufacturing R&D subprogram will also carry out analyses to identify the differences between the cost to manufacture key components of hydrogen and fuel cell systems in the U.S. compared to other countries; the manufacturing competitiveness analysis will be used to identify future Manufacturing R&D efforts that have the greatest impact on cost reduction and on supporting domestic hydrogen and fuel cell manufacturing.

The Manufacturing R&D subprogram will coordinate with DOE's Clean Energy Manufacturing Initiative Office and Advanced Manufacturing Office, the Department of Defense (DOD), and the Department of Commerce (National Institute of Standards and Technology) to leverage other activities. In particular, the Manufacturing R&D subprogram will coordinate analysis activities with the Clean Energy Manufacturing Initiative to enhance U.S. manufacturing competitiveness.

In addition, funds may be used to support efforts such as peer reviews, data collection and dissemination, technical assistance, and technology-to-market activities.

**Manufacturing R&D**
**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **Manufacturing R&D $3,000,000** | **$4,000,000** | **+$1,000,000** |
| • Continue developing fuel cell fabrication processes and to demonstrate methods to inspect full MEAs and cells prior to assembly into stacks, which will help achieve the FCEV life-cycle cost of $0.38 per mile by 2020.<br>• Demonstrate continuous in-line measurement at 100 ft. /min for MEA and MEA component fabrication (3X increase from 2013).<br>• Develop cell manufacturing processes that increase throughput and efficiency and decrease complexity and waste (project ends in FY 2015).<br>• Support approximately three projects to achieve these outcomes.<br>• Initiate three new outreach and analysis projects from FY 2014 FOA on supply chain development and global manufacturing competitiveness analysis in collaboration with the DOE's Clean Energy Manufacturing Initiative.<br>• Initiate a FOA topic to fund 1 to 2 project(s) to develop and demonstrate an innovative, low cost processes for manufacturing fiber reinforced pipeline capable of carrying hydrogen at 100 bars, durable for 50 years, and having a leak rate less than 6 kg-$H_2$/mile-year for funding in FY 2016. | • Demonstrate continuous in-line quality control methods for detecting pin-holes in fuel cell membranes <150 micrometers in diameter.<br>• Report on development of outreach activities that facilitate the development of a robust domestic hydrogen and fuel cell supply chain.<br>• Identify supply chain gaps and strategies to overcome these gaps and reduce supply chain costs.<br>• Deliver comprehensive global manufacturing competiveness analysis focused on both polymer electrolyte membrane fuel cell systems (automotive and stationary) and high pressure (700 bar) hydrogen storage systems. The report will describe:<br>▪ The current industry structure both domestically and internationally to benchmark markets;<br>▪ The value stream from raw materials (or component parts where more relevant) to consumer products;<br>▪ Areas where the U.S. has (or may have) viable manufacturing opportunities and identify potential vulnerabilities to U.S. competitiveness; and<br>▪ Segments identified as having particularly well-suited to U.S. strengths (e.g., requiring a highly skilled, innovative workforce).<br>• Initiate 1 to 2 project(s) from FY 2015 FOA to develop high-volume, fiber reinforced pipeline manufacturing methods with the ultimate goal to help achieve the DOE target of hydrogen delivery at < $2/gge from the point of production to the point of use. | • The funding increase will provide resources to fund the fiber reinforced pipeline manufacturing project.<br>• The funding increase will also provide resources to continue to rapidly advance the development of quality control tools for the manufacturing of fuel cell components and systems. |

## Hydrogen and Fuel Cell Technologies
## Systems Analysis

**Description**

The Systems Analysis subprogram provides the analytical and technical basis for informed decision making for the program's R&D direction and prioritization. Systems Analysis is an essential component of the program and it contributes to understanding and assessing market growth and job creation, technology needs and progress and potential environmental impacts, and the energy-related economic benefits of fuel cells across applications and for multiple fuel pathways on a life cycle basis. These efforts assess R&D gaps, planning, and budgeting, as well as synergies and interactions with other energy sectors such as natural gas. The Systems Analysis subprogram assesses the requirements of potential end-users to determine metrics for multiple components, subsystems, and systems. Results also support annual updates to key planning documents that provide the current direction and planned milestones for the program. Systems Analysis also supports key collaborations, particularly through partnerships such as U.S. DRIVE and H2USA—a public-private partnership developed in FY 2013 to address the barrier of infrastructure.

The Systems Analysis subprogram ($3 million) will continue to develop, refine, and utilize analytical models and tools. In FY 2016, the Systems Analysis subprogram will:

- Assess the return on investment (ROI) of DOE R&D funding related to follow on investment in fuel cell and hydrogen technologies;
- Assess hydrogen infrastructure build-out scenarios for transportation applications such as those in support of H2USA;
- Assess program milestones and technology readiness goals, including risk analysis, financial evaluations and environmental analysis;
- Identify research and technology gaps in order to guide investments and enable targeted R&D that will help achieve the fuel cell portion of levelized cost per mile of $0.13 per mile by 2020 (and these gaps will also be assessed for other applications, including material handling and stationary power, including CHP systems);
- Assess life-cycle GHG emissions, petroleum reduction and cost for on-board storage options, resource and technology limitations, renewable fuel supply evolution, infrastructure issues and limitations, and the potential environmental impacts of widespread commercialization for fuel cell application for transportation and stationary and backup power;
- Assess the use of hydrogen produced from renewable resources (such as wind and solar) for energy storage (and as an energy carrier) to understand technology opportunities to alleviate electrical grid congestion and enable the distribution of energy from the point of generation to end users through multiple transport modes such as electrical transmission; and
- Assess the natural gas and hydrogen infrastructure to determine potential synergies and opportunities to reduce cost through economies of scale applicable to hydrogen.

The Systems Analysis subprogram will also provide support and input for all elements of the program's efforts—such as:

- Underlying technical analysis for technology-related go/no-go decisions.
- Updates and maintenance of the Analysis Portfolio, prioritized analysis list, and Analysis Resource Center database—to ensure analysis consistency and transparency.
- Modeling and analysis of synergies between hydrogen and fuel cells with other emerging technologies, fuels such as natural gas, and energy systems to identify and understand potential opportunities/system trade-offs, assess the benefits of achieving economies of scale, and identify ways to reduce infrastructure cost; and the Systems Analysis subprogram will also work with other subprograms to update other models as needed.
- Provide analytical support for the DOE QER and QTR.

In addition to analyses of the environmental benefits of fuel cells mentioned above, the Systems Analysis subprogram will also estimate the commercial impact and return on investment by determining the number of patents and commercial technologies developed through the program's funding. For example, as of 2014:

- The program's funding has also led to about 40 commercial technologies, 65 emerging technologies (expected to be commercial within three years) and more than 500 patents.
- A sample of the program's projects were tracked and found to have resulted in revenues of >5x the amount of DOE funding; and funds invested in projects were found to result in >5.5x additional investment by industry.

In addition, funds may be used to support efforts such as peer reviews, data collection and dissemination, technical assistance, and technology-to-market activities.

**Systems Analysis**
**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 Enacted |
|---|---|---|
| **Systems Analysis $3,000,000** | **$3,000,000** | **$0** |
| • Continue the use of analytical models and tools and also to support the H2USA partnership that has been developed to address the hydrogen infrastructure barrier and conduct a workshop and webinar to demonstrate the application of the tools for station economic analysis.<br>• Complete analysis of the program's performance, the cost status of key technologies, and the potential use of fuel cells for a portfolio of commercial applications and issue a report measuring FCTO's continued progress in advancing the fuel and hydrogen technologies.<br>• Complete analysis of impacts such as job creation from infrastructure development for early market fuel cell applications.<br>• Using the Macro System Model, analyze the life-cycle GHG emissions and cost of on-board storage options including cold, chemical, and adsorbent systems and issue a report on the pathway costs and GHG emissions compared to current pathway.<br>• Complete life cycle analysis for water use of at least two hydrogen production pathways, with emphasis on renewables and issue a report on the findings.<br>• Assess and compare the potential economic, environmental, and GHG emissions reduction benefits of utilizing fuel cells for power generation from various fuel sources.<br>• Support approximately six direct-funded National Laboratory projects to achieve these outcomes. | • Continue to assess the ROI of DOE R&D funding in advancing fuel cell and hydrogen technologies that will be used to assess the Programs progress and technology advances.<br>• Assess impact of fuel cell performance on the life cycle cost on a cost per mile for FCEVs that will identify the benefits for continued fuel cell R&D.<br>• Assess program milestones and technology readiness goals, including risk analysis, financial evaluations and environmental analysis.<br>• Complete life cycle analysis for water use of at least three hydrogen production pathways, with emphasis on renewables that will be used to identify hydrogen production technologies within regional water constraints.<br>• Assess the natural gas and hydrogen infrastructures to determine potential synergies and opportunities to reduce cost through economies of scale applicable to hydrogen.<br>• Continue to support approximately six direct-funded National Laboratory project to achieve these outcomes. | • The primary change is increased focus on infrastructure analysis, particularly return on investment analysis. These activities include quantifying the impact of fuel cell R&D advances on improved fuel cell performance and progress to targets. Emphasis on quantifying GHG emission reduction and water use for renewable hydrogen production is expected to be increased. |

**Description**

The Technology Validation subprogram provides accurate assessments of the state of hydrogen and fuel cell technologies—providing valuable feedback to R&D efforts, and validating the performance of pre-commercial technologies to enable informed decisions for public and private investment in continued R&D or commercial deployment. These efforts form a crucial part of an integrated strategy to move technologies from the laboratory to commercialization. The validation of pre-commercial technologies ensures the technologies are ready for the deployment phase. To enable the automotive, energy, and utility industries to determine whether technology readiness has been achieved, vehicles and hydrogen infrastructure components are validated under real-world operating conditions against their technical targets. The Technology Validation subprogram has supported the program's mission by providing critical data to predict whether FCEVs can meet the 2020 targets of 60 percent peak efficiency, 5,000-hour fuel cell durability, a range greater than 300 miles, 5-minute fill time, and hydrogen fuel costs of less than $4/gge. Specifically, the Technology Validation subprogram will validate the performance and vehicle interfaces of FCEVs to demonstrate an increase in durability from 2,521 hours in 2012 to 5,000 hours by 2020. Technology Validation also provides information in support of codes and standards development, as well as for the development of best practices regarding safety.

The Technology Validation ($7 million) subprogram will continue to fund cost-shared demonstrations of pre-commercial technologies in integrated systems and collect and analyze real-world operational data. In addition to equipment and operational costs, the Technology Validation subprogram projects may include activities such as siting, installation, commissioning and system design and integration to bridge gaps between the R&D program portfolio and real-world operations necessary for validation. The Technology Validation subprogram may also augment and leverage existing or externally funded deployments with data collection activities that provide the data for validation.

In FY 2016, the Technology Validation subprogram will assess current technology and provide feedback to hydrogen and fuel cell R&D activities to help achieve an FCEV life-cycle cost of $0.38 per mile by 2020. The Technology Validation subprogram activities include validating advanced fuel cell hybrid powertrains used in delivery trucks and other fleet vehicles, and advanced hydrogen production and delivery components such as cryogenic hydrogen pumps, hydrogen compressors, bulk transport and storage of hydrogen, and dispensing protocols and equipment. In FY 2016, hydrogen station performance will be validated against refueling protocols (e.g. SAE J2601) using a mobile hydrogen station testing device, and various hydrogen contaminant detectors will be installed at hydrogen stations to evaluate their performance, cost, and operation and maintenance needs. The Technology Validation subprogram will collect data from advanced light-duty FCEVs, hydrogen refueling stations, and other vehicles such as fuel cell–powered transit buses (in collaboration with the U.S. Department of Transportation (DOT)). These ongoing data collection efforts allow for tracking advancements in performance, reliability, and durability of technologies in real-world operational systems. Assessing durability is critical for evaluating the viability of technologies, but requires significant time, warranting an ongoing effort over the life cycle of a technology and as the technology advances. These efforts identify needs and provide direct feedback to R&D efforts.

Technology Validation projects include demonstrating and validating advanced stationary fuel cell systems that span a range of sizes and types and use various fuel sources, including waste gas from wastewater treatment facilities, landfills, or industrial processes; anaerobic digester gas from agricultural or other biological waste; or hydrogen produced from renewable sources. Data will also be collected from fuel cell systems that can, for example, co-produce hydrogen, electricity, and heat; these tri-generation systems offer the ability to upgrade low-grade, low-value fuels to high-grade, high-value energy products—electricity and hydrogen, in addition to heat usable in buildings or industrial processes. The world's first tri-generation system was demonstrated to have 54 percent combined efficiency for co-producing hydrogen and power.

The Technology Validation subprogram will increase its emphasis on Grid Modernization ($5.5 million); integrating electrolyzers and reversible fuel cells with the grid to test and validate dispatch capability and technical potential to provide high-value services such as demand response. Activities may include testing, demonstrating and validating the use of hydrogen for industrial-scale energy storage leveraging public-private partnerships, and national laboratory and university

capabilities for full-scale testing in various environments. The Technology Validation subprogram will coordinate these efforts through DOE's Grid Integration Initiative to avoid duplication (e.g. with Office of Electricity efforts).

In addition, funds may be used to support efforts such as peer reviews, data collection and dissemination, technical assistance, and technology-to-market activities.

**Technology Validation**
**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 Enacted |
|---|---|---|
| **Technology Validation $11,000,000** | **$7,000,000** | **-$4,000,000** |
| • Validate advanced stationary fuel cell systems, such as tri-generation systems capable of producing hydrogen, heat, and power to assess their economic and environmental benefits.<br>• Demonstrate a zero-emission medium-duty fuel cell hybrid electric truck with a projected driving range greater than 100 miles (meeting parcel delivery route requirements).<br>• Demonstrate an electrolyzer capable of producing hydrogen for a refueling station with an output pressure of greater than 50 bars to evaluate their reliability and station system efficiency improvements over 30 bar electrolyzer systems.<br>• Demonstrate the potential for doubling hydrogen capacity at refueling stations by certifying composite storage tanks to operate with deeper pressure cycles.<br>• Test and analyze fuel cells as industrial-scale energy storage devices using large-scale testing and demonstration capabilities to demonstrate how these distributed resources can enable a higher penetration of renewable power on the grid (National Laboratory, university, and regional stakeholder partnership).<br>• Support about four direct-funded National Laboratory projects and about two projects awarded from a solicitation. | • Demonstrate a medium-duty fuel cell hybrid electric parcel delivery truck with a projected driving range of 120 miles on a single hydrogen fill.<br>• Demonstrate a hydrogen delivery trailer capable of delivering hydrogen at >8500 psig to validate the effect of higher delivery pressure on the cost of dispensed hydrogen for fuel cell vehicles.<br>• Evaluate hydrogen station performance and safety characteristics against fueling protocols to demonstrate how the hydrogen station testing device can reduce the time to commission hydrogen stations.<br>• Evaluate performance, cost, operation and maintenance of hydrogen contamination detector technologies installed in hydrogen stations to mitigate potential damage to fuel cell systems in vehicles from fuel contamination.<br>• Benchmark meter accuracy for measuring the mass of hydrogen dispensed into vehicles to support regulatory bodies responsible for regulating the sale of hydrogen and inform R&D programs of technical status.<br>• Evaluate durability, range and fuel economy of light-duty vehicles in real operation against the R&D targets (5,000 hours, 300 miles, 60 miles per gge).<br>• Support at least three direct-funded National Laboratory projects and about five projects awarded from a solicitation. | • The testing and analysis of fuel cells as industrial-scale energy storage devices initiated/front funded in FY 2015 will have been fully funded. |

## Hydrogen and Fuel Cell Technologies
## Safety, Codes and Standards

**Description**

The Safety, Codes and Standards subprogram conducts R&D that provides critical data required for the development of technically sound codes and standards, which will be needed for the widespread commercialization and safe deployment of hydrogen and fuel cell technologies. The Safety, Codes and Standards subprogram also conducts extensive collaborative efforts among government, industry, standards development organizations, universities, and national laboratories in an effort to harmonize regulations, codes, and standards (RCSs) both domestically and internationally. The Safety, Codes and Standards subprogram also develops information resources and best practices for the safe use of hydrogen. The Safety, Codes and Standards subprogram utilizes extensive external stakeholder input from, for example, automobile manufacturers and the energy, insurance, and aerospace sectors, as well as the fire protection community and academia, to enhance and create safety knowledge tools for emergency responders and authorities having jurisdiction. Continual availability of safety knowledge tools, distributed via an array of media outlets to reach the largest number of safety personnel possible, is a Safety, Codes and Standards subprogram priority. The Safety, Codes and Standards subprogram also supports the development and implementation of best practices and procedures to ensure safety in the operation, handling, and use of hydrogen and fuel cell technologies in program-funded projects.

The Safety, Codes and Standards subprogram ($7 million) implements research to understand the impact of fuel quality and risk associated with infrastructure as well as continues to develop critical outreach tools to guide the deployment of hydrogen infrastructure. In FY 2016, metering technologies and fuel dispensing requirements will be investigated to allow accurate measurement of hydrogen and the impact of fuel contaminants on fuel cell system performance will be quantified to help achieve the FCEV life-cycle cost of $0.38 per mile by 2020. The Safety, Codes and Standards subprogram will collaborate with DOT, the Environmental Protection Agency (EPA), National Institute of Standards and Technology (NIST), and other government agencies, as well as the International Partnership for the Hydrogen and Fuel Cells in the Economy and the International Energy Agency to ensure that fuel, fuel storage, and dispensing standards development proceeds in agreement with existing regulatory authorities. The cooperating agencies will maximize available resources and expertise in areas such as hydrogen dispensing and measurement (NIST), vehicle safety (DOT National Highway Traffic Safety Administration), and the second phase of the Global Technical Regulation (DOT, EPA). In FY 2016, the Safety, Codes and Standards subprogram will continue research on mechanism-based models for hydrogen behavior in materials and optimize test methods to reduce the time required to qualify materials, components, and systems.

In the area of safety research, the Safety, Codes and Standards subprogram will continue analysis of creditable accident scenarios to identify potential system weaknesses, with complementary R&D efforts focusing on mitigating the identified weaknesses to improve overall system safety. FY 2016 funding will also support risk assessment activities, which will provide information to guide the codes and standards development process. The Safety, Codes and Standards subprogram will conduct liquid hydrogen experiments in order to develop a science-based approach to address risk and reduce the hydrogen station physical footprint to further facilitate the deployment of hydrogen infrastructure by allowing for more potential hydrogen refueling sites to be available. In addition, the Safety, Codes and Standards subprogram will develop an advanced hydrogen quantitative risk assessment tool to address hydrogen releases in restricted structures such as tunnels, parking garages (e.g. semi-enclosed), maintenance repair facilities, bridges and limited access highways.

In addition to R&D activities, the Safety, Codes and Standards subprogram will continue to promote and enhance safety information tools and monitor the safety of DOE hydrogen projects through the comprehensive website (H2tools.org) and the Hydrogen Safety Panel (HSP) respectively. The HSP will address safety for DOE-funded projects by conducting site visits, interviews, and safety plan reviews of hydrogen projects. To facilitate the approval and implementation of fuel cell projects using hydrogen, the Safety, Codes and Standards subprogram will also conduct training in strategic locations (e.g. Northeast Corridor) and deploy a common curriculum for firefighters and fire department training coordinators, law enforcement personnel, and emergency medical technicians, as well as code officials, fire marshals, city planners, state government representatives, and other fuel cell users. Building on prior-year efforts and to leverage state and local activities, the Safety, Codes and Standards subprogram will also expand the implementation and deployment of an introductory course designed specifically for code officials in key areas where hydrogen and fuel cell technologies are being deployed.

In addition, funds may be used to support efforts such as peer reviews, data collection and dissemination, technical assistance, and technology-to-market activities.

**Safety, Codes and Standards**
**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 Enacted |
|---|---|---|
| **Safety, Codes and Standards $7,000,000** | **$7,000,000** | **$0** |
| • Continue efforts in fuel quality and metering to quantify the impact of fast fueling (SAE standard J2601) that provides a consumer experience similar to gasoline refueling.<br>• Publish consistent hydrogen fuel quality testing protocols (e.g., PEM stacks) to allow for comparable results between testing laboratories.<br>• Complete hydrogen fueling station template including the codes necessary for widespread commercialization of infrastructure.<br>• Implement a standardized training mechanism and information related to the model codes and train at least 250 first responders and code officials.<br>• Develop a predictive engineering model for hydrogen dispersion and ignition that will support code refinement.<br>• Support approximately six National Laboratory core and enabling capabilities to achieve these outcomes. | • Decrease the hydrogen refueling station physical footprint for gaseous or liquid hydrogen delivery using a performance-based risk mitigation approach.<br>• Develop the initial liquid hydrogen release models to inform the risk assessment for separation distances that will be used for revising the current codes.<br>• Implement quantitative risk assessment model to address restricted structures such as tunnels, parking garages (e.g.-semi-enclosed), maintenance repair facilities, bridges and limited access highways.<br>• Train at least 150 first responders and code officials regarding hydrogen and fuel technologies in the Northeast U.S. corridor.<br>• Support coordination of state rollouts and public-private partnerships (e.g. H2USA) to leverage deployment of hydrogen infrastructure.<br>Continue to support approximately six National Laboratory core and enabling capabilities to achieve these outcomes. | • Increase focus on activities to streamline permitting of hydrogen fueling stations as fuel cell electric vehicles enter the market. These activities include performance-based risk mitigation and quantitative risk assessment modeling. Emphasis on quantifying the impact of fast fueling is expected to decrease. |

## Hydrogen and Fuel Cell Technologies
## Market Transformation

**Description**

The Market Transformation subprogram activities make up a key final phase in the program's comprehensive strategic timeline for moving technologies from the laboratory to the commercial marketplace. This market-acceleration strategy uses commercial ready technology to deploy and evaluate various fuel cell applications. The primary goal of the Market Transformation subprogram is to increase penetration of hydrogen and fuel cell technologies in key early markets by developing business cases in emerging commercial applications. The subprogram's approach is aligned with national laboratory and market research studies that outline necessary deployment measures to reach the program's goals.

The Market Transformation subprogram activities will also stimulate further market activity by supporting the growth of the domestic fuel cell manufacturing industry, overcoming deployment challenges associated with adoption of new technologies, and establishing key elements of the refueling infrastructure that will be essential for market growth. For example, the subprogram successfully stimulated early markets for fuel cells and catalyzed industry investment with cost-shared deployments of approximately 1,600 fuel cell powered lift trucks and backup power systems that led to over 11,000 additional orders by industry with no additional DOE investment. In addition to their direct positive impact on the market, these deployments will also provide valuable data on the performance of the technologies and lessons learned from early adopters, which will help the private sector build business cases and encourage further adoption for various applications including road vehicles.

The subprogram actively collaborates with other Federal agencies to facilitate the deployment of hydrogen and fuel cells in key early markets, including specialty vehicles, backup/remote power, auxiliary power, primary power for critical applications, fleet road vehicles and renewable hydrogen production (including the use of hydrogen for energy storage). The subprogram also coordinates with regional, state, and local initiatives involving hydrogen and fuel cells. The Market Transformation subprogram strives to achieve sufficient business activity to result in a self-sustaining market for the technologies.

The Market Transformation ($3 million) subprogram will continue to fund cost-shared deployment activities and provide technical support to deployment efforts, which will help address deployment costs and market barriers that industry does not currently address. The program will build on the successful deployments of backup power fuel cell systems and fuel cell powered lift trucks and catalyze markets for emerging applications that it has identified as strategically valuable and commercially viable. In FY 2016, the program will complete assessment of early market fuel cell systems and provide feedback to R&D areas to help achieve the hydrogen and fuel cell portion of the levelized cost per mile of $0.13 per mile in 2020. Focus areas include:

- Specialty vehicles such as airport ground support trucks;
- Hybrid power for electric fleets; and
- Related models, tools, and templates for accelerating the hydrogen and fuel cell user base and expanding commercialization.

In FY 2016, the Market Transformation subprogram will conduct and coordinate the development of inter-governmental deployment tools that support cost-effective siting of fuel cells for fleet vehicles such as all-electric range extenders, APUs, and other emerging applications. It will also support activities to reduce costs associated with the installation process, and it will coordinate the development of strategies for projects using hydrogen for utility-scale renewable energy storage.

In addition, funds may be used to support efforts such as peer reviews, data collection and dissemination, technical assistance, and technology-to-market activities.

**Market Transformation**
**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes<br>FY 2016 vs FY 2015 Enacted |
|---|---|---|
| **Market Transformation $3,000,000** | **$3,000,000** | **$0** |
| • Complete assessment of early market fuel cell systems and provide feedback to R&D areas to help achieve the hydrogen and fuel cell portion of the FCEV levelized cost per mile of $0.13 per mile by 2020 focusing on specialty vehicles and hybrid power.<br>• In collaboration with FAA, FTA, GSA, DOD and other Federal agencies, deploy fuel cell powered GSEs at 1 major airport and hybrid trucks/buses at 1 Federal site.<br>• Develop an on-line planning tool that calculates installed cost and air emission reductions (i.e., criteria pollutants and GHGs) to accelerate demonstrations and deployments by reaching 400 CHP projects.<br>• Support strategic deployments of early market fuel cells to spur commercial adoption and seek to enable a five-fold increase in the number of installed fuel cells relative to the FY 2012 baseline achieving further cost reductions across the industry through economies of scale, improvements in the supply chain, and increased investment in manufacturing.<br>• Support two awards for hybrid trucks for parcel deliveries, a ground support equipment fleet deployment project at an international airport, and at least three direct-funded National Laboratory projects to achieve the outcomes. | • In collaboration with the U.S. Maritime Administration, complete the development and deployment of a maritime fuel cell power generator including energy savings and business value proposition evaluations. In collaboration with other federal agencies, such as DOD and U.S. Postal Service, state and local governments, co-fund and provide technical support for strategic deployments of fuel cell fleet vehicles by siting at Federal properties and expanding existing early market fleet refueling equipment.<br>• Complete the development and deployment of refrigerated truck auxiliary power technology and document the petroleum savings and business value propositions.<br>• In collaboration with General Services Administration and other Federal agencies conduct a pilot program for demonstrating the use of fuel cell vehicles in Federal fleets.<br>• Initiate operations of a 100 kW maritime power system; select and award projects to deploy a fleet of Class 1/2/3 hybrid vans for passenger or cargo transportation; and fund at least three direct-funded National Laboratory projects to achieve the outcomes. | • Increase focus on strategic deployment of fuel cell electric vehicle fleets, early market applications, and the required refueling equipment and decrease focus on airport ground support equipment and hybrid parcel delivery vans. |

## Hydrogen and Fuel Cell Technologies
## NREL Site-Wide Facility Support

**Description**

In FY 2016, EERE Programs will continue to directly fund NREL site-wide facility costs that are not included in the Facilities and Infrastructure budget rather than fund those costs as laboratory overhead. This approach is consistent with Generally Accepted Accounting Practices and DOE management at other national laboratories. EERE began this practice in FY 2014 to effectively control NREL's labor rate multiplier. One outcome has been reducing the cost of accessing unique NREL capabilities (such as facilities and staff expertise) by industry and academia. This practice also makes site operating costs more transparent in order to facilitate cost control and planning. In FY 2014, this practice resulted in a reduction in the lab-wide direct labor multiplier of approximately 15 percent compared to FY 2013. The proposed FY 2016 Budget Request continues the approach applied in 2014 and 2015.

This NREL Site-Wide Facility Support subprogram funding supports research programs by providing basic site services, functions, and infrastructure for site operations, which includes: management, building operations, building and grounds maintenance, fire and emergency response, engineering and construction support, minor construction projects, electrical safety program, utilities, and facilities planning support; and activities within the Sustainability and Environmental Health and Safety (EHS) portfolios. These activities and their costs are relatively fixed and only vary significantly based upon variations in commodities, construction activity, emergencies, weather patterns, etc. They are considered the core functions for site operations, safety, environmental compliance, and sustainability at NREL. In FY 2016, this funding will continue to support more than 60 full time equivalents that manage and provide support for these core functions. It will also fund site-wide subcontracts such as janitorial services, refuse and recycling, and subcontracts for minor construction. Additionally, this funding will support site-wide costs associated with maintaining NREL's leadership position, such as: maintaining International Organization for Standardization (ISO), American Association for Laboratory Accreditation (A2LA), and other lab-wide accreditations, managing facilities to enable mission goals, improving sustainability, pollution prevention, waste minimization, improving energy efficiency, reducing water use, and maintaining an effective emergency management system.

The FY 2016 Budget Request remains consistent with the method EERE developed in FY 2015. This approach is a more precise, equitable, and economically neutral method that ensures a predictable net-zero impact on programs' funding. For each program, the contribution to direct funding for site-wide facility support is equivalent to the estimated contribution the program otherwise would have made through overhead charges. This method is based upon each program's level of funding to NREL, adjusted to account for anomalies from large capital expenditures and major subcontracts.

**NREL Site-Wide Facility Support**
**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 Enacted |
|---|---|---|
| **NREL Site-Wide Facility Support $1,800,000** | **$1,800,000** | **$0** |
| • Directly fund NREL site-wide facility support costs that are not included in the Facilities and Infrastructure budget rather than continue to fund these costs in the laboratory overhead rate. | Directly fund NREL site-wide facility support costs that are not included in the Facilities and Infrastructure budget rather than continue to fund these costs in the laboratory overhead rate. | • No change. |

**Hydrogen and Fuel Cell Technologies**
**Performance Measures**

In accordance with the GPRA Modernization Act of 2010, the Department sets targets for, and tracks progress toward, achieving performance goals for each program.

| | FY 2014 | FY 2015 | FY 2016 |
|---|---|---|---|
| Performance Goal (Measure) | **Fuel Cell Power - Improve the catalyst specific power of fuel cells (kW per gram of platinum group metal)** | | |
| Target | 6.3 | 6.5 | 6.9 |
| Result | Met – 6.3 | Not Applicable | Not Applicable |
| Endpoint Target | 8 kW/g by 2020; The catalyst specific power target contributes to the $40/kW fuel cell system cost target in 2020 and ultimate $30/kW fuel cell system cost target. | | |

## Solar Energy

### Overview

The DOE SunShot Initiative is a collaborative national effort to make the U.S. a leader in the global clean energy race by accelerating solar energy technology development. The DOE SunShot Initiative will enable widespread, large-scale adoption of solar power technologies across America by making solar energy systems cost-competitive with other forms of energy by the end of the decade. Fundamentally, the DOE SunShot Initiative embraces two complementary approaches, namely converting solar photons to electricity through direct conversion in a semiconductor and through conversion of intermediate solar thermal energy to electricity. These approaches and objectives will help re-establish American technological and market leadership in solar energy, diversify the Nation's electricity supply, reduce environmental impacts of electricity generation, strengthen U.S. manufacturing competitiveness, and catalyze domestic economic growth.

EERE's Solar Energy Technologies Program (SETP) supports the DOE SunShot Initiative's mission to make solar energy technologies, including both solar photovoltaic (PV) and concentrating solar power (CSP) technologies, cost-competitive with traditional sources of electricity, without subsidies, by 2020. This will require cost reductions of 75 percent relative to 2010 baseline levels. Reducing the total installed cost for utility-scale solar electricity to roughly $0.06/kWh (corresponding to approximately $1.00/$W_{DC}$ for system prices) without subsidies will help enable rapid large-scale adoption of solar electricity across the U.S. SETP has similar aggressive targets for residential and commercial market segments as well. By the end of 2014, reductions of 56 percent, 52 percent, and 54 percent were achieved for U.S. PV system costs at the utility, commercial, and residential scales respectively. These cost reductions reflect an overall progress of about 70 percent of the way towards the 2020 goals. These achievements have SETP on target to achieve the 75 percent cost-reduction goal by 2020. FY 2016 represents the halfway mark in the decade-long DOE SunShot Initiative, which was launched in 2011.

Deployment of PV across the U.S. has been growing at a rapid rate. With a record 7 GW deployed in 2014, which is more than a 16 fold increase from the 2009 level of 0.44GW[1]. From 2009 to 2014 the compound annual growth rate is 31 percent and there is now more than 20 GW of solar power installed across the U.S. This represents close to 2 percent of the nation's electricity generating capacity and has resulted in significant job growth. By the end of 2014, there were approximately 174,000 people in the U.S. employed in the solar sector according to the National Solar Jobs Census, representing a 21.8 percent job growth rate over the prior year[2]. The rapid market and job growth has been made possible by rapid declines in systems costs. Nevertheless, significant work remains before solar achieves unsubsidized cost-competitiveness with conventional energy resources and realizes its full potential throughout the country. Solar hardware costs have fallen significantly, however, these costs have not reached the 2020 SunShot goals. Market barriers and grid integration challenges also continue to hinder greater deployment. Non-hardware solar "soft costs"—such as permitting, financing, and customer acquisition—are becoming an increasingly large fraction of the total cost of solar and now, for example, constitute up to 64 percent of the cost of a residential system.[3] With this in mind, SETP is increasing its emphasis on reducing balance of systems (BOS) soft costs. This includes helping to streamline processes of permitting, inspection, and interconnection, as well as performing key analyses of policy options and their potential impact on the deployment of solar technologies.

Through the DOE SunShot Initiative, SETP closely coordinates activities with the Office of Science and ARPA-E to prevent duplication of efforts while maximizing the department-wide impact on solar energy.

### Highlights of the FY 2016 Budget Request

The Solar Energy Technologies Program will launch significant efforts in the following major areas in FY 2016:

- With solar already close to 2 percent of the Nation's electricity generating capacity—and with a clear pathway toward 10 percent—the challenges of even higher levels of grid integration need to be researched today for cost effective

[1] "U.S. Solar Market Insight Report: 2013 Year in Review," GTM Research and SEIA, March 2013. This study includes solar energy firms working in installation, manufacturing, sales and distribution, project development, R&D, etc.
[2] "National Solar Jobs Census 2014,"The Solar Foundation, Jan. 2015.
[3] " "Benchmarking Non-Hardware Balance-of-System (Soft) Costs for U.S. Photovoltaic Systems, Using a Bottom-up Approach and Installer Survey – Second Edition," Friedman et al., NREL December 2013.

solutions to be available in the years ahead. SETP supports development of cutting edge approaches to reduce the cost and improve the reliability and functionality of power electronics associated with solar energy systems as part of the broader DOE Grid Modernization effort. The program will support industry through development of test and evaluation standards and by developing technologies and tools for meeting grid requirements. SETP works to develop advanced technologies as well as engage with utilities to develop operational methodologies that could enable greater levels of solar grid integration.

- Non-hardware "soft costs" remain one of the largest challenges to achieving the 2020 DOE SunShot Initiative targets. Following prior successful efforts in reducing residential soft costs, SETP's new efforts focusing on commercial-scale solar will reduce barriers for businesses to choose solar energy. Emphasizing installation quality and advanced workforce training standards will ensure that industry has the skills needed to make solar a reliable and low-maintenance energy source for consumers and businesses alike.
- Leveraging promising component level research in CSP supported in recent fiscal years that developed sub-systems, a CSP Systems Integration funding opportunity announcement (FOA) in FY 2016 will begin to merge best-in-class sub-system technologies to develop systems that demonstrate the path to achieving the 2020 DOE SunShot Initiative goal. Examples include the integration of low cost heliostat fields and construction technologies with high temperature receivers. This work will help usher in a new class of CSP power plants with even higher performance than the more than 1GW of CSP plants that came online in FY 2014.
- Next Generation PV Research & Development (R&D) III and Foundational Program to Advance Cell Efficiency are also both FY 2016 FOA topics in the request. These topics will continue to support U.S. leadership in PV innovation that has led to more than 50 percent of the world records in solar power conversion efficiency over the past 35 years. In FY 2013 and FY 2014, SETP supported projects at DOE's National Laboratories established seven new world records, a rate 3.5 times higher than the average for the prior decade. There remains tremendous opportunity for further improvements in cell efficiency.
- Solar Manufacturing Technologies IV, the 4$^{th}$ round of a successful manufacturing R&D FOA will continue to support innovative manufacturing technologies and advanced materials that could give U.S. manufacturing companies a competitive edge over subsidized foreign competitors. Continued DOE support will focus on technological advances and innovative solutions to increase module and process efficiencies, and further drive down costs towards the DOE SunShot Initiative 2020 targets. By eliminating the perceived cost advantage of overseas manufacturing (low cost labor, low cost capital) with automation and high throughput low capex production techniques, U.S. companies can produce products in the U.S. competitively. In 2014, several U.S. companies with underlying technologies originally developed with DOE support have announced new factories in the U.S. creating new jobs in their communities.

As part of the greater DOE Grid Modernization crosscut, SETP will focus on developing controls and associated system architectures needed to manage a diverse set of resources and grid assets, including photovoltaic systems, across the distribution system; investigating how energy storage can help mitigate the variability of the solar resource and enable energy from the system to be more easily dispatched over the course of a given day; investigating tools and algorithms to develop stochastic representations of solar power output; and determining the lowest cost flexible options to increase the hosting capacity of the system. SETP will also partner with a national laboratory consortium to design, simulate and demonstrate a transactional energy ecosystem as the basis for accomplishing grid integration goals and realizing the full potential of energy and grid related opportunities.

**FY 2016 Crosscuts ($K)**

| | Grid Modernization | Total |
|---|---|---|
| **Solar Energy** | **60,000** | **60,000** |

**Solar Energy**
**Funding ($K)**

| | FY 2014 Enacted[1] | FY 2014 Current[2] | FY 2015 Enacted | FY 2016 Request | FY 2016 vs FY 2015 |
|---|---|---|---|---|---|
| **Solar Energy** | | | | | |
| Concentrating Solar Power | 48,571 | 47,004 | 46,400 | 48,400 | +2,000 |
| Photovoltaic R&D | 56,641 | 55,999 | 35,300 | 62,000 | +26,700 |
| Systems Integration | 52,816 | 52,487 | 43,700 | 76,500 | +32,800 |
| Balance of Systems Soft Cost Reduction | 42,558 | 42,343 | 40,700 | 67,300 | +26,600 |
| Innovations in Manufacturing Competitiveness | 44,472 | 44,472 | 57,800 | 73,400 | +15,600 |
| NREL Site-Wide Facility Support | 12,000 | 12,000 | 9,100 | 9,100 | 0 |
| **Total, Solar Energy** | **257,058** | **254,305** | **233,000** | **336,700** | **+103,700** |

SBIR/STTR:

- FY 2014 Transferred: SBIR $2,498,400; STTR $255,000
- FY 2015 Enacted: SBIR: $1,933,000; STTR $267,000
- FY 2016 Request: SBIR: $1,767,000; STTR $265,000

[1] FY 2014 Enacted funding reflected the contractor foreign travel rescission of $153,433.
[2] The funding reflected the transfer of SBIR/STTR to the Office of Science.

**Solar Energy**
**Explanation of Major Changes ($K)**

| | FY 2016 vs FY 2015 |
|---|---|
| **Concentrating Solar Power:** The increase in FY 2016 funding will support the additional due diligence (e.g. independent engineering) above and beyond standard SETP procurement processes required for the proper selection of projects of the scale of a 1-10MW CSP system integration. | **+2,000** |
| **Photovoltaic R&D:** The increase in funding from FY 2015 to FY 2016 is due to the coincidence of two cyclical funding programs that focus on long range research (Next Generation PV Technologies IV) as well as mid-range translational research (Foundational Program to Advance Cell Efficiency III). The FY 2015 request was lower than historical averages because only 1 funding program was scheduled to be released. The increase also reflects the shift of PV module reliability research at the National Laboratories and the Regional Test Centers from the Systems Integration subprogram to the PV subprogram. | **+26,700** |
| **Systems Integration:** The increased funding reflects the importance of addressing systems integration challenges, as the nation moves towards higher levels of renewables on the grid. The additional funds will support two FOAs (Solar HiPEN and Solar Dispatchability) for developing the transformative solutions that are critical to enabling high penetration of solar into the grid. A number of projects from FOAs issued in FY 2010-FY 2012 will be completed by the end of FY 2015. The two FOAs will fund research, development, and demonstration to bridge the gaps between the outcomes of the completed projects and the SunShot Systems Integration targets. A portion of the increase is to fund the DOE-wide grid integration cross cut. | **+32,800** |
| **Balance of Systems Soft Cost Reduction:** The funding increase supports new work focused on reducing barriers for businesses to choose solar. Leveraging the successful work with state/local governments to streamline processes for homeowners, many similar challenges in soft costs exist for the commercial sector. Relative to FY 2015, additional funding will support new activities to address potential soft cost reduction for the utility and commercial scale markets, which make up over 2/3 of U.S. installations. The increase also supports significant development of new resources through national labs, SEEDS and SolarOPs II to expand access to solar to low-income, rural, and commercial market segments. The increase will also strengthen work to reduce soft costs through the development of big data and information assets as well as installation quality and standards. | **+26,600** |
| **Innovations in Manufacturing Competitiveness:** In addition to a $10 million increase for a new Materials Genome FOA, the increase relative to FY 2015 supports a higher number of awards for the SUNPATH and SolarMaT FOAs due to the increased activity up and down solar value chain, as well as the growing market and growing number of US manufacturers. | **+15,600** |
| **Total, Solar Energy** | **+103,700** |

## Solar Energy
## Concentrating Solar Power

**Description**

The Concentrating Solar Power (CSP) subprogram supports research and development of CSP technologies as a unique path to achieve the DOE SunShot Initiative cost targets with systems that can supply solar power on demand with thermal storage.

The near-term goal of the CSP subprogram is to reduce the levelized cost of CSP energy at utility scale to $0.125/kWh without subsidies by the end of FY 2015 from a baseline of $0.185/kWh in FY 2012 and $0.21/kWh in FY 2010. The final goal is $0.06/kWh by 2020, which is cost competitive with traditional electricity sources.[1] Advances in the technology, especially for CSP power towers, significantly reduced the benchmark LCOE from $0.185/kWh to $0.135/kWh between 2012 and 2013. The CSP subprogram seeks to accomplish these technical objectives through competitively funded research programs at industry, National Laboratories, and academia. In FY 2016, the CSP subprogram will support four focus areas to support the achievement of the SunShot Initiative goals. These four focus areas (Solar Collection ($15 million); Receivers and Heat Transfer Fluids ($10 million); Power Conversion and Systems ($10 million); and Thermal Energy Storage ($13.4 million)) are described below.

Focused research in Solar Collection will reduce the cost of the solar field, which comprises up to 40 percent of the total system costs for CSP technologies. The CSP subprogram aims to dramatically reduce the cost of the solar field while improving optical accuracy and ensuring durability. In order to accomplish these goals, SETP supports R&D efforts to develop high optical accuracy reflectors, reduce collector structure weight and material, develop lean and rapid methods for manufacturing, assembly and installation, develop highly efficient tracking and control methods as well as accurate metrology tools, and reduce collector soiling and the water required for operations and maintenance.

Focused research on Receivers and Heat Transfer Fluids (HTFs) will significantly increase the operating temperatures, efficiency, and lifetime of solar receivers while lowering costs. SETP will fund R&D on receiver systems, HTFs, and related aspects within the industry, national laboratories, and universities. This funding will support the development of new receiver designs, novel solar selective coatings and the exploration of high temperature receiver corrosion and HTF stability. Additionally, this funding will help engineer HTFs for high temperature stability and improved thermophysical properties.

Focused research on Power Conversion and Systems will improve efficiency in CSP power generation. Power plant components and systems for CSP benefit from mature and well-understood technologies found elsewhere in the power generation industry. For example, the most common cycles employed by conventional CSP plants include subcritical Rankine and Stirling cycles. Gross thermal-to-electric conversion efficiencies are typically 35 percent–45 percent, and working fluids include steam, hydrogen, and helium. Research into supercritical carbon dioxide cycles is also ongoing due to their promise to deliver higher conversion efficiencies (>50 percent) and is coordinated with the Offices of Nuclear Energy and Fossil Energy through the STEP Initiative. Additionally, because CSP facilities are typically located in desert areas where water is scarce, high efficiency cycles utilizing dry cooling are needed. These may include systems that use topping and bottoming cycles, hybridization with fossil fuels, or other hybrid options.

Focused research in Thermal Energy Storage (TES) will develop storage solutions to compensate for the variable nature of solar power generation. A feature of CSP that distinguishes it from other renewable technologies is its ability to include TES at the point of power generation to mitigate the variability of solar availability. The CSP subprogram funds R&D on sensible,

[1] Key additional details of this target include:
- Cost target is unsubsidized;
- Due to costs varying across geographic regions, the target is averaged across the U.S.;
- Includes the value of storing energy into the evening hours as CSP thermal storage technologies improve;
- Long-term goal: $3.50/W including 16 hours storage (equivalent to $0.06/kWh) – thermal storage allows a much higher capacity factor, enabling $0.06/kWh to be met with $3.50/W installed capacity; and,
- NREL runs this LCOE analysis annually based on best known industry data.

latent, and thermochemical energy storage and related aspects within the industry, National Laboratories and universities. This funding is intended to develop novel thermal energy storage methods and materials to meet technical and cost targets.

The CSP subprogram engages the DOE National Laboratories in advanced R&D focused on the technical targets and goals of the DOE SunShot Initiative. Funding awards are made based on competitive solicitations and peer-reviews of research proposals. Projects are selected for nominally 3 year funding, and awarded in annual increments. The request for FY 2016 funding is to continue the efforts at the national labs in the areas of solar field cost reduction, high temperature receiver development, advanced research and development of TES, advanced power cycles, and systems integration that are in line with the major CSP focus areas detailed above. The funding will also support the core capabilities at NREL on System Advisor Modeling and the National Solar Thermal Test Facility (NSTTF) at Sandia National Laboratory. To ensure that both government and private sector sponsored research costs adequately reflect facility usage, the funding supports 50 percent of the direct operations and maintenance (O&M) costs of the NSTTF with the balance loaded on the research that is performed at the facility. This is a shift away from directly funding the full costs of the facility O&M and has been the standard SETP practice since FY 2012.

Leveraging promising component-level research in CSP that developed sub-systems in prior fiscal years, CSP Systems Integration in FY 2016 begins to integrate best-in-class sub-system technologies to demonstrate technologies at the 1-10MW scale, which is important to achieving the 2020 DOE SunShot Initiative goal. The effort will refine and optimize subcomponent technologies that are currently under development in the major CSP Focus Areas toward an integrated solution. Moreover, significant systems integration challenges exist in combining the subcomponent technologies of the solar field, thermal receivers, TES and power block. The subprogram will address these challenges systematically to deliver system solutions that seek to demonstrate the techno-economic metrics of the DOE SunShot Initiative goal.

The DOE SunShot Initiative postdoctoral research fellowship program funds ($0.67 million) emerging research leaders who will pursue breakthrough solar energy technologies. These 2-year awards provide doctoral degree recipients the opportunity to conduct applied research or analysis at universities, National Laboratories, and other research facilities as well as at DOE.

In addition, funds may be used to support efforts such as peer reviews, data collection and dissemination, technology assistance, and technology-to-market activities. The remainder of the funds will buy down out-year mortgages.

**Concentrating Solar Power**
**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **Concentrating Solar Power $46,400,000** | **$48,400,000** | **+$2,000,000** |
| • Leverage promising early research supported by the DOE in FY 2013 and FY 2014 to develop advanced supercritical CO2 Brayton cycle power systems offering higher efficiency and lower cooling water needs compared with conventional steam-Rankine cycles.<br>• Issue a solicitation and competitively select 7 to 10 projects focused on novel collection strategies for CSP applications with the potential to reduce CSP LCOE by 20%. | • Continue the efforts at the national labs in the areas of solar field cost reduction, high temperature receiver development, advanced research and development of thermal energy storage, advanced power cycles, and systems integration. The funding will also support the core capabilities at NREL on System Advisor Modeling and the (NSTTF) at Sandia National Laboratory.<br>• Issue a solicitation and competitively select 2 to 4 projects focused on integrating best-in-class sub-system technologies at the 1-10MW scale with the greatest potential toward achieving the 2020 DOE SunShot Initiative goal. The effort will refine and optimize subcomponent technologies toward an integrated solution.<br>• Award 1 to 3 emerging research leaders who will pursue breakthrough CSP technologies with 2-year awards to conduct applied research at universities, national laboratories, and other research facilities. | • The increase in the FY 2016 funding request will support the additional due diligence (e.g. independent engineering) above and beyond standard SETP procurement processes required for the proper selection of projects of the scale of a 1-10MW CSP system integration. |

## Solar Energy
## Photovoltaic R&D

**Description**

The Photovoltaic R&D (PV R&D) subprogram aggressively supports development of low-cost, high-efficiency photovoltaic (PV) technologies through the DOE SunShot Initiative, which seeks to make solar electricity cost-competitive with other sources of energy by 2020.

The near-term goal of the PV R&D subprogram is to reduce the levelized cost of solar PV energy at utility scale (cents/kWh) to $0.11/kWh without subsidies by the end of FY 2015. The ultimate goal is $0.06 /kWh by 2020, which is cost competitive with traditional electricity sources.[1] Achieving these goals will require significant technological innovations and reductions in cost in all PV system components. These components are broadly defined as modules, power electronics, and balance of systems (BOS), which includes all other components and costs required for a fully installed system, including permitting and inspection costs. For the PV utility scale system, a breakdown of the targeted $1/Wdc installed cost includes $0.50/Wdc for the module, $0.10/Wdc for the power electronics, and $0.40/Wdc for the BOS elements. By the end of 2013, reported prices in 2013 dollars were as follows: module price of $0.63/Wdc, average utility-scale inverter price of $0.18/Wdc, and BOS price for utility scale systems of $1.11/Wdc. With significant progress made to date on module costs, further efforts in module-related cost reduction will focus on module reliability and efficiency improvements that reduce the BOS-Soft Costs.

The PV R&D subprogram advances the state-of-the-art in PV, by taking a technology-agnostic approach to funding R&D across the technology type and readiness spectrum with industry, academic and national laboratory partners through a competitive process. Specifically, the subprogram seeds research to advance materials, processes, and device approaches that enable higher PV performance, greater reliability, and reduced cost as manufacturing and deployment scale. The subprogram also funds translational research and development to bridge gaps between applied research accomplishments and device and materials development and manufacturing environment needs. The PV R&D portfolio spans work from early stage solar cell research to the point where companies might begin to commercialize the technologies and techniques. For example, projects include a combinatorial approach to find new earth abundant absorber materials, new silicon solar cell structures using organic and metal oxide heterojunctions, high efficiency III-V on silicon multi-junction solar cells, the development of a two photon photoluminescence technique to separate bulk and surface lifetimes in thin films, and model systems for Cadmium-Telluride and Copper-Zinc-Tin -Sulfide solar cells to probe fundamental efficiency limits. As the goals of the DOE SunShot Initiative come within reach, the PV R&D subprogram is shifting focus towards the remaining critical challenges including module cost, reliability, and life cycle and supply chain sustainability. In FY 2016, the PV R&D subprogram will support two primary focus areas -- PV Module Performance ($34 million), and Long Term Cost Reduction ($28 million) -- to support the achievement of the SunShot Initiative goals.

Focused research in PV Module Performance encompassing both efficiency and reliability, forms the foundation for the global solar industry. Innovations such as those supported by SETP over the past 30 years have enabled a dramatic decline in PV module prices of more than 95 percent. Furthermore, SETP investments funded over half of the world record solar cell efficiencies achieved in the past three decades. Increasing the reliability and durability of modules is an area of increasing emphasis that can provide US manufacturers a competitive edge in the global market. In addition to supporting R&D to significantly advance the performance of existing photovoltaic technologies, such as crystalline silicon, thin-film, and multi-junction (III-V) PV, the DOE SunShot Initiative supports focused research in Long Term Cost Reduction, including emerging PV concepts that are still in the proof-of-concept phase. These laboratory bench scale projects have the potential to revolutionize the photovoltaic industry. This area includes advanced module concepts as well as module packaging materials, which provide opportunities for further cost reduction and expanded markets.

[1] Key additional details of this target include:

- Cost target is unsubsidized system and installation cost;
- Due to costs varying across geographic areas, this target is averaged across the U.S.;
- 2011 baseline: $0.15/kWh unsubsidized system and installation LCOE;
- Module cost goal is $0.50 per watt by 2020; and
- Power electronics and balance of system cost goals to be pursued by other subprograms

In FY 2016, the PV R&D subprogram will support ongoing R&D (postdoctoral research and National Center for Photovoltaics (NCPV) R&D at National Renewable Energy Laboratory (NREL)) as well as two solicitations based on prior successful programs. The PV R&D subprogram supports ongoing merit-reviewed research activities at the National Laboratories, primarily at the NCPV at the NREL. NCPV work covers foundational research on applied problems (such as model systems for known materials), materials and device optimization, advancing existing and emerging photovoltaic technologies, and developing new measurement and characterization techniques. NCPV also works in collaboration with industry through unique capabilities, such as specialized equipment that simultaneously allows the creation and analysis of PV devices. To coordinate better with the materials and device science, in FY 2016, the PV module reliability efforts at the national laboratories and the Regional Test and Evaluation Partnerships also known as Regional Test Centers (RTCs) moved from the Systems Integration subprogram to the PV R&D subprogram. This research includes understanding degradation mechanisms at the fundamental level in order to develop approaches to extend and improve the reliability of products that reach the marketplace.

The FY 2016 Budget includes $4.2 million to fund RTCs located in Denver, Colorado; Albuquerque, New Mexico; Las Vegas, Nevada; Orlando, Florida; and Williston, Vermont. DOE provides photovoltaic (PV) and concentrating photovoltaic (CPV) validation testing and systems monitoring for businesses and other industry stakeholders. The primary mission of the RTCs is to develop standards and guidelines for validating the performance and operation of PV modules and systems. The RTCs also serve as test beds for large-scale systems and provide independent validation of PV performance and reliability. These centers were established on 05/14/2011 with an expected termination date of 09/30/2018. The RTCs to date have received $15.8 million with $4.2 million planned for FY 2015. In FY 2016, the RTCs begin a transition to a funding model requiring at least 50% cost share from industry users. The locations and purpose of each RTC are listed below.

Denver, Colorado RTC - Managed by the National Renewable Energy Laboratory (NREL) with locations at the Solar Technology Acceleration Center (SolarTAC) as well as the main NREL campus in Colorado, this RTC provides testing within a steppe climate. Albuquerque, New Mexico RTC - Managed by Sandia National Laboratory (SNL) with locations at the National Solar Test Facility (NSTTF) as well as the main Sandia National Laboratory (SNL) campus, this RTC provides testing within a hot-dry climate. Las Vegas, Nevada RTC - Managed by Sandia National Laboratories (SNL) via an agreement with the Las Vegas Valley Water District and the University of Nevada's Center for Energy Research, this RTC provides testing within a subtropical desert climate. Orlando, Florida RTC - Managed by Sandia National Laboratories (SNL) via a subcontract with the Florida Solar Energy Center (FSEC), this RTC provides testing within a hot-humid climate. Williston, Vermont RTC - Located on IBM property, this RTC focuses on performance data and supports collaborative research related to the integration of PV technologies into Vermont's statewide electrical grid.

In FY 2016, the subprogram will issue two solicitations based on prior successful programs: the Foundational Program to Advance Cell Efficiency (F-PACE III) and Next Generation PV R&D (Next Generation PV IV). F-PACE III will provide $15.3 million to fund projects focused on improving the power conversion efficiency of established PV technologies, including Silicon, Cadmium-Telluride, Copper-Indium-Gallium-Selenide and III-Vs, as well as addressing challenges to incorporating those gains in module manufacturing. This work enables progress towards the DOE SunShot Initiative targets. The Next Generation PV Technologies work in this subprogram is a core activity and the fourth solicitation will provide $15.3 million to fund projects with the potential to develop revolutionary and highly disruptive PV technologies. The expected outcomes are prototype PV cells, modules, and/or processes that directly influence the cost per watt paradigm. Examples of the types of devices are perovskites, multi-junction on silicon, as well as hybrid technologies. Development work on emerging PV technologies and module components is essential to ensuring continued innovation and supporting the development and expansion of advanced PV options that will enable PV systems that are even cheaper than $1/W in the long run.

The DOE SunShot Initiative postdoctoral research fellowship program funds ($0.67M) emerging research leaders in the field that will pursue breakthrough solar energy technologies. These 2-year awards provide doctoral degree recipients the opportunity to conduct applied research or analysis at universities, National Laboratories, and other research facilities as well as at DOE.

In addition, funds may be used to support efforts such as peer reviews, data collection and dissemination, technology assistance, and technology-to-market activities. The remainder of the funds will buy down out-year mortgages.

**Photovoltaic R&D**
**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **Photovoltaic R&D $35,300,000** | **$62,000,000** | **+$26,700,000** |
| • Issue one FOA to fund 4 to 10 projects improving PV reliability and durability and increasing the certainty in PV module performance prediction.<br>• Fund 15 ongoing merit-reviewed research projects at the National Center for Photovoltaics (NCPV), which complete in FY 2015. These projects cover foundational research on applied problems (such as model systems for known materials), advancing existing and emerging photovoltaic technologies, and developing new measurement and characterization techniques. NCPV also works in collaboration with industry through unique capabilities, such as specialized equipment that simultaneously allows the creation and analysis of PV devices.<br>• Fund 4 to 6 emerging research leaders through SunShot Postdoctoral Research Awards who will pursue breakthrough PV technologies and publish impactful peer-reviewed articles. | • Initiate 15 to 25 merit-reviewed research projects at the national laboratories, primarily at the National Center for Photovoltaics (NCPV). This work advances existing and emerging photovoltaic technologies, develops new measurement and characterization techniques, and develops novel module components and architectures. NREL also works in collaboration with industry through unique capabilities, such as specialized equipment that simultaneously allows the creation and analysis of PV devices. (PV module reliability efforts moved from the Systems Integration subprogram to the PV R&D subprogram).<br>• Issue Next Generation PV IV solicitation and competitively select 10 to 12 projects focused on investigating new concepts for PV cells and modules that have the potential to disrupt the PV market beyond the DOE SunShot Initiative goals.<br>• Issue Foundational Program to Advance Cell Efficiency III solicitation and competitively select 4 to 7 projects focused on increasing efficiency and overcoming technological challenges with established PV technologies.<br>• Fund 4 to 6 emerging research leaders through SunShot Postdoctoral Research Awards who will pursue breakthrough PV technologies and publish impactful peer-reviewed articles. | • The increase in funding request from FY 2015 to FY 2016 is due to the coincidence of two cyclical funding programs that focus on long range research (Next Generation PV Technologies IV) as well as mid-range translational research (Foundational Program to Advance Cell Efficiency III). The FY 2015 request was lower than historical averages because only one funding program was scheduled to be released. The increase also reflects the shift of PV module reliability research at the National Laboratories and the Regional Test Centers from the Systems Integration subprogram to the PV subprogram. |

## Solar Energy
## Systems Integration

**Description**

The Systems Integration (SI) subprogram supports the development of innovative, cost-effective solutions that allow increasing amounts of solar energy to integrate seamlessly into the electricity grid while mitigating associated risks. As the deployment of photovoltaic systems in electric distribution systems has aggressively accelerated over the past few years, utilities, regulatory agencies, and developers have been faced with a significant number of integration challenges. Utilities, for example, are concerned with variability, voltage regulation, unintentional islanding, protection coordination (planning for fault currents with distributed generation), and reverse power flows. The SI subprogram aims to address these technical integration challenges through a coordinated effort—across EERE and with the DOE Office of Electricity Delivery and Energy Reliability—that supports research, development, and demonstration of technologies focused mainly behind-the-meter. Such solutions can improve system reliability and encourage widespread deployment of solar technologies, including both PV and CSP. In FY 2016, the SI subprogram will support four focus areas to support the achievement of the SunShot Initiative. The four focus areas (Grid Performance and Reliability ($20 million); Dispatchability ($20 million); Power Electronics ($16.5 million); and Communications ($20 million)) are described below.

Focused research on Grid Performance and Reliability will achieve high penetrations of safe, reliable and cost-effective solar energy at the distribution level (<69 kV) and on the transmission grid. In order to accomplish these goals, the SI subprogram supports: developing state-of-the-art utility modeling, simulation, and analysis tools to address technical issues surrounding grid planning, operations, and reliability; developing advanced grid-friendly PV interconnection technologies; accelerating cost-effective deployment of PV generation on the distribution and transmission grid; developing validated inverter, solar system planning, operations and feeder models to enhance PV integration analysis techniques; demonstrating the feasibility of high-penetration PV scenarios under a wide range of system conditions through laboratory and field testing; advancing interconnection and performance standards and codes to enable high levels of PV integration for grid reliability; and engaging with industry and stakeholders to inform and receive feedback on PV integration.

Focused research on Dispatchability will ensure that solar power plants based on PV and CSP technologies at utility and distributed scales are capable of being dispatched in a fashion that is comparable to or better than conventional power plants. The SI subprogram addresses the issue of dispatchability with a two-pronged approach: 1) extensive analyses to understand the impact of high penetration of solar power plants on the bulk power system and distribution system operations, and 2) research to understand and enhance the dispatch capability of PV solar power plants and to investigate the value of varying energy storage capabilities for CSP plants. The SI subprogram also supports the development of standardized methods for testing grid performance of PV solar power plants, and exploring and demonstrating the value of energy storage.

Focused research in Power Electronics will develop intelligent devices that can maximize the power output from the PV arrays on the one side and serve as the interfaces to the electric grid (or end use circuits) on the other, while ensuring overall system safety, reliability, and controllability. A technical challenge for power electronics is the optimal tradeoff between these three design drivers of performance, reliability, and cost. In order to accomplish these goals, the SI subprogram supports cost reductions and efficiency improvements through: innovative circuit design, development of advanced components and optimal control; development of power electronics technologies to improve energy yield while reducing balance of system (BOS) hardware costs, process costs and installation time; development and field demonstration of smart inverter functionalities; and development of accelerated life testing methods and physics of failure models to predict faults and improve reliability.

Focused research in Communications technologies will effectively inform grid operations with high penetration levels of solar. In order to accomplish this, visibility is required across multiple spatial scales (from the end user load through the distribution substation and beyond) and at multiple time scales (from microseconds to hours and days). Advances in information, communications, and sensor technologies are needed to adequately monitor the behavior and manage the impact of the solar technologies integrating into the grid. Enterprise-level integration of PV management systems, with grid management systems, is also critical to provide important information to grid operators. In order to achieve these goals, the SI subprogram supports the development of open and interoperable communication and control architectures, communication requirements such as network latency, scalability, and availability, smart inverter communication standards (such as IEC 61850, DNP3, and SEP 2) and enterprise integration standards based on a common information model (CIM).

The SI subprogram also supports the implementation of standard communication protocols in inverter hardware and enterprise software and demonstration of end-to-end system integration and interoperability on actual distribution feeders with utilities as well as interoperability with building energy management systems.

As solar approaches 2 percent of the Nation's electricity generation capacity, the critical systems integration challenges outlined above need to be addressed and solar technology needs to be comprehensively integrated with other generation, distribution, and load assets on the grid. In prior years, solar has mainly focused on two of the National Laboratories to execute research in this area. In FY 2016, coordination of expertise among a greater number of the National Laboratories with industry (utilities as well as equipment and service providers) will more rapidly address the systems integration challenges identified above. Furthermore, National Laboratories are well suited to provide technical leadership on numerous code and standard making panels and committees that relate to grid integration including the National Electrical Code, Underwriters Laboratories standards review committees, International Electrotechnical Commission committees, and the Institute of Electrical and Electronic Engineers PV and PV systems related committees.

Research and development in Solar HiPEN and Dispatchability ($17.85 million) will focus on technologies that will enable utilities to integrate "High PENetration" levels of solar energy. For example, a new standard under development, IEEE 1547.8, will allow inverters to participate actively in managing PV as part of the distribution management through volt/var control that can prevent system voltage excursions with higher levels of PV penetration. This activity will support development of technologies that meet this standard. It will also help validate and demonstrate to utilities and equipment manufacturers that these technologies effectively meet both PV system and electricity grid requirements. Integration of energy storage—including electrochemical and thermal storage as well as load control within a building—can also increase the grid's hosting capability for renewables. HiPEN research aims to mitigate the impact of intermittency of PV by leveraging energy storage and intelligently using storage to maximize the value of the PV system while minimizing the capacity (cost) of the storage technology.

Through the greater DOE Grid Modernization crosscut ($60 million), SETP will also focus on developing controls and associated system architectures needed to manage a diverse set of resources and grid assets, including photovoltaic systems, across the distribution system; investigating how energy storage can help mitigate the variability of the solar resource and enable energy from the system to be more easily dispatched over the course of a given day; investigating tools and algorithms to develop stochastic representations of solar power output; and determining the lowest cost-flexible options to increase the hosting capacity of the system. SETP will also partner with a National Laboratory consortium to design, simulate and demonstrate a transactional energy ecosystem as the basis for accomplishing grid integration and realizing the full potential of energy and grid related opportunities.

The DOE SunShot Initiative postdoctoral research fellowship program funds ($0.66 million) emerging research leaders in the field that will pursue breakthrough solar energy technologies. These 2-year awards provide doctoral degree recipients the opportunity to conduct applied research or analysis at universities, national laboratories, and other research facilities as well as at the Department of Energy.

In addition, funds may be used to support efforts such as peer reviews, data collection and dissemination, technology assistance, and technology-to-market activities.

**Systems Integration**
**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **Systems Integration $43,700,000** | **$76,500,000** | **+$32,800,000** |
| • Issue ENERGISE solicitation and competitively select 10 to 12 projects to develop solar energy system technologies that will enable utilities to integrate higher levels (>100% of peak load on a line segment as defined by FERC SGIP) of solar penetration on the grid. Research and development will include tools for analysis and mitigation of the effects of high penetration of solar.<br>• Issue SHINES solicitation and competitively select 3 to 5 projects to integrate distributed battery storage with distributed solar systems.<br>• Partner across EERE and OE in the launch of the Grid Modernization Laboratory Consortium Initiative to develop and demonstrate technologies and tools to ensure customer-owned electric vehicles, distributed renewable generation, (including solar energy technologies), and building equipment can be integrated to optimize their overall performance.<br>• Continue to fund DOE National Laboratories Research and Development for FY 2015, and issue SuNLaMP solicitation for FY 2016 – FY 2018 multi-year national laboratory competitive funding in areas across SunShot, including the Systems Integration focus area.<br>• Pay off mortgages from past FOAs. | • Competitively selected SuNLaMP project proposals from DOE national laboratories and coordinate expertise among a greater number of the national laboratories with industry (utilities as well as equipment and service providers) to more rapidly address systems integration challenges. Continue support X selected projects as part of the OE-EERE Grid Modernization Laboratory Consortium initiative.<br>• Issue Solar Dispatchability solicitation and competitively select 5 to 10 projects focused on technologies that will enable utilities to integrate high levels (>100% of peak load on a line segment as defined by FERC SGIP) of solar energy into the electric grid in a dispatchable manner. Dispatchability research aims to mitigate the impact of intermittency of PV by leveraging the integration of building/home energy management systems with energy storage and intelligently using the combination of all energy generation and load assets to maximize the value of the integrated system while minimizing grid impact. This effort will build off the efforts on Solar Forecasting, the National Laboratories R&D, and HiPen funding programs, and bridge the gap between the outcomes of the programs and the SunShot Systems Integration targets.<br>• Issue Solar HiPen (High PENetration) solicitation and competitively fund 5 to 10 projects focused on technologies that will enable utilities to integrate high levels (>100% of peak load on a line segment as defined by FERC SGIP) of solar energy into the electric grid in a safe, reliable, and cost-effective | • The increased funding reflects the importance of addressing systems integration challenges, as the nation moves towards higher levels of renewables on the grid.<br>• The additional funds will support two FOAs (Solar HiPEN and Solar Dispatchability) for developing the transformative solutions that are critical to enabling high penetration of solar into the grid. A number of projects from FOAs issued in FY 2010-FY 2012 will be completed by the end of FY 2015. The two FOAs will fund research, development, and demonstration to bridge the gaps between the outcomes of completed projects and the SunShot Systems Integration targets (+$25.8 million).<br>• A portion of the increase is to fund the DOE-wide grid integration cross cut. |

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| | manner. As penetration of solar increases, the challenges of reliability, safety, and communications complexity increase tremendously. Improved communications and power electronics hardware and software tools are necessary to produce transformative solutions that address the challenges and enable the utilities to seamlessly interconnect and integrate solar into the grid. This effort will build off the developments from the HiPen and SEGIS-AC funding programs that are winding down in FY 2015, and bridge the gap between the outcomes of the programs and the SunShot Systems Integration targets.<br>• Fund 2 to 3 emerging research leaders through the DOE SunShot Initiative Postdoctoral Research Awards who will pursue breakthrough solar integration technologies. | |

**Description**

The Balance of Systems Soft Cost Reduction (BOS) subprogram supports the development of innovative and scalable solutions, enabling communities and leaders to build their local economies, creating sustainable market conditions, and establishes clean energy initiatives that meet their needs. Soft costs include financing, customer acquisition, permitting, installation, labor, inspection, and other non-hardware costs. Taken together, soft costs and barriers to solar deployment now make up over half the cost of total system prices for residential and small and large commercial PV systems. Moreover, soft costs can vary significantly as a result of a fragmented energy market system that presents a highly variable landscape for those looking to deploy solar. For instance, the same solar equipment may vary widely in its final installation price due to process and market variations across jurisdictions. This creates significant barriers to rapid industry growth. Development and adoption of standards at the local level and applying regional approaches can create a more uniform and therefore a more business enabling environment.

As overall solar prices have dropped, the U.S. has enjoyed unprecedented growth in both solar installations and jobs through the development of successful business and deployment models across the country. Between 2008 and 2014, the U.S. saw a 19-fold increase in renewable energy generation from solar. Technology development, commercialization, and manufacturing scaling have contributed significantly to rapid reductions in hardware costs since the inception of the DOE SunShot Initiative. However, hardware costs now account for less than half the installed price of solar and addressing "Balance of System-Soft Costs" presents the most substantial opportunity to spur strong U.S. growth in solar deployment in the coming years.

The BOS subprogram has built a diverse portfolio of soft cost activities, working with a broad range of stakeholders to expand access to solar energy to every home, business and community. The subprogram also supports the development of an exciting new generation of powerful data, network, and IT-related tools that amplify the effectiveness of these local initiatives and help grow markets intelligently. These tools increase market transparency, improve consumer protection, and improve access to low-cost financing for a growing number of consumers. Together, these efforts will make it faster, easier and cheaper than ever to deploy solar technology. In FY 2016, the BOS subprogram will support four focus areas to support reductions in soft costs and promote uniform access to solar. The four focus areas (Empowering State and Local Leaders ($25.2 million); Harnessing Big Data Analysis and Technical Solutions ($14 million); Training a Strong Solar Workforce ($12 million); and Developing Solar Finance and Business Solutions ($16.1 million) are described below.

Focused research on Empowering State and Local Leaders supports leaders that develop strategies and solutions to directly reduce the costs and barriers to solar access and that may slow deployment at the local level. BOS programs are structured to measure the effectiveness of a variety of these local programs and strategies. Through the Rooftop Solar Challenge (RSC 1 in FY 2012 and RSC 2 in FY 2013), the BOS subprogram benchmarked hundreds of communities and empowered them to advance their solar market maturity through measures that have saved Americans nearly 800 years of "red tape" related roadblocks to date. These projects have shortened permitting and inspection times by 40 percent and reduced permitting fees by 12 percent for participants. Innovations developed through RSC communities are now being shared through training and technical assistance from the BOS subprogram's Solar Outreach Partnership (SolarOPs) program. Building networks that can support the development and diffusion of proven and effective programs for solar deployment continues to be a core strategy SETP employs for expanding access to solar energy.

Focused research in Harnessing Big Data Analysis and Technical Solutions supports the creation, analysis and functionalization of data and information. At the most fundamental level, soft costs are the result of the time and effort people spend to accomplish tasks related to solar deployment. Automation, increased access to data and information, and software and information management tools can help reduce the time and effort needed to complete a solar installation. By combining the power of big data with cutting-edge social science, projects funded in FY 2013 under the BOS subprogram's Solar Energy Evolution and Diffusion Studies (SEEDS) program are enabling researchers to test, measure and validate local deployment program effectiveness, accelerating innovation in business and market development while advancing foundational knowledge of social science dynamics. In addition, soft costs-related Incubator awards support small businesses and startups that provide solutions to soft cost challenges for a variety of stakeholders, including installers, finance providers, state and local jurisdictions, and the public. Through these efforts, along with a variety of solutions

developed by DOE partners including national laboratories, non-profit organizations, and others, a wide range of tools are now available to support solar deployment.

Focused research in Training a Strong Solar Workforce supports the creation of consistent, high-quality workforce training and skills-credentialing in the solar industry. With record levels of employment in the solar industry, growing at nearly 30,000 new jobs per year, SETP's support to enable this high quality workforce has been crucial for the industry. The Solar Instructor Training Network (SITN) is a nationwide network of qualified solar instructors who train solar installers, technicians, designers, and sales professionals in every region of the U.S. through partnerships with nearly 400 community colleges. In partnership with several military bases, SETP's training efforts have also focused on supporting transitioning military personnel to enter the solar workforce. SETP's workforce training supports the development of high-quality training resources for building code officials and local inspectors, and has helped ensure that consumers receive optimal production and safety from PV installations, thereby increasing consumer confidence and lowering the cost of financing. In addition, the Grid Engineering for Accelerated Renewable Energy Deployment (GEARED) program has created a network of regional university partnered training consortia that connect utilities and solar manufacturers with university power system engineering programs to train current and future engineers. These new engineers will be able to integrate renewable energy into the grid and transform the electric utility sector into a marketplace that supports innovation.

Focused research on Developing Solar Finance and Business Solutions supports work in finance, real estate, and community and shared solar development. The National Laboratories, universities, nonprofits and talented startups have led workshops, gathered stakeholders for work sessions, and built a suite of new tools to support solar growth. The Solar Access to Public Capital (SAPC) group is working with financial institutions, project developers, and manufacturers to publicly release standardized contracts and methods for assessing risk portfolios in order to unlock new streams of capital and ensure adequate solar project financing is available to meet market demand.

In FY 2016, $9.1 million in new and ongoing research and analysis on key areas in reducing the balance of systems costs will be conducted at the National Laboratories, including financing costs as well as other non-hardware costs for solar installations such as permitting and interconnection as well as system design and engineering. In the past, comparative studies of installation practices in other countries have identified areas of opportunity for U.S. based installers to streamline installation practices and save time and money. In support of the focus on Empowering State and Local Leaders, the National Laboratories also provide technical assistance to state and local governments in development of programs that seek to improve solar market access and market conditions such as utility administered solar programs, reduced permitting times. Finance costs are addressed through the Solar Access to Public Capital team led by NREL which focuses on approaches to help financial institutions expand solar loan portfolios. Funding at the National Laboratories also supports research and collaboration with the Federal Aviation Administration on the impacts of glint and glare and ways to mitigate these impacts as needed when solar installations are sited near airports. Environmental impacts including wildlife of both large scale CSP and PV plants are also studied.

The commercial scale solar market (differentiated from residential and utility scale) is currently the largest solar market segment in a number of U.S. states, but is also a highly volatile market. Stakeholders served by the commercial/mid- scale installations include not just commercial buildings, businesses, and industrial facilities but also multi-unit housing, community and shared solar arrays, municipalities, universities, schools, hospitals and ground-mounted arrays on already disturbed lands. Building on lessons learned from existing programs and pilots, tools and resources will be developed to increase the availability of utility programs, local financing (including financing for low-income customers), bridge the gap between building/land owners and tenants, streamline and simplify IT tools, and establish aggregated procurement strategies (lowered cost through group purchasing power). In FY 2016, the Commercial-scale solar FOA ($16.1M) will support training and technical assistance for utility personnel, facilities managers, finance officers, and commercial stakeholders to meet the needs of a variety of stakeholder groups. This funding program will address many challenges in each of the four focus areas listed above as it spans the need to work with state/local governments, harnessing IT solutions, development of an advanced workforce, and development of finance and business solutions that enables the expansion of the commercial solar market segment. Some of this work will be conducted through an interagency effort leveraging the 1500 participants in the EPA Green Power Partnership and some of it will be competitively awarded to support 15 to 18 projects across the U.S. aimed at replicable models for mid-scale market deployment.

The SEEDS research program supports data-driven, real-time, and low-cost impact evaluation of solar energy diffusion efforts to make them more effective and cost effective. By embedding rigorous evidence-based feedback methods into local and regional solar deployment plans, scientists can pilot next generation evaluation tools using big data such as predictive analytics and randomized control field trials. In FY 2016, the next SEEDS program round will provide $14 million to support 8 to 10 projects that include: interdisciplinary team science; nimble and iterative experimental designs; and nascent solar deployment techniques such as utility-sponsored shared solar, nonresidential distributed solar, and bundling solar with other energy technologies such as energy efficiency or vehicle technologies. The learnings in this effort will help other EERE offices understand the correlation between solar consumers and users of other EERE technologies and enable effective local program design to reduce costs.

Partnerships with installers, utilities, and manufacturers enable not only higher quality products in the marketplace, but also quality installations to reduce interconnection and inspection costs while protecting consumers. In FY 2016, Installation Quality Assurance and Standards will provide $12 million to support 3 to 6 projects that support stakeholder-convening processes to develop standards for products and practices that increase quality while reducing costs to consumers as well as rapid national dissemination and implementation of these standards in the marketplace. This reduces not only installation costs, but also can reduce manufacturing costs upstream and financing costs downstream through supply chain efficiencies and reduced project risk.

The Solar Outreach and Analysis Partnerships (SolarOPs II) is designed to accelerate solar energy adoption on the local level by providing timely and actionable information to local governments, utilities, regulators and stakeholders. In FY 2016, SolarOPs II will provide $15.1 million to achieve its goals through a mix of educational workshops, peer-to-peer sharing opportunities, research-based reports, and online resources. This program takes a comprehensive approach to solar energy deployment by: developing high-quality resources through analysis and research (8 to 10 awards); conducting outreach and sharing best practices for increasing solar energy use with thousands of local jurisdictions across the nation; (1 to 4 awards) working in partnership with industry experts and national membership, associations to enable local governments across the U.S. to expand their local solar markets; providing information in relevant areas, such as solar markets, financial incentives, workforce training, and utility and community engagement.

In addition, funds may be used to support efforts such as peer reviews, data collection and dissemination, technology assistance, and technology-to-market activities.

**Balance of Systems Soft Cost Reduction**
**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **Balance of Systems Soft Cost Reduction $40,700,000** | **$67,300,000** | **+$26,600,000** |
| • Build on the success of the Solar Training Network to leverage training at 400 community colleges to meet the growing demand for workers (30,000+/year) in the solar industry, not only in residential installation, but also through new credentials for operations & maintenance technicians, commercial/mid-scale and utility scale project leaders and engineers.<br>• Initiate partnerships to provide background analysis, technical assistance, program and resource development for Federal agencies BLM for solar on public lands, USDA in rural communities, HUD in low-income housing and EPA with commercial partners.<br>• Launch the SunShot Catalyst prize program to create an innovation ecosystem that enables rapid software development and leverage existing open data to reduce customer acquisition, installation and financing costs.<br>• Support the establishment of solar performance and installation data and information asset standards through the Solar Informatics initiative to enable risk assessment, open new streams of capital, and enable low cost financing which currently equals the cost of solar hardware, but can be greatly reduced.<br>• Leverage two successful rounds of the Rooftop Solar Challenge to support technical assistance for designation of hundreds of leading local jurisdictions that implement practices to enable stable solar markets to thrive and reduce solar costs by up to 30%. | • Conduct new and ongoing research and analysis on key areas in reducing the balance of systems costs at the national laboratories, including: financing costs through the NREL Solar Access to Public Capital team which, in FY 2016 will help financial institutions expand solar loan portfolios; leveraging big data assets through SEEDs II and upcoming rounds of Catalyst to reduce customer acquisition costs and improve local program design. Funding at the national laboratories also supports research to mitigate environmental, wildlife, and visual impacts. (BOS Focus Areas 1, 2 and 4).<br>• Launch a Commercial/Mid-Scale Solar Program to accelerate growth in this high-potential U.S. solar market segment through development of new business models and standardization of practices for utility, commercial, multi-family, municipal and community partners (BOS Focus Areas 3 and 4).<br>• Launch a second round of the successful SEEDS Program combining big data with real-world practice and cutting edge analysis to improve solar technology development and market diffusion. (BOS Focus Area 1 and 2).<br>• Installation, Quality Assurance and Utility/Manufacturing Standards Effort will comprehensively address best practices for products and installation to reduce costs and ensure consumer protection. (BOS Focus Area 3).<br>• Solar Analysis and Outreach Partnerships II Program will provide actionable resources and facilitate peer to peer learning for utilities and local stakeholders to support the growth of stable local solar markets. (BOS Focus Area 1). | • The funding increase supports new work focused on reducing barriers for businesses to choose solar. Leveraging the successful work with state/local governments to streamline processes for homeowners, many similar challenges in soft costs exist for the commercial sector.<br>• Relative to FY 2015, additional funding will support new activities to address potential soft cost reduction for the utility and commercial scale markets, which make up over 2/3 of U.S. installations.<br>• The increase supports significant development of new resources through national labs, SEEDS and SolarOPs II to expand access to solar to low-income, rural, and commercial market segments.<br>The increase will also strengthen work to reduce soft costs through the development of big data and information assets as well as installation quality and standards. |

## Solar Energy
## Innovations in Manufacturing Competitiveness: Tech to Market

**Description**

The Innovations in Manufacturing Competitiveness (IM) subprogram supports the Department's Clean Energy Manufacturing Initiative, a Department-wide approach to increase U.S. competitiveness in clean energy manufacturing while advancing progress toward the nation's energy goals. The overall goal of this subprogram is to reverse the trend of offshoring PV and CSP component manufacturing and assembly through technology and process innovations that can enable American companies to manufacture and deploy solar technologies competitively. It also seeks to strengthen the Nation's competitive advantage in the associated solar energy manufacturing supply chain. The focus for the IM subprogram is to increase America's market share for added value manufacturing commensurate with domestic market demand.

Over the last several decades, the average selling price of PV modules has declined on a trend line often referred to as a learning curve. In part through committed EERE investments in RD&D, the cost of solar PV modules has been reduced by 95 percent over the past 35 years, and by 75 percent over just the last 4 years. PV innovations have helped enable the decline in PV module prices. These innovations include those supported by DOE. More than half of the world record solar cell efficiencies achieved over the past 35 years were accomplished through DOE investments. Despite U.S. technological leadership, intense international competition and support from foreign governments has created adverse conditions for manufacturers based in the U.S. This is evidenced by the decline in PV cell and module manufacturing share. In order for American manufacturers to compete globally, innovation in manufacturing and technology is essential. To that end, the IM subprogram is focused on efforts to ensure that technologies developed in the U.S. can compete in the global marketplace. This also includes focusing on segments of the value chain where America has defensible competitive advantages. The U.S. is unlikely to regain the entire value chain for solar manufacturing, but by focusing specifically on those areas where indigenous factors (such as innovation, low cost and reliable electricity, and abundant natural gas) as well as a focus on quality and deployment efficiency can provide domestic manufacturers a defensible competitive advantage, they can capture more value add in the final product.

In 2014, the U.S. solar manufacturing industry expanded again. Several new manufacturing facilities with direct DOE technology development linkage began construction to address U.S. as well as growing global markets. The DOE strategy to invest in manufacturing technology innovation that could enable U.S. companies the competitive advantage in an un-level global marketplace helps strengthen the U.S. innovation ecosystem. In FY 2016, the IM subprogram will support two primary focus areas to support the achievement of the SunShot Initiative. The two focus areas (Technology to Market ($28.7 million) and Manufacturing Technologies ($44.6 million) are described below.

Focused research in the Technology to Market portfolio focuses to supporting innovation at the earliest stages of commercialization. The flagship program in the Technology to Market portfolio is the DOE SunShot Initiative Incubator program, currently in its ninth round. Past recipients have attracted more than $18 in follow-on funding for every $1 in federal investment. Tightly formulated commercial and technical deliverables are the cornerstone of the program. The program also boasts breadth and permanence: the solicitation is open to a wide range of topics and recurs annually, subject to appropriations. The DOE SunShot Initiative Incubator program supports small businesses seeking to commercialize innovative PV and CSP device concepts and manufacturing pilot lines, as well as innovations in hardware installation, grid conversion technologies, and novel business models and software platforms for reducing soft costs. Examples of past successes include several small businesses that have developed innovative PV technologies that then were later acquired by much larger corporations, including a Fortune 10 and a Fortune 100 corporation which then scaled the technology for manufacturing in the U.S. In FY 2016, the DOE SunShot Initiative Incubator 11 will be the eleventh round of the successful DOE SunShot Initiative Incubator program which provides early-stage assistance to help small businesses cross technological barriers to commercialization while encouraging private sector investment. The DOE SunShot Initiative Incubator program shortens the time between laboratory-scale proof of concept and prototype development. The project payments are made upon completion and verification of aggressive project deliverables.

Focused research in Manufacturing Technologies helps support growth of the domestic manufacturing industry. The Solar Manufacturing Technologies (SolarMAT) Program ($19.125 million) funds the development and demonstration of innovative, but commercially and technically viable, manufacturing technology that can achieve a significant market or

manufacturing impact in 1 to 4 years from project completion. This activity is motivated by the need for manufacturing advances in both photovoltaic and concentrating solar power technologies to significantly reduce costs of solar-generated electricity in the U.S. and to provide U.S.-based manufacturers a manufacturing edge in a very competitive global marketplace. The focus is on developing manufacturing technology to drive down the cost of manufacturing and/or the cost of implementing technology that increases solar power conversion efficiency in manufacturing and deployment. This could include research in enhanced automation of manufacturing processes that would reduce capital and labor requirements at factories and installations in the U.S., thereby enhancing the ability for the private sector to achieve U.S.-based cost-effective manufacturing.

The Scaling Up Nascent PV AT Home (SUNPATH) Program seeks to increase U.S. manufacturing and ensure that innovative technologies are manufactured domestically through investments that create sustainable and globally competitive cost and performance advantages. The goal of SUNPATH III ($25.5 million) is to support the initial ramp up to pilot-scale manufacturing of innovative new manufacturing processes and tools, thus enabling U.S. industry to overcome a funding gap. SUNPATH III also has a validation requirement where the solar technologies funded, developed, and manufactured in the program are validated in solar products at a statistically sufficient scale in multiple locations/climates in the U.S. The validation of innovative new solar technologies will improve bankability, thereby lowering risks associated with new manufacturing approaches.

The FY 2016 Budget for this subprogram includes $10 million to support a Massively Parallel Combinatorial Process Development for Competitive Manufacturing initiative in collaboration across DOE through the Department's Clean Energy Manufacturing Initiative and in support of the Administration's Materials Genome Initiative. Combinatorial process development can be used to rapidly and cost effectively move technologies from initial development to full optimization. This process has been used successfully in the integrated circuit and pharmaceutical industries to rapidly screen and optimize processes to enable competitive U.S. manufacturing. Massively Parallel Combinatorial Process Development for Competitive Manufacturing will use high performance computing and high throughput combinatorial synthesis to develop validated models capturing the effects of processing and end use performance to accelerate the development of solar materials from the point of discovery to qualification. Techniques developed in this program can also be useful if applied to other EERE technologies such as fuel cells or solid state lighting.

In addition, funds may be used to support efforts such as peer reviews, data collection and dissemination, technology assistance, and technology-to-market activities. The remainder of the funds will buy down mortgages.

**Innovations in Manufacturing Competitiveness: Tech to Market**
**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **Innovations in Manufacturing Competitiveness** | | |
| **$57,800,000** | **$73,400,000** | **+$15,600,000** |
| • Issue SolarMAT III solicitation and competitively select 3 to 5 projects focused on developing solar manufacturing technologies with the greatest potential to reduce cost in manufacturing and supply chain across the entire solar value chain, so as to reduce the trade imbalance in the solar industry.<br>• Implement Incubator round 10 to provide early stage assistance to help 10-15 small business commercialize innovative solar technologies.<br>• Issue SUNPATH II solicitation and competitively select 2 to 3 pilot-scale projects focused on innovative new manufacturing processes and tools with the potential to demonstrate cost reduction via end-to-end line integration at the range of the product-equivalent capacity of 1-30MW. SUNPATH II aims to reduce trade imbalance in solar industry to ensure the United States production is commensurate with its growing market.<br>• Expand the PV Manufacturing Initiative -- a consortia of industry and university partners and multi-user manufacturing development facilities – to include new technologies and cross-cutting themes to speed the implementation of new cutting edge technologies in industry manufacturing and installation processes. | • Issue SolarMAT IV solicitation and competitively select 5 to 10 projects focused on developing solar manufacturing technologies with the greatest potential to reduce cost in manufacturing and supply chain so as to reduce the trade imbalance in the solar industry.<br>• Implement Incubator round 11 to provide early stage assistance to help 10 to 20 small businesses commercialize innovative solar technologies.<br>• Issue SUNPATH III solicitation and competitively select 5 to 8 pilot-scale projects focused on innovative new manufacturing processes and tools with the potential to demonstrate cost reduction via end-to-end line integration at the range of the product-equivalent capacity of 1-30MW. SUNPATH III aims to reduce trade imbalance in solar industry to ensure the United States production is commensurate with its growing market.<br>• Initiate Massively Parallel Combinatorial Process Development for Competitive Manufacturing initiative to rapidly screen and optimize manufacturing processes to reduce the cost of module to $0.50/W and the development cycle of a new material by 50% in time. | • The increase includes a higher number of awards for the SUNPATH and SolarMaT FOAs due to the increased activity up and down solar value chain, as well as the growing market and growing number of US manufacturers. The Materials Genome FOA would add $10 million alone. |

## Solar Energy
## NREL Site-Wide Facility Support

**Description**

In FY 2016, EERE programs will continue to directly fund NREL site-wide facility costs that are not included in the Facilities and Infrastructure budget rather than fund those costs as laboratory overhead. This approach is consistent with Generally Accepted Accounting Practices and DOE management at other National Laboratories. EERE began this practice in FY 2014 to effectively control NREL's labor rate multiplier. One outcome has been reducing the cost of accessing unique NREL capabilities (such as facilities and staff expertise) by industry and academia. This practice also makes site operating costs more transparent in order to facilitate cost control and planning. In FY 2014, this practice resulted in a reduction in the lab-wide direct labor multiplier of approximately 15 percent compared to FY 2013. The proposed FY 2016 Budget Request continues the approach applied in 2014 and 2015.

The NREL Site-Wide Facility Support subprogram funds research programs by providing basic site services, functions, and infrastructure for site operations, which includes: management, building operations, building and grounds maintenance, fire and emergency response, engineering and construction support, minor construction projects, electrical safety program, utilities, and facilities planning support; and activities within the Sustainability and Environmental Health and Safety (EHS) portfolios. These activities and their costs are relatively fixed and only vary significantly based upon variations in commodities, construction activity, emergencies, weather patterns, etc. They are considered to be the core functions for site operations, safety, environmental compliance, and sustainability at NREL. In FY 2016, this funding will continue to support more than 60 full time equivalents that manage and provide support for these core functions. It will also fund site-wide subcontracts such as janitorial services, refuse and recycling, and subcontracts for minor construction. Additionally, this funding will support site-wide costs associated with maintaining NREL's leadership position, such as: maintaining International Organization for Standardization (ISO), American Association for Laboratory Accreditation (A2LA), and other lab-wide accreditations, managing facilities to enable mission goals, improving sustainability, pollution prevention, waste minimization, improving energy efficiency, reducing water use, and maintaining an effective emergency management system.

The FY 2016 Budget Request remains consistent with the method EERE developed in FY 2015. This approach is a more precise, equitable, and economically neutral method that ensures a predictable net-zero impact on programs' funding. For each program, the contribution to direct funding for site-wide facility support is equivalent to the estimated contribution the program otherwise would have made through overhead charges. This method is based upon each program's level of funding to NREL, adjusted to account for anomalies from large capital expenditures and major subcontracts.

**NREL Site-Wide Facility Support**
**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **NREL Site-Wide Facility Support $9,100,000** | **$9,100,000** | **$0** |
| • Directly fund NREL site-wide facility support costs that are not included in the Facilities and Infrastructure budget rather than continue to fund these costs in the laboratory overhead rate. | • Directly fund NREL site-wide facility support costs that are not included in the Facilities and Infrastructure budget rather than continue to fund these costs in the laboratory overhead rate. | • No changes. |

## Solar Energy
## Performance Measures

In accordance with the GPRA Modernization Act of 2010, the Department sets targets for, and tracks progress toward, achieving performance goals for each program.

| | FY 2014 | FY 2015 | FY 2016 |
|---|---|---|---|
| Performance Goal (Measure) | **Photovoltaics (PV)- Reduce the unsubsidized LCOE from PV at large scale for utility, commercial, and residential applications (cents kilowatt hour); Targets in the table represent utility-scale installations** | | |
| Target | 13 | 10 | 9 |
| Result | Exceeded - 11 | Not Applicable | Not Applicable |
| Endpoint Target | 6 cents/kWh by 2020, cost competitive with traditional electricity sources | | |

## Wind Energy

### Overview

The mission of the Wind Energy Program is to accelerate the widespread U.S. deployment of clean, affordable, and reliable wind power to promote energy security, economic growth, and environmental quality. The Wind Energy Program's central focus is to perform research, development, demonstration, and market acceleration activities that will enable wind power to achieve Levelized Cost of Energy (LCOE) parity with energy generation from traditional sources across the Nation. With wind supplying approximately 4.5 percent of the Nation's energy mix today, important regional strides have been made in several high-quality land-based areas and wind has tremendous potential for growth to further contribute to a diverse and clean U.S. electric power portfolio.

Total cumulative U.S. wind installed capacity at 2014 year-end was approximately 65 GW, representing a nearly fourfold increase in installed capacity from 17 GW at 2007 year end. According to resource estimates conducted by the National Renewable Energy Laboratory, the annual technical potential of the U.S. land-based and offshore wind resources is equivalent to 11,000 GW and 4,200 GW of electric generating capacity, respectively, of which a portion may be economically feasible to develop[1]. Achieving the program's wind power LCOE goals will support cost-effective deployment of wind power at high penetration levels, with the potential to meet up to 20 percent of projected U.S. electricity demand in 2030. However, significant improvements in cost and performance for high-potential utility-scale wind power plant systems (both land-based and offshore) and distributed wind systems are still required for wind power to achieve these aggressive levels of deployment within the next two decades. In addition, major market barriers and challenges must be addressed to enable cost-competitiveness and increased deployment of wind power, including access to transmission, mitigation of radar, and environmental and permitting issues that affect access to higher wind classes and constrain siting opportunities.

The Wind Energy Program activities target lowering U.S. wind power costs (Land, Offshore and Distributed) to become directly cost-competitive absent subsidies with traditional electricity sources. The program recognizes that innovation in a single component or subsystem alone will not achieve its LCOE goals. Significant continued improvements in wind turbine capital cost, energy capture, and operating expenses will require an integrated system optimization approach. With this in mind, the FY 2016 Budget includes $26.8 million to support the "Atmosphere to Electrons" (A2e) initiative. A2e moves beyond a traditional, individual turbine centric focus, to one that encompasses an entire wind plant, comprised of multiple turbines, to address underlying physical and technical barriers to optimized performance. The program invests in wind plant research and development (R&D) to spur required innovations in high-fidelity modeling capabilities that leverage DOE High-Performance Computing (HPC) assets and the development of novel measurement techniques to monitor the flow into and through the wind plant. FY 2016 Wind Energy Program investments will also continue to develop and maintain world class testing facilities at the National Laboratories which provide critical capabilities for improving reliability, lowering technical risk, and spawning innovative component, integrated turbine system, and entire wind plant technologies. Finally, while there are currently no U.S. offshore wind installations, the program is committed to supporting research, development, and demonstration of innovative foundation designs to overcome key technical and non-technical challenges associated with offshore wind.

In FY 2016, the Wind Energy Program proposes to change the subprogram name "Resource Characterization and Technology RD&T (Land, Offshore, Distributed)" to "Technology RD&T and Resource Characterization (Land, Offshore, Distributed)" to more accurately reflect the breadth of activity in this subprogram. The title change has no effect on subprogram content or activities.

### Highlights of the FY 2016 Budget Request

In FY 2016, the A2e initiative will holistically approach wind plant optimization by assessing performance, identifying barriers to improvement, and developing innovative component and system technology solutions. Addressing wind plant underperformance caused by turbine-to-turbine flow interactions represents a significant opportunity to enhance power production from both existing as well as future wind plant installations -- up to 20 to 30 percent based on model prediction

[1] Lopez, A.; Roberts, B.; Heimiller, D.; Blair, N.; Porro, G. (2012). *U.S. Renewable Energy Technical Potentials: A GIS-Based Analysis*. NREL/TP-6A20-51946. Golden, CO: National Renewable Energy Laboratory. Accessed January 2015: http://www.nrel.gov/docs/fy12osti/51946.pdf

in complex terrain installations. The A2e initiative, in partnership with industry, academia, and other partners will develop new high-fidelity models validated with field data. Improved modeling capabilities will lead to technology innovations that enable significantly improved siting practices and next generation machines with cumulative plant awareness to enhance wind plant performance.

Under the A2e initiative, the program will enhance capabilities at the "Scaled Wind Farm Technology Facility" (SWiFT) located at the Reese Technology Center in Lubbock, Texas to conduct high resolution turbine wake measurements. Data will be collected in field tests at SWiFT and at the NREL National Wind Technology Center (NWTC) to study inflow, wake effects, and feed-forward control system architectures. Analysis of the data will provide fundamental insight into the behavior of turbine-to-turbine flow interactions that are the key issues in resolving wind plant underperformance. Systematic validation data of turbine wake interaction effects collected at both test centers will be critical to support the high-fidelity modeling initiatives. These facilities also provide the well characterized test beds for controls research essential for both turbine and wind plant optimization research activities.

In FY 2016, the program will initiate wind turbine component R&D to develop a new generation of high tip speed, low noise rotor designs that can be economically manufactured and integrated into wind turbines. Higher tip speeds have beneficial system-wide effects that could reduce the overall mass and cost of large wind turbines. The subprogram will also fund R&D of new drivetrain concepts including advanced generator topologies, superconducting generators, modular construction, and onsite assembly techniques. Selected concepts will be demonstrated at a commercially relevant scale in a representative industrial environment to accelerate incorporation into a commercial wind turbine.

In FY 2016, the program will provide $40.0 million for year five of a six fiscal-year program previously competed through the Offshore Wind Advanced Technology Demonstration Project FOA, to support the establishment of a competitive U.S. offshore wind industry through offshore system development and demonstration. The three Offshore Wind Technology Demonstration projects downselected in FY 2014 will complete final engineering design, finalize vendors, and begin procurement and fabrication of major project components, such as foundations and turbines. These efforts specifically address technology and deployment challenges unique to U.S. waters in order to tap into America's offshore wind resources that are large, stable, and located near major load centers.

Under the mitigate market barriers program, a new $4.5 million research initiative focused on Eagle Impact Mitigation Technologies will support the development and evaluation of advanced mitigation technologies that will help to better characterize and reduce potential impacts to eagles, and support industry in obtaining new permits required by the Bald and Golden Eagle Protection Act. An additional $5 million will go to expanding the program's ongoing work to better understand and develop mitigation measures to address the impacts of wind on bird and bats to help enable the effective coexistence of sensitive wildlife with expanded wind deployment. The program will continue support for the Collegiate Wind Competition to challenge university teams to develop innovative engineering and business solutions to important wind energy technology problems. The program will further develop the wind-based transmission line planning tool architecture, by coding and implementing in software the calculation of transmission constraints on proposed line routes, and concurrent energy production for a proposed wind farm connected to a grid with dynamic line ratings.

A Wind Energy Program "Incubator" funding opportunity will invest 5 percent of Wind Energy Program funding toward new off-roadmap innovative technologies and solutions that can help meet or exceed existing goals but are not represented in a significant way in the current portfolio or technology roadmaps. Successful Incubator projects will reduce the risk associated with potential breakthrough approaches and technologies so they may be "on-ramped" to future program roadmaps and the program portfolio.

Within the FY 2016 Budget Request, the Wind Energy Program supports the Grid Modernization crosscut. U.S. prosperity and energy innovation in a global clean energy economy depends on the modernization of the national electric grid. To support this transformation, DOE's Grid Modernization crosscut will create tools and technologies that measure, analyze, predict, and control the grid of the future; focus on key policy questions related to regulatory practices, market designs, and business models; and collaborate with stakeholders to test and demonstrate combinations of promising new technologies. In FY 2016, the goal of Wind Energy Program-specific Grid Modernization crosscut activities is to better incorporate wind forecasting into system operations; perform regional evaluation of power system flexibility options and opportunities; conduct analysis of system reserve requirements under various high wind penetration scenarios; and develop stochastic

unit commitment and dispatch tools and next generation wind integration studies (e.g. the North American Renewables Integration Study).

**FY 2016 Crosscuts ($K)**

| | Grid Modernization | Total |
|---|---|---|
| **Wind Energy** | **12,027** | **12,027** |

**Wind Energy**
**Funding ($K)**

| | FY 2014 Enacted[1] | FY 2014 Current[2] | FY 2015 Enacted | FY 2016 Request | FY 2016 vs FY 2015 |
|---|---|---|---|---|---|
| **Wind Energy** | | | | | |
| Technology RD&T and Resource Characterization (Land, Offshore, Distributed) (formerly Resource Characterization and Technology RD&T (Land, Offshore, Distributed)) | 0 | 0 | 34,658 | 58,160 | +23,502 |
| Technology Validation and Market Transformation | 0 | 0 | 46,250 | 41,990 | -4,260 |
| Mitigate Market Barriers | 0 | 0 | 11,207 | 28,062 | +16,855 |
| Modeling and Analysis | 0 | 0 | 10,185 | 12,588 | +2,403 |
| NREL Site-Wide Facility Support | 9,000 | 9,000 | 4,700 | 4,700 | 0 |
| Technology Development and Testing | 61,145 | 60,133 | 0 | 0 | 0 |
| Technology Application | 17,981 | 17,902 | 0 | 0 | 0 |
| **Total, Wind Energy** | **88,126** | **87,035** | **107,000** | **145,500** | **+38,500** |

SBIR/STTR:

- FY 2014 Transferred: SBIR $955,000; STTR $136,000
- FY 2015 Enacted: SBIR $935,000; STTR $129,000
- FY 2016 Request: SBIR $1,653,000; STTR $248,000

[1] FY 2014 Enacted funding reflected the contractor foreign travel rescission of $52,601.
[2] Funding reflected the transfer of SBIR/STTR to the Office of Science.

**Wind Energy**
**Explanation of Major Changes (SK)**

| | FY 2016 vs FY 2015 |
|---|---|
| **Wind Energy** | |
| **Technology RD&T and Resource Characterization (Land, Offshore, Distributed)** (formerly Resource Characterization & Technology RD&T (Land, Offshore, and Distributed)): The increase funds new advanced components development including rotor designs incorporating higher tip speeds and innovative drivetrain concepts; establishment of a new R&D and demonstration partnerships with industry and academia for smart wind plant technologies; and a new aeroacoustics experimental testing program in partnership with industry to accelerate the development and commercialization of promising noise-reduction technologies. | **+23,502** |
| **Technology Validation and Market Transformation**: The decrease is a result of two engineering and cost analyses completed in FY 2015 and not continued in FY 2016. | **-4,260** |
| **Mitigate Market Barriers:** The increase funds new Eagle Impact Mitigation Technologies research that will support the development of mitigation technologies necessary for the industry to obtain new permits required under the Bald and Golden Eagle Protection Act, as well as an expansion of the program's ongoing efforts to address the impacts of expanded wind development on wildlife. It also covers activities related to DOE's Grid Modernization Crosscut efforts and collaboration with the Office of Electricity Delivery and Energy Reliability on managing distributed assets. | **+16,855** |
| **Modeling and Analysis**: The increase is due to development of advanced analytical capabilities to quantify potential impacts of programmatic R&D investments, including LCOE impacts, at the system level. | **+2,403** |
| **Total, Wind Energy** | **+38,500** |

## Wind Energy
## Technology RD&T and Resource Characterization (Land, Offshore, Distributed)
## (Formerly Resource Characterization and Technology RD&T (Land, Offshore, Distributed))

**Description**

The Technology Research, Development, and Testing (RD&T) and Resource Characterization (Land, Offshore, Distributed) subprogram consists of activities that are directed to improve component, system, and plant technologies for land-based, offshore, and distributed wind systems to enable cost-competitiveness with traditional sources of electricity generation without subsidies. To achieve the program's LCOE goals, the subprogram focuses in several critical areas: (1) the Atmosphere to Electrons (A2e) initiative, which seeks to optimize overall wind power plant performance and operations; (2) wind-specific manufacturing R&D projects focusing on solicitations to develop innovative wind turbine rotor and drivetrain concepts; (3) offshore wind-specific R&D projects exploring fixed and floating substructure concepts, hurricane wind flow, innovative operations and maintenance strategies, offshore meteorological and oceanographic data collection, and offshore condition health monitoring; (4) wind power forecasting and the deployment of atmospheric measurement systems; (5) maintenance, operation and enhancement of DOE's world-class testing infrastructure; and (6) R&D focused on the distributed wind sector.

The A2e initiative ($26.7 million) is a major new DOE-led consortium of National Laboratories, universities, industry, and international stakeholders that is focused on optimizing wind power plant performance and operations by improving industry's understanding of the physics of wind, reducing energy losses, improving forecasting, improving reliability, and reducing the risk profile associated with owning, operating, and investing in wind energy. Leveraging DOE's High Performance Computing capabilities (HPC), A2e will enable analysis of wind plants as a whole, including wind flows within the wind plant and complex turbine-to-turbine interactions. DOE HPC capabilities will allow stakeholders to utilize high fidelity models to glean new knowledge and physical understanding, achieve wind power plant design innovation, evolve plant-level integrated system controls, and validate wind turbine innovations with a high degree of confidence in the simulation results. Fully integrated systems engineering models of the entire wind plant will inform design reviews, optimization analyses, and technology prioritizations critical to the development of high-performance wind power plants. Model and simulation results, as well as new understanding of underlying wind plant physics, will allow researchers to address key technology gaps and inform future technology development programs.

In order for A2e to conduct a comprehensive model development effort, it is necessary to develop a verification and validation (V&V) framework that identifies and prioritizes key physical processes impacting wind plant performance. According to the V&V framework priorities, A2e will build a new suite of high-fidelity modeling tools to accurately replicate the physics of airflow in the atmospheric boundary layer—the portion of the atmosphere nearest to the surface – and interactions with and among wind turbines, terrain, and other structures at a wind plant. Initial high fidelity model development will investigate how turbine rotor wakes develop and evolve. In order to validate the modeling tools, A2e will be required to conduct extensive experimental measurement and data collection campaigns at wind-tunnels, at the SWiFT test facility, and in operating wind plants.

In FY 2016, A2e R&D activities will include: (1) initiating a joint computational-experimental campaign modeling the atmosphere at heights relevant to wind turbines and coupling those large-scale models to the finer resolution models necessary to capture wind turbine response and performance; (2) building new modeling capabilities to simulate the complexities of the full multi-array wind plant environment to assess energy conversion potential of existing and future wind plants, including experimental test campaigns to provide validation data; (3) analyzing individual and coupled multi-turbine control paradigms allowing integrated system control to optimize plant performance and grid interconnection; (4) developing the next generation of turbine component and integrated plant system design tools that optimize both cost and performance, and (5) assessing the real and perceived wind energy development risk assumptions held by financial community to identify opportunities to lower financing costs by reducing the uncertainty of existing predictive modeling capabilities.

In FY 2016, the subprogram will fund the next phase of wind-specific manufacturing R&D projects at $12.2 million, complementary to EERE's Clean Energy Manufacturing Initiative (CEMI), seeking to leverage American competitive advantages and overcome competitive disadvantages in the production of wind energy products. The subprogram will issue

new solicitations totaling $12 million to develop higher tip speed, low noise signature rotor designs and new drivetrain concepts. High tip speed rotor designs that can be economically manufactured and integrated into wind turbines without increasing noise have beneficial system-wide effects that could reduce the overall mass and cost of large wind turbines. Rotor tip speed is limited by noise constraints; higher tip speeds enable lighter rotor systems. As offshore turbines continue to grow past 10MW, the gravity loads on the rotor system become a primary design constraint that higher tip speed designs can counteract. The subprogram will also fund R&D of new drivetrain concepts including advanced generator topologies, superconducting generators, and modular construction and onsite assembly techniques. Selected concepts will be demonstrated at a commercially relevant scale in a representative industrial environment to accelerate incorporation into a commercial wind turbine. Additionally, the subprogram will fund research on advanced materials and components enabling new architectures for larger, light-weight turbines that reduce overall mass (reducing costs), provide access to better wind resources (larger rotors, taller towers), and improve system performance (increased capacity factor). These improvements in turbine component and system cost, strength, weight, and fatigue resistance aim to reduce operation and maintenance (O&M) costs and reduce the failure rate for large components, such as blades, gearboxes, and generators. Through technology components R&D activities that provide better understanding of turbine loading and response, the subprogram provides a unique coordination role to help develop codes and standards for new turbine designs that enter the market.

Consistent with the DOE and Department of Interior's National Offshore Wind Strategy, subprogram funding will support: (1) research including the design and optimization of innovative fixed and floating substructure concepts; (2) simulation of complex hurricane wind flow conditions on offshore wind turbines; (3) implementation of innovative offshore operations and maintenance strategies; (4) analysis of on-site offshore meteorological and oceanographic data collected in FY 2015 in regions identified for future offshore wind development; and (5) development of condition health monitoring technologies for offshore wind plants.

In FY 2016, the subprogram will continue to support research to improve the forecasting of wind power, including the deployment of atmospheric measurement systems to improve physics-based knowledge of the atmosphere as well as to validate and verify improved atmospheric modeling. This data will provide the necessary knowledge to improve characterization of physical drivers of the wind at heights relative to wind plants. Incorporating this new understanding of fundamental atmospheric physics into foundational atmospheric models such as the Weather Research and Forecasting (WRF) model, the High-Resolution Rapid Refresh (HRRR) model will yield more accurate and timely wind forecasting capabilities beneficial to the wind industry and other stakeholders.

In FY 2016, the subprogram will continue funding operation and enhancement of DOE's world-class testing infrastructure, including the NWTC, SWiFT, Massachusetts blade test facility, and Clemson drive train facility, that provides a wide breadth of testing and research capabilities critical for supporting U.S. wind energy innovation and cost of energy reductions for all market segments, including development of improved test methods which better reflect the conditions wind turbines are likely to experience in the field.

In FY 2016, the subprogram will allocate $4.4 million to R&D focused on the distributed wind sector. Domestic sales from U.S. small wind suppliers accounted for 88 percent of the U.S. small wind market in 2013, up from 71 percent in 2012, and supports U.S. workers in distributed wind manufacturing, retail, operations and maintenance jobs. The global market for small wind turbines is projected to double from 2013 to 2018 to roughly 180 megawatts.[1] To capture the opportunities of this expanding market, in FY 2016, the subprogram's Competitiveness Improvement Program (CIP) will continue to support both existing and emerging small and medium-sized wind turbine manufacturing companies, and assist them in improving component designs, improving manufacturing competitiveness, and system certification.

[1] Navigant Research (2013). Small Wind Power.

**Technology RD&T and Resource Characterization (Land, Offshore, Distributed)**
**(Formerly Resource Characterization and Technology RD&T (Land, Offshore, Distributed))**
**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **Technology RD&T and Resource Characterization (Land, Offshore, Distributed) $34,658,000** | **$58,160,000** | **+$23,502,000** |
| • Complex aerodynamics R&D and testing campaigns to determine the effect of wakes on plant performance:<br>▪ Conduct a side by side experimental assessment of resource characterization instrumentation to benchmark the capabilities of the instrumentation in measuring the atmospheric inflow conditions. The activity will fund DOE labs, universities, and instrument developers to participate in the joint measurement campaign. This activity will be completed in FY 2015.<br>▪ Mesoscale-Microscale coupling algorithm development – Conduct a round robin verification and validation exercise of different modeling approaches currently being pursued at the national labs to determine the best practices for downscaling regional weather information (at km grid scales) down to wind plant scales of interest (~meter grid sizes). The ability to downscale the wind speeds and turbulence are critical to accurately estimate the performance of wind plants.<br>▪ Near-Wake Characterization and High-Fidelity Model Development – Starting in FY 2015, the project will develop plans to conduct experimental campaign that will collect high resolution data of the turbine wake development, evolution, and dissipation process. The understanding of wake evolution | • Conduct joint computational-experimental campaigns, including the following core activities:<br>▪ High fidelity simulations coupling the large-scale physics of the atmosphere to the smaller-scale physics of wind plant and wind turbine inflow in conjunction with validation data collected in field experiments.<br>▪ High fidelity simulations in conjunction with scaled experiments to study turbulent inflow and near-wake development.<br>• Initiate a new aeroacoustics experimental testing program at the SWiFT facility. The objective of this AOP task is to experimentally quantify noise reductions of promising technologies. The goal of the aeroacoustics program is to achieve at least 1dB noise reduction through targeted R&D programs. This experimental capability at the SWiFT will also be able to support the higher tip speed rotor FOA project.<br>• Utilize the SWiFT facility to test experimental wind plant controls that may be capable of optimizing wind plant performance and reducing wake losses, which currently account for 6-10% energy losses in operating wind plants. Experiments will investigate the extent to which novel plant level control strategies may be able to reduce wake losses in existing and future wind plants.<br>• Develop turbine component and wind plant system design tools that integrate cost models with system dynamics models for land-based and | • New initiative to develop a new generation of rotor designs incorporating higher tip speeds without accompanying increases in noise signatures that can be economically manufactured and integrated into wind turbines. Increased rotor tip speed has the potential to significantly reduce up-tower mass, improve aerodynamic efficiency, increase plant capacity factors and enable much larger rotor systems for offshore.<br>• New initiative to explore new innovative drivetrain concepts such as superconducting generators or unconventional generator topologies, demonstrated at a commercially relevant scale in a representative industrial environment to accelerate incorporation into a commercial wind turbine.<br>• The A2e initiative will establish new R&D and demonstration partnerships with industry and academia for smart wind plant technologies. This will involve the development of high-fidelity modeling capability to design wind plant controllers, develop sophisticated instrumentation for real-time flow monitoring and control, as well as developing reliable forecasting and dispatch strategies. Plant-level control will be developed and demonstrated in conjunction with turbine-level controls that have potential for reducing wake losses experienced by existing and future wind power plants.<br>• A new aeroacoustics experimental testing |

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| and its interaction with downstream turbines is fundamental to predicting the loss of performance in large wind plants.<br>• Initiate partnerships with wind plant owner/operators to collect performance and O&M data that will be used as a publically available industry benchmark. In FY 2015, the goal is to gather data that is representative of at least 20% of the installed US wind fleet. Industry benchmarking is necessary to identify fleet-wide reliability issues that will be used to prioritize future reliability research. Additionally, industry will benefit from this aggregated data to identify opportunities for improving operational availability to a target of 98%.<br>• Develop the systems engineering analysis capability to assess the impact of turbine wake interaction in the siting process. The integrated model will be used to analyze the benefits of adopting multiple turbines for a site over the current practice of a single turbine configuration for each wind plant.<br>• Improve the reliability and performance of wind turbines through improved design standards. An improved understanding of wind turbine loading conditions, gleaned from data collection and improved modeling capabilities, can have an impact on the way blades are designed, which can results in lighter, lower cost components. DOE participates in several international design standard working groups, often in a leadership role. This leadership role entails organizing working group meetings and setting the agenda and priorities for the working group. Success can be measured via substantive improvements to existing design standards that were introduced | offshore applications.<br>• Correlate the uncertainty and underperformance of wind plants and associated financial risk to identify technology improvement opportunities.<br>• Issue a FOA to develop a new generation of rotor designs incorporating higher tip speeds without accompanying increases in noise. Increased rotor tip speed has the potential to significantly reduce up-tower mass, improve aerodynamic efficiency, increase plant capacity factors and enable much larger rotor systems for offshore. Concepts are sought that can reduce the noise signature by more than 1dB. A 3% increase in annual energy production can be realized for every 1dB noise reduction.<br>• Strategic investment in technologies that leverage American competitive advantages and overcome competitive disadvantages in the production of wind energy products:<br>▪ Issue a FOA to evaluate innovative drivetrain concepts such as advanced generator topologies, superconducting generators, modular construction and onsite assembly techniques. Concepts that show promise to significantly improve torque density, overall system mass, and LCOE are sought. Up to two projects will be selected for demonstration at a commercially relevant scale in a representative industrial environment to accelerate incorporation into a commercial wind turbine. Specific technical goals:<br>o 50% improvement in torque density (Nm/m3) while maintaining an equivalent cost/torque<br>o 24% reduction in COE related to Levelized Replacement Costs (LRC) and Operations | program in partnership with industry to accelerate the development and commercialization of promising noise-reduction technologies. This A2e effort compliments the new generation of high tip-speed rotor designs that will be funded in FY 2016.<br>• The BRC Leading edge erosion and soiling study will be completed – this project examined the effect of leading edge erosion and soiling on the performance of the blade. The goal is to quantify the loss of performance through analysis and wind tunnel experiments.<br>• The complex aerodynamics project to experimentally assess resource characterization instrumentation will be completed.<br>• A new wake measuring instrumentation system at the SWiFT facility capable of measuring airflows at the wind turbine and wind plant level using systems such as high spectral resolution imaging lidars and mobile research radars will have been implemented in FY 2015. FY 2016 research efforts at SWiFT for the Near-Wake Characterization and High-Fidelity Model Development will use this system for collecting validation data. |

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| and/or supported by DOE supported organization.<br>• Continue the manufacturing initiative to enable taller land-based wind turbines. This initiative is tackling the problem of transportation and logistics challenges that have capped the size of land-based turbines, preventing further LCOE reductions thorough economies of scale. This multi-phase initiative is planned to specifically address taller towers, longer blades and larger drivetrains. In FY 2014, a FOA was issued for taller tower technologies. The FY 2015 FOA will address transportation and logistics barriers associated with very large turbine blades. Design innovations are sought to overcome the transportation barriers for blades longer than 60m and wider than 4.3m. Cost effective taller turbines will open up broad geographic areas in the US for wind turbine deployment that are currently uneconomical due to poor wind resource.<br>• Continue the following activities as part of the blade reliability collaborative (BRC):<br>▪ Effects of defects – This project will assess the ability of non-destructive inspection (NDI) technologies to detect manufacturing flaws in a cost-effective manner. The results will be used to determine the minimum economically detectable flaw size. The goal of this effort is to update the design standards to improve reliability of wind turbine blades by accounting for undetectable manufacturing flaws.<br>▪ Leading edge erosion and soiling study – continue examining the effect of leading edge erosion and soiling on the performance of the blade. The goal is to quantify the loss of performance through analysis and wind tunnel experiments. This project will be completed in | & Maintenance (O&M)<br>o 50% improvement in mean time between replacement of gearboxes and/or generators<br>o 20% reduction in deployment cost<br>▪ Develop and test new concepts in composites and resins that may be suitable as lower lifecycle cost blade manufacturing materials.<br>• Analyze and continue to collect meteorological and oceanographic data using offshore buoys.<br>• Investigate the impacts of hurricane wind and wave conditions on offshore wind turbines. FY 2016 efforts will add complexity to existing studies by examining the role of turbulence, shear, and other complex flow phenomena on loads.<br>• Offshore wind plant reliability R&D, including condition health monitoring and optimized O&M strategies tailored to offshore environment. The objectives of this task are to improve turbine availability, reliability and reduce O&M cost. Specific objectives include evaluation of oil sampling systems ability to indicate gear and bearing damage; evaluation of novel diagnostic and prognostic methods based on turbine SCADA data; and continuing to populate and analyze the gearbox failure database.<br>• The Wind Forecasting Improvement Project (WFIP) Phase 2.0 is a three year project targeted at better understanding atmospheric phenomenon in complex terrain. WFIP II will begin to analyze data gathered in FY 2015 and continue in FY 2016. The FY 2016 objective is to gather field data over an 18 month period starting in Q4 of FY 2015. In FY 2017, the field data will be used to improve forecasting models. The goal of WFIP II is a 10% improvement of the short term wind | |

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| FY 2015.<br>• Site, capital equipment, and testing facility maintenance, upkeep, and environmental compliance and safety support for NREL's research and test facilities at the NWTC, including the existing blade structural test facility, 225kW, 2.5MW and 5.0MW dynamometers, 7.0MVA Grid Simulator, and the Controls Advanced Research Turbines. The NWTC will continue to complete all scheduled and unscheduled maintenance and repair activities, as required, on all DOE turbines, test sites, met towers and site infrastructure to ensure safe and reliable operation of DOE-owned turbines, infrastructure, and test sites, as needed, to support field testing activities by DOE or outside partners. NWTC must remain in excellent condition in order to meet the demands of DOE and external testing requests. Technical staff will continue to complete O&M activities, as required, and document all activities within the NWTC's turbine sites database. The NWTC will continue to ensure research-grade instrumentation is operated and maintained in accordance with IEC and QA requirements, including changing instruments on all DOE test sites and meteorological towers at required calibration intervals (or sooner if failures occur from environmental factors) and maintaining documentation accordingly. Under this project all field test facilities will be operated and maintained in accordance with DOE safety orders, and will also meet the safety and operational certification standards required by the American Association of Laboratory Accreditation (A2LA). These world class research facilities support development of innovative blade testing methodology, wind | forecast that will result in savings of approximately $200-300M/year for the operators at current deployment levels.<br>• Site, capital equipment, and testing facility maintenance, upkeep, and safety support for NREL's research and test facilities at the NWTC, including the existing blade structural test facility, 225kW, 2.5MW and 5.0MW dynamometers, 7.0MVA Grid Simulator, and the Controls Advanced Research Turbines. The NWTC will continue to complete all scheduled and unscheduled maintenance and repair activities, as required, on all DOE turbines, test sites, met towers and site infrastructure to ensure safe and reliable operation of DOE-owned turbines, infrastructure, and test sites, as needed, to support field testing activities by DOE or outside partners. NWTC must remain in excellent condition in order to meet the demands of DOE and external testing requests. Technical staff will continue to complete O&M activities, as required, and document all activities within the NWTC's turbine sites database. The NWTC will continue to ensure research-grade instrumentation is operated and maintained in accordance with IEC and QA requirements, including changing instruments on all DOE test sites and meteorological towers at required calibration intervals (or sooner if failures occur from environmental factors) and maintaining documentation accordingly. Under this project all field test facilities will be operated and maintained in accordance with the standard original configuration. Under this project all field test facilities will be operated and maintained in accordance with DOE safety orders, and will also | |

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| turbine controls testing, and full-scale field testing of utility scale wind turbines and components.<br>• Support the development of blade and drive train test procedures and methods through partnerships with the Massachusetts blade test facility and the Clemson drive train facility. These state of the art facilities have unique testing capabilities and are sized to support the trend toward larger wind turbines for both utility scale and offshore wind.<br>• Implement a new wake measuring instrumentation system at the SWiFT facility capable of measuring airflows at the wind turbine and wind plant level using systems such as high spectral resolution imaging lidars and mobile research radars.<br>• Leverage FY 2014 investment to develop Distributed Wind Deployment System (dWindDS), a deployment modeling capability, to size the distributed wind market potential and analyze the factors most impacting deployment.<br>• NREL to conduct Round 3 of the Distributed Wind Competitiveness Improvement Program (CIP):<br>▪ Solicitation to develop next generation small and medium wind energy systems.<br>▪ Goal to reduce LCOE to be competitive with other distributed generation technologies and retail electricity rates, and increase the number of certified turbine models.<br>▪ Topics include component improvement and system optimization, advanced manufacturing, and product certification.<br>▪ Funding to make at least one award in each topic area.<br>• Continued market data collection, analysis, and reporting for performance tracking and to inform | meet the safety and operational certification standards required by the American Association of Laboratory Accreditation (A2LA). These world class research facilities support development of innovative blade testing methodology, wind turbine controls testing, and full-scale field testing of utility scale wind turbines and components.<br>• Support the development of blade and drive train test procedures and methods through partnerships with the Massachusetts blade test facility and the Clemson drive train facility.<br>• NREL to conduct Round 4 of the Distributed Wind Competitiveness Improvement Program (CIP):<br>▪ Solicitation to develop next generation small and medium wind energy systems.<br>▪ Goal to reduce LCOE to be competitive with other distributed generation technologies and retail electricity rates, and increase the number of certified turbine models.<br>▪ Topics will include component improvement and system optimization, advanced manufacturing, and product certification. Based on insights gained from workshops in FY 2015 additional topic areas may be developed.<br>▪ Funding to make at least one award in each topic area.<br>• Produce an annual Distributed Wind Market Report covering U.S. wind power in distributed applications—including small, mid-size, and utility-scale installations.<br>• Develop a distributed wind site assessor toolbox and qualification program to enable improved wind turbine siting with anticipated improvement in installed cost and system performance; thereby increasing public confidence in distributed wind | |

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| program strategy, including benchmark research, analysis, and reporting on the soft costs for distributed wind systems.<br>• Based on findings of FY 2014 Request for Information, conduct a workshop and research to analyze the baseline cost and accuracy of distributed wind system siting, soft costs, and performance prediction to identify improvement opportunities. | systems. | |

## Wind Energy
## Technology Validation and Market Transformation

**Description**

The Technology Validation and Market Transformation subprogram seeks to demonstrate and validate new wind energy technologies—for land-based, offshore, and distributed applications—in the U.S. In FY 2016, the focus is on overcoming the significant hurdles faced in building a U.S. offshore wind industry. The U.S. offshore wind industry is in its very early stages, with no commercial-scale offshore wind turbines having yet been installed in the nation's waters. In order to grow, industry must be able to show that offshore wind generation can be cost-competitive within the unique and regionally-diverse physical and market constraints of the U.S. In addition to cost, technology challenges include durability for extreme wind and wave events such as hurricanes, sensitivity to offshore operating conditions that are unique to the U.S., and compatibility with port and manufacturing infrastructure. Other challenges include trying to reduce permitting timelines, and validating performance in order to reduce financing risks.

With over 50 quads (equivalent to 4,000 gigawatts of wind generating capacity) of gross annual energy resources potential (more than three times the Nation's current annual electricity production) within 50 miles of U.S. coasts, offshore wind has the opportunity to become a major source of clean energy for the coastal and Great Lakes states that account for nearly 80 percent of U.S. electric demand. These states also tend to have high electricity rates and, in areas such as the Northeast and Mid-Atlantic, have carbon-intensive electricity supplies. Offshore wind offers a significant sustainable energy source with the potential to become competitive with local hurdle rates, and it can serve as a hedge against fluctuating fuel prices, without the need for long-distance overland transmission.

As a key part of the 2011 "National Offshore Wind Strategy: Creating an Offshore Wind Industry in the U.S.," the Department announced FY 2012 funding to seven offshore wind energy technology demonstration projects. In FY 2014, a competitive down-select was held, and three projects were selected for continued funding. The first will utilize an innovative, U.S.-developed twisted jacket foundation that is simpler and less expensive to manufacture and install than traditional offshore wind foundations. Additionally, it will utilize innovative farm control methodologies in order to maximize power production. The second will install and test a hurricane-resilient design to ensure that offshore wind facilities placed in hurricane-prone U.S. waters are reliable, safe, and cost-effective. Advanced turbine control methodology will be employed to maximize downstream turbine performance. The third will deploy a floating semi-submersible foundation demonstrating an innovative solution for deep water wind turbine projects and lowering costs by simplifying installation and eliminating the need for highly specialized ships.

Once the final engineering designs are complete, in FY 2016 the teams will begin procurement and fabrication of major project components, such as foundations and turbines. The subprogram will leverage a set of cooperative agreements that provide funding, technical assistance, and inter-agency coordination to accelerate the implementation of these projects. The subprogram also intends to validate new technologies to reduce costs through innovative designs for deep-water resource areas, eliminate uncertainties by tackling large-scale market and permitting barriers, and demonstrate innovative technologies that address key local concerns (e.g., marine mammal protection and electro-magnetic interference (EMI)) to support growth of a robust offshore wind energy industry. Projects are required to be grid-connected and producing power by the end of 2017.

The DOE Advanced Technology Demonstration activity will be funded at $40.0 million in FY 2016, year five of a six fiscal-year FOA, to provide important evidence to the global market — from financiers to original equipment manufacturers to engineer-procure-construct contractors to utilities — that offshore projects in the U.S. can actually be realized despite the challenges identified above, especially the need for technology optimized to U.S. conditions that provide a pathway to meet LCOE goals.

All of the projects will be well-instrumented and required to collect data for five years post-commissioning (FY 2017), which will be leveraged by the subprogram to establish a U.S.-specific performance baseline, inform improvements to design codes and standards, and identify further opportunities for technology refinement. By working through regulatory processes in both state and Federal waters, DOE, in coordination with appropriate sister agencies, can overcome

uncertainties by quantifying and reducing the risks and timelines associated with permitting and siting. Broad inter-agency collaboration with the DOE offshore wind effort is enabling areas of improvement and lessons-learned for future projects.

By funding these projects now, DOE is ensuring that the demonstrated technologies will not only address specific local domestic issues and opportunities, but can be competitive and innovative in the global market as offshore wind becomes an increasingly viable option for the growing clean energy economy. By lowering the cost of offshore wind through technology transfer and successful demonstration to the investment community, costs will be decreased, confidence gained, and deployment accelerated to directly support realization of the Administration's 2020 and 2035 clean energy goals.

**Technology Validation and Market Transformation**
**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **Technology Validation and Market Transformation** | | |
| **$46,250,000** | **$41,990,000** | **-$4,260,000** |
| • Complete review and independent verification of front-end engineering design and installation reports from three Offshore Wind Technology Demonstration projects. The reports will detail the relevant innovations and provide pathways toward deepwater deployment of offshore wind systems.<br>• Complete the environmental and permitting process for three Offshore Wind Technology Demonstration projects that provide timelines to commissioning in the 2017 timeframe.<br>• Initiate fabrication and installation of three Offshore Wind Technology Demonstration projects.<br>• Complete engineering and cost analysis of an innovative floating offshore wind platform, including the evaluation of the value proposition of building the platform out of composites instead of steel.<br>• Complete engineering and cost analysis of a friction wheel stabilized monopile offshore wind tower for the Great Lakes, monopile applicable to the unique icing and soil conditions in the Great Lakes, and to quantify the applicability of the unique foundation to other regions of the U.S. | • Continue fabrication and installation of three Offshore Wind Technology Demonstration projects. The three projects will continue to be evaluated and monitored by an independent third-party for validation and verification of cost, schedule and milestones to minimize risk and ensure a 2017 project commissioning. | • The decrease is a result of two engineering and cost analyses completed in FY 2015 and not continued in FY 2016. |

## Wind Energy
## Mitigate Market Barriers

**Description**

The Mitigate Market Barriers subprogram consists of all program activities to reduce the costs and duration of market barriers, including grid integration challenges and permitting issues such as the potential impacts of development on wildlife, radar systems, and airspace. One of the primary subprogram objectives is improving the ability of the industry to navigate the permitting process for wind power by developing and improving risk mitigation options for wildlife and radar concerns. Subprogram activities reduce investment uncertainties by enabling realistic capital and operating cost estimates for financing purposes.

In FY 2016, the subprogram will fund $12.4 million in activities to improve the understanding of risks to sensitive wildlife species and develop technologies that can mitigate those risks. New Eagle Impact Mitigation Technologies research will support R&D, and field-testing and validation of technologies to reduce the potential impacts of wind energy facilities on Bald and Golden Eagles. The subprogram will also greatly expand ongoing efforts to address the impacts of wind on sensitive avian and bat species more broadly, which will include both work to further refine bat mitigation solutions developed and tested under an FY 2015 Funding Opportunity Announcement as well as expanded research to better understand the potential risk factors associated with wind development to species currently being considered for listing under the Endangered Species Act that are particularly sensitive to habitat fragmentation, such as Greater Sage-Grouse and Greater and Lesser Prairie Chickens. These efforts will also include a new emphasis on research to improve the integration of real-time detection and mitigation of effects on wildlife of concern (such as the activation of deterrent devices or the operational alteration of wind facilities) into the operation of wind facilities. Additionally, the subprogram will develop wildlife impact mitigation monitoring and mitigation tools to facilitate environmentally responsible deployment of offshore wind technologies.

In FY 2016, the subprogram will fund research and work with federal and other agencies to further develop solutions to wind turbine-radar interactions, which seek to mitigate electromagnetic interference and enable industry to identify and employ mitigation technology and/or techniques. FY 2016 focus areas include algorithms to filter out wind turbine signatures from radar displays, fusion of multiple radars to increase coverage over and around wind facilities, and pilot deployments of high-TRL mitigation option at sites with high concentrations of wind turbines.

In FY 2016, the subprogram will fund $12.0 million in development of tools and analysis that better describe wind plants for grid system planning and grid operations analysis purposes, including the development of active power controls for turbines. Additionally, the subprogram will partner with a National Laboratory consortium to design, simulate and demonstrate a transactional energy ecosystem as the basis for accomplishing grid integration and realizing the full potential of energy and grid related opportunities. Such a system facilitates energy exchange between distributed energy technologies to improve grid balancing and increase system reliability.

In FY 2016, the subprogram will fund education and outreach activities to disseminate information and promote public understanding of wind technologies, with continued support to Wind Energy Regional Resource Centers (RRCs) to ensure that decision makers have accurate, impartial information about benefits and challenges facing wind deployment. In addition, young engineers and business students will be challenged to solve key wind energy technology and market problems through the Collegiate Wind Competition (CWC).

**Mitigate Market Barriers**
**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **Mitigate Market Barriers $11,207,000** | **$28,062,000** | **+$16,855,000** |
| • Collaborate with DOD, DHS, and FAA on the development and deployment of technologies that mitigate wind turbine effects on long range surveillance and airport radars. In FY 2015, DOE will deploy a wind farm modeling tool for wind farm developers and government agencies so that wind turbines can be sited without causing interference when in the line of sight of radar sensors, and initiate a program to validate high-TRL radar interference mitigation technologies at new and operating wind facilities.<br>• Support development of effective bat deterrent technology options and continue R&D into innovative methods for detecting and mitigating wildlife impacts at wind facilities through a Funding Opportunity announcement that will result in 4 to 6 projects focused on lab testing of low-TRL mitigation technologies and field demonstration and validation of high-TRL mitigation technologies to show significant reductions in bat mortality at wind facilities where these mitigation technologies are deployed.<br>• Through focused investment at DOE national labs, build off FY 2014 interagency work to develop novel Offshore Wind Environmental Assessment monitoring techniques and technologies necessary to support NEPA and other environmental permitting of future commercial offshore wind energy facilities. Begin to aggregate environmental data gathered by developers for later development.<br>• Engagement and Outreach – The subprogram | • Issue new Eagle Impact Mitigation Technologies solicitation and competitively select 5 to 7 research projects to support the development and validation of technologies that reduce potential impacts of wind energy facilities on Bald and Golden Eagles. These technologies currently are in the nascent stages of development but are necessary for the industry to obtain new permits required under the Bald and Golden Eagle Protection Act. A field-testing and validation component will independently test the performance of high-technology readiness level (TRL) measures such as eagle detection and deterrence devices, while an R&D focus component will be aimed at the development of lower-TRL concepts to improve the efficacy and reduce the cost of and need for detect-and-deter or other mitigation technologies. These include automated image-processing algorithms to improve detection rates and accuracy, as well as the development of advanced, site-specific eagle risk prediction models that could incorporate consideration of these risks as an additional variable in wind facility siting.<br>• Significantly expand ongoing laboratory efforts to address the effects of wind development on sensitive bird and bat species, including further work to refine bat mitigation technologies developed and demonstrated under an FY 2015 FOA, a renewed emphasis on research to better understand and mitigate risks of wind development on species of habitat fragmentation | • The increase results from new Eagle Impact Mitigation Technologies research that will support the development of mitigation technologies necessary for the industry to obtain new permits required under the Bald and Golden Eagle Protection Act;<br>• A major expansion of ongoing efforts to address the effects of wind development on sensitive wildlife more broadly, including work following on an FY 2015 FOA to develop and demonstrate bat mitigation technologies, a renewed focus on species at risk of habitat fragmentation from wind, such as Greater Sage-Grouse, and R&D to improve the integration of detection of sensitive species and mitigation measures into wind farm operations; and<br>• The increase results from a combination of new and increased continuing activities related to DOE's Grid Modernization Crosscut efforts and managing distributed assets and the next-generation distribution management system with OE. This includes implementation of DOE's multiyear plan related to a grid modernization laboratory consortium. |

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| works to disseminate accurate and impartial technical information about wind energy's impacts and benefits. In FY 2015 the subprogram will:<br>o Support stakeholder engagement activities including the continuation of six Wind Energy Regional Resource Centers across the country working to reach key stakeholders in their respective regions and disseminate critical information such as new wind potential maps and facts about improvements in wind turbine technologies and siting techniques that open up significant wind deployment opportunities in previously non-viable markets, such as the Southeastern U.S. During this first year, the Centers plan to impact over 4,000 key stakeholders to meet their performance goals.<br>o To address anticipated workforce shortages in selected fields, in FY 2015 the subprogram will initiate planning for the next Collegiate Wind Competition (expected spring 2016) including selection of participants, challenge topic and rules development, and competition event planning.<br>• Characterized the capabilities of the controllable grid interface at NWTC, a critical test capability which allows industrial users and researchers to subject wind turbine drivetrains to severe electrical power anomalies in a safe, controlled, laboratory environment. The controllable grid interface provides the capability to conduct grid fault tests in compliance with international standards at significantly reduced time and cost when compared to field testing.<br>• Continue analysis of high wind-penetration scenarios to inform wind technology roadmaps for better meeting power system operational | concerns, such as Greater Sage-Grouse, and expanded R&D on technologies to improve the real-time detection of wildlife species of concern and implementation of mitigation measures such as deterrents or operational changes to wind facilities.<br>• Develop a comprehensive one-stop permitting resource and application toolkit, leveraging the Renewable Permitting Information Dashboard (RAPID) developed by the Solar and Geothermal Programs, to help standardize the process and significantly reduce uncertainty in permitting timelines and costs for developing wind energy projects on federal lands.<br>• Initiate a National Public Acceptance Baseline Study to provide the first quantitative assessment of the factors associated with public acceptance of wind energy development across the country.<br>• With interagency partners, continue to develop measures to mitigate wind turbine-radar interactions.<br>• Continue support to WINDExchange and Wind Energy Regional Resource Centers to ensure decision-makers are using the best available science to support decisions around wind energy policies and projects.<br>• Continue level support to the Collegiate Wind Competition to challenge students to solve key engineering and business challenges facing wind energy technologies by engaging 150-180 students from 10-12 universities across the country. The competing teams have not yet been selected.<br>• Conduct next generation integration studies utilizing newly developed 10-year wind data sets, including a Pan-North American variable generation and hydropower integration study | |

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes<br>FY 2016 vs FY 2015 |
|---|---|---|
| requirements.<br>• Initiate development of tools and algorithms for stochastic representations of wind power output and for determining the lowest cost strategies for enhancing flexibility for wind technologies on a regional basis.<br>• Develop tools for concurrent cooling and dynamic transmission line rating.<br>• Continue evaluation of the impact of high penetrations of renewable energy on the electricity grid. | looking across North America.<br>• Further develop the wind-based transmission line planning tool architecture.<br>• Improve integration of wind forecast information into grid operational tools.<br>• Further refine active power controls capabilities at a wind farm level (coordinated with the program's A2e efforts).<br>• In support of DOE's Grid Modernization crosscut, funding will be used to evaluate regional flexibility capabilities, including support for initiation of longer term studies leveraging work completed in the Western and Eastern U.S. (e.g. Western Wind and Solar Integration Studies, Eastern Regional Grid Integration Studies) that determine the impact of wind technologies on a more regional basis.<br>• As part of the greater DOE Grid Modernization crosscut, the Wind Energy Program develops tools and algorithms to develop stochastic representations of wind power output; and determining the lowest cost strategies for enhancing flexibility for wind technologies on a regional basis. | |

## Wind Energy
## Modeling and Analysis

**Description**

The Modeling and Analysis subprogram consists of all program activities regarding crosscutting tool development and analysis to support effective, proactive annual, multi-year and multi-decade program planning and project management, annual market reporting and technology and investment assessments. Use of analysis tools—including reference models, systems engineering models, and deployment models—is critical to justify the basis for maintaining and/or modifying program implementation strategies. Analysis helps prioritize the highest impact program activities and helps identify additionally needed analysis tools and improvements.

The Modeling and Analysis subprogram also includes all program activities to effectively plan, integrate, implement, and report in accordance with the annual operating plan and the EERE and program Strategic Plans. The subprogram also provides strategic support to the program and DOE national laboratories and technology partners with the program. This includes activities that support overall program communications needs and requirements and plays an important role in disseminating the success of program initiatives. Under communications, the subprogram develops, provides, and disseminates meaningful, impactful communications that inform stakeholders of DOE's efforts in managing the public's investment in wind technologies as well as improving the performance and lowering the cost of wind power.

Modeling includes wind-specific estimations of electricity production cost, electric sector capacity expansion, and national energy-economy modeling activities. Specific focus areas include wind technical and economic feasibility analysis, and technology deployment analysis. In FY 2016, the Modeling and Analysis subprogram activities include wind techno-economic and life-cycle assessments to help the program focus its technology development priorities and identify key drivers and hurdles for wind energy technology commercialization. These enhanced capabilities will allow the program to better identify and fund technology improvement opportunities that will have a significant and more immediate impact on the wind industry. In FY 2016, the subprogram will complete a revised wind cost (LCOE) model that provides a more refined estimate of total system cost based on current cost trends that exist today in the wind energy market. Additionally, the model will contain a parametric capability that allows the program to perform cost sensitivity analyses based on the incorporation of several new and emerging technologies applied to the current technology platforms for both land based and offshore wind. In FY 2016, the Distributed Wind Deployment System (DWDS) expansion model will be fully integrated into the Regional Energy Deployment System (ReEDS).

In FY 2016, the subprogram will continue to support outreach and engagement activities related to the public dissemination of the Wind Vision study. These groundbreaking documents will communicate to the public-at-large the program's insights and priorities in R&D investments. In FY 2016, the subprogram will look to align, update and coordinate program strategic planning with emerging DOE and EERE strategies. The subprogram will implement a merit review process for all new proposed projects; seeking input on program direction from both industry and academic experts before launching new initiatives. Audit and merit reviews are conducted to assess program performance and prioritization, as well as compliance with regulatory and statutory requirements. National Laboratory management includes activities to manage the investments and support activities performed by the National Laboratories supporting the program.

**Modeling and Analysis**
**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **Modeling and Analysis $10,185,000** | **$12,588,000** | **+$2,403,000** |
| • Collect and analyze wind cost and deployment data to understand current market status and future potential.<br>• Provide unbiased wind market information to stakeholders to decrease uncertainty about wind power project performance.<br>• Publish the Annual Wind Market Report that provides unbiased information to stakeholders on the health of the domestic wind market in the U.S.<br>• Conduct technology characterization data gathering, system cost analyses using lab generated analysis tools and evaluate the impact of new technologies on system cost (sensitivity analyses).<br>• Initiate scoping and development of a requirements document for an integrated wind plant system model that integrates cost models with system dynamics models (blade models, drivetrain models, floating platform models, etc.). This will be a first of its kind model, which will be used to link engineering metrics to the cost of energy model, thereby allowing the program to better identify technology improvement opportunities.<br>• Apply and improve core capacity expansion models—including ReEDS, Plexos and NEMS— to identify and leverage opportunities for accelerated wind deployment.<br>• NREL ReEDS revised to incorporate Distributed Wind Generation estimates.<br>• Lower barriers to wind energy deployment by increasing the familiarity with variable wind generation's actual costs and benefits with the five | • Collect and analyze wind cost and deployment data to understand current market status and future potential.<br>• Provide unbiased wind market information to stakeholders to decrease uncertainty about wind power project performance.<br>• Publish the Annual Wind Market Report that provides unbiased information to stakeholders on the status of the domestic wind market in the U.S.<br>• Conduct technology characterization data gathering, system cost analyses using lab generated analysis tools and evaluate the impact of new and emerging technologies on system cost (sensitivity analyses).<br>• Complete development and validation of integrated wind plant system model, which couples state of the art dynamics (blades, drivetrain, floating platform etc.) and cost models for the purposes of understanding how specific innovation opportunities will impact LCOE. This will be a first of a kind model in its emphasis on plant or system level impacts rather than individual plant components (e.g., turbine, installation, layout) and will support a much higher degree of sophistication in programmatic R&D strategy development.<br>• Apply and improve core capacity expansion models—including ReEDS, Plexos and NEMS—to identify and leverage opportunities for accelerated wind deployment.<br>• Lower barriers to wind energy deployment by increasing the familiarity with variable wind generation's actual costs and benefits with the five | • The increase is due to development of advanced analytical capabilities to quantify potential impacts of programmatic R&D investments, including LCOE impacts, at the system level. A significant amount of work and manpower is required to derive and code a model that evaluates technological plant and system improvements and how these changes impact the cost of energy derived from the overall system. |

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes<br>FY 2016 vs FY 2015 |
|---|---|---|
| Power Markets within the U.S.<br>• Develop and implement processes to gather, evaluate, verify, and analyze data and information regarding technical and project management performance and progress relative to the program's cost and performance goals.<br>• Support and participate in program comprehensive wind energy project reviews.<br>• Develop and update multiyear program plans (MYPP), technology roadmaps, and vision reports. | Power Markets within the U.S.<br>• Continued to implement processes to gather, evaluate, verify, and analyze data and information regarding technical and project management performance and progress relative to the program's cost and performance goals.<br>• Support and participate in program comprehensive wind energy project reviews.<br>• Develop and update MYPP technology roadmaps, and vision reports. | |

## Wind Energy
## NREL Site-Wide Facility Support

**Description**

In FY 2016, EERE programs will continue to directly fund NREL site-wide facility costs that are not included in the Facilities and Infrastructure budget rather than fund those costs as laboratory overhead. This approach is consistent with Generally Accepted Accounting Practices and DOE management at other National Laboratories. EERE began this practice in FY 2014 to effectively control NREL's labor rate multiplier. One outcome has been reducing the cost of accessing unique NREL capabilities (such as facilities and staff expertise) by industry and academia. This practice also makes site operating costs more transparent in order to facilitate cost control and planning. In FY 2014, this practice resulted in a reduction in the Lab-wide direct labor multiplier of approximately 15 percent compared to FY 2013. The proposed FY 2016 Budget Request continues the approach applied in FY 2014 and FY 2015.

This subprogram funding supports research programs by providing basic site services, functions, and infrastructure for site operations, which includes: management, building operations, building and grounds maintenance, fire and emergency response, engineering and construction support, minor construction projects, electrical safety program, utilities, and facilities planning support; and activities within the Sustainability and Environmental Health and Safety (EHS) portfolios. These activities and their costs are relatively fixed and only vary significantly based upon variations in commodities, construction activity, emergencies, weather patterns, etc. They are considered to be the core functions for site operations, safety, environmental compliance, and sustainability at NREL. In FY 2016, this funding will continue to support more than 60 full time equivalents that manage and provide support for these core functions. It will also fund site-wide subcontracts such as janitorial services, refuse and recycling, and subcontracts for minor construction. Additionally, this funding will support site-wide costs associated with maintaining NREL's leadership position, such as: maintaining International Organization for Standardization (ISO), American Association for Laboratory Accreditation (A2LA), and other lab-wide accreditations, managing facilities to enable mission goals, improving sustainability, pollution prevention, waste minimization, improving energy efficiency, reducing water use, and maintaining an effective emergency management system.

The FY 2016 Budget Request remains consistent with the method EERE developed in FY 2015. This approach is a more precise, equitable, and economically neutral method that ensures a predictable net-zero impact on programs' funding. For each program, the contribution to direct funding for site-wide facility support is equivalent to the estimated contribution the program otherwise would have made through overhead charges. This method is based upon each program's level of funding to NREL, adjusted to account for anomalies from large capital expenditures and major subcontracts.

**NREL Site-Wide Facility Support**
**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **NREL Site-Wide Facility Support $4,700,000** | **$4,700,000** | **$0** |
| • Directly fund NREL site-wide facility support costs that are not included in the Facilities and Infrastructure budget rather than continue to fund these costs in the laboratory overhead rate. | • Directly fund NREL site-wide facility support costs that are not included in the Facilities and Infrastructure budget rather than continue to fund these costs in the laboratory overhead rate. | • No Change. |

## Wind Energy
## Performance Measures

In accordance with the GPRA Modernization Act of 2010, the Department sets targets for, and tracks progress toward, achieving performance goals for each program.

| | FY 2014 | FY 2015 | FY 2016 |
|---|---|---|---|
| Performance Goal (Measure) | **Onshore Wind- Cost of land-based wind energy (cents/kWh)**[1] | | |
| Target | 7.2 | 6.7 | 6.5 |
| Result | Exceeded - 6.9 | Not Applicable | Not Applicable |
| Endpoint Target | 5.7 cents/kWh by 2020<br>4.2 cents/kWh by 2030 | | |
| Performance Goal (Measure) | **Offshore Wind - Cost of offshore wind (cents/kWh)** | | |
| Target | 20 | 18.5 | 18.1 |
| Result | Exceeded – 18.8 | Not Applicable | Not Applicable |
| Endpoint Target | 16.7 cents/kWh by 2020<br>13.6 cents/kWh by 2030 | | |

[1] All targets at a 7 percent discount rate.

## Water Power

**Overview**

The Water Power Program supports research, development, demonstration, and deployment (RDD&D) in two distinct renewable power domains: (1) Hydropower and (2) Marine and Hydrokinetic (MHK) energy.

With 78 gigawatts (GW) of installed capacity, hydropower currently provides approximately 50 percent of all U.S. renewable electricity generation and 7 percent (213 terawatt hours, or TWh, in 2013) of annual total U.S. electricity production. The Water Power Program's Hydropower RDD&D activities support critical efforts in technology development, market acceleration and grid integration across three important hydropower resource classes: (1) Existing Water Infrastructure, (2) Undeveloped Streams, and (3) Pumped-Storage Hydropower. The existing water infrastructure resource class represents up to 12 GW (31 TWh/year) of technical hydropower resource potential, of which a portion may be economically feasible to add to the U.S. electrical grid from the development of non-powered dams,[1] after considering environmental limitations, dam integrity and safety issues, and existing non-energy uses such as flood control, water supply, navigation, environmental restoration, or recreation. In addition, restoring and upgrading existing hydropower facilities represents up to an additional 5 GW (approximately 13 TWh/year) of potential capacity.[2] The Water Power Program's assessment of this existing water infrastructure resource class calls for technology advancements that reduce environmental footprints, lower replacement and production costs, and enable more robust management of increasingly complex and competitive water resource demands. Developing hydropower technology from undeveloped streams represents another opportunity to increase the generation of renewable electricity throughout the country. Undeveloped streams resource class – those segments of natural waterways outside the physical footprint of existing water infrastructure – represents over 60 GW (340 TWh/year) of technical hydropower resource potential, of which a portion may be economically feasible to develop after factoring other uses and environmental considerations including threatened and endangered species. The third resource class, pumped storage hydropower (PSH), represents an opportunity for hydropower to enable the integration of variable renewable generation, such as wind and solar power, into the U.S. electrical grid. The Water Power Program's focused approach to hydropower RDD&D, known hereafter as the "HydroNEXT Initiative," is a comprehensive strategy that addresses the entire technology RDD&D pipeline across each of the resource classes noted above. Initially, HydroNEXT will focus on new and innovative generation technology development, including performance testing and environmental validation. Promising hydropower technologies identified in the initial phase will be considered for demonstration and ultimately deployment by industry.

With more than 50 percent of the U.S. population living within 50 miles of the Nation's coasts, MHK technologies, such as those that capture energy from ocean currents, river currents, and waves, hold significant potential to supply renewable electricity to consumers in coastal load centers, particularly in areas with high costs of electricity. The Water Power Program has determined that cost-effective MHK technologies could provide a substantial amount of valuable renewable electricity for the Nation due to the MHK technical resource potential, as well as its proximity to major coastal load centers, predictability, and forecastability. This potential (technically extractable) resource includes 1170 TWh/year of wave energy[3], 250 TWh/year of tidal energy[4], and 283 TWh/year of combined ocean and river current energy located throughout diverse regions of the continental U.S., Hawaii, and Alaska of which a portion may be economically feasible to develop.[5,6] For

[1] An Assessment of Energy Potential at Non-Powered Dams in the U.S. Prepared for the U.S. Department of Energy, Wind and Water Power Program by Oak Ridge National Laboratory, April 2012.

[2] Zhang, Q. and B. T. Smith. 2014. Final Report: Demonstration Assessments of the Hydropower Advancement Project. ORNL/TM-2014. Oak Ridge, TN: Oak Ridge National Laboratory. 2014.

[3] P. Jacobson, G. Hagerman, and G. Scott, (2011). "Mapping and Assessment of the U.S. Ocean Wave Energy Resource," Electric Power Research Institute, Report Number 1024637, 2011.

[4] K. Haas, H. Fritz, S. French, B. Smith, and V. Neary, (2011). "Assessment of Energy Production Potential from Tidal Streams in the U.S.," Georgia Tech Research Corporation, 2011.

[5] K. Haas, H. Fritz, S. French, and V. Neary, (2013). "Assessment of Energy Production Potential from Ocean Currents Along the U.S. Coastlines," Georgia Tech Research Corporation, 2013.

[6] T. Ravens, K. Cunningham, and G. Scott, (2012). "Assessment and Mapping of the Riverine Hydrokinetic Resource in the Continental U.S.," Electrical Power Research Institute, Report Number 1026880, 2012.

example, based on other energy industries' recovery of technically available energy, extracting just five percent of the technical resource potential for the U.S. could result in MHK powering seven million American homes with clean energy.

DOE investments in high-risk, early-stage MHK technology development, and key supporting design tools used broadly by this emerging sector, currently fill a critical gap that the private sector is unable to address sufficiently on its own. DOE's MHK portfolio focuses on funding innovation to drive down the cost of electricity through significant performance improvements and reductions in initial investment costs. Cost-competitiveness of MHK energy will require that individual devices can capture more than double the amount of energy than is technically feasible by current prototypes. The Water Power Program is committed to a multi-pronged effort that will allow the MHK sector to rapidly advance and achieve cost-competitiveness with local hurdle rates in major coastal load centers by 2030. Based on the quantitative estimates of resource and deployment potential resulting from these assessments, the MHK subprogram will place priority focus on technology development for wave energy devices while continuing to support key tidal and ocean current energy developments.

**Highlights of the FY 2016 Budget Request**

Existing U.S. hydropower assets and water infrastructure provide opportunities to recover, optimize, and add new capacity with advanced and sustainable hydropower technologies. Specifically, FY 2016 activities in this area are the first step in a multi-year HydroNEXT program that supports enabling technology that allows for growth in hydropower from currently non-powered dams (NPD). The initial focus of research and development (R&D) will be on modular powertrain technologies with the potential to minimize the need for costly, customized, site-specific engineering at existing NPD sites. NPD's represent up to 12 GW (31 TWh/year) of technical hydropower resource potential, of which a portion may be economically feasible to develop. After considering environmental limitations, dam integrity and safety issues, and existing non-energy uses, a portion of this technical potential may be economically feasible to develop to expand the amount of reliable base-load low-carbon electricity in the U.S. The Hydropower Technologies subprogram is seeking to unlock this resource through investments in modular technology R&D and standardized site engineering templates and environmental evaluations, and through continued collaborations with relevant Federal agencies to improve regulatory efficiencies.

The Hydropower Technologies subprogram has determined through a comprehensive technical resource assessment, released in FY 2014, that undeveloped streams in the U.S. represent more than 60 GW of potential hydropower capacity of which a portion may be economically feasible to develop after factoring other uses and environmental considerations including threatened and endangered species. New hydropower facilities with less than 30 megawatts (MW) of capacity represent the majority of development opportunities. However, the expansive and expensive civil works typically required by conventional technology and development designs overwhelm the cost-benefit feasibility of new projects. As a result, advances in technology to promote low-impact new development by reducing civil and environmental impact mitigation costs are required to improve the cost-benefit ratio of these new projects. Building on FY 2015 investments, FY 2016 activities in this area will focus on continued advances in high efficiency modular powertrains.

In FY 2016, small-scale standardized modular PSH technology R&D will target reduction of powertrain costs, and costs associated with civil works, typically 40 to 50% of total project costs, to achieve feasibility in distributed (<1 MW), municipal-industrial-commercial (1 to 20 MW), and utility (20 to 100 MW) scale contexts for PSH deployment. Specific R&D activities will initiate PSH research and development by investing in innovation in two areas: (1) scalable PSH facility designs using commercial off-the-shelf (COTS) pumps, turbines, piping, tanks, and valves to achieve reductions in PSH deployment costs, and (2) hybrid PSH technology designs combining water storage with other forms of energy storage within energy and water delivery and collection systems.

Shared test facilities provide industry with a cost-effective means by which to test and validate their as-built designs and are critical to demonstrate the risk reduction required to enable follow-on private sector financing. In FY 2016, the MHK subprogram will complete front end engineering and design for a potential full-scale grid-connected open water wave test facility capable of testing and demonstrating Wave Energy Converter (WEC) components and systems under operating and survival conditions. The results of this completed engineering and design phase will be used to support a programmatic go/no-go decision on further facility construction funding. To support the emerging industry, the facility would have four test berths at depths greater than 50 meters, with an annual average power density greater than 30 kilowatts per meter (kW/m) to allow for survivability tests. This project will leverage the results from the MHK subprogram's FY 2013 awards that are evaluating site locations and delivering preliminary designs and cost estimates.

In FY 2016, the MHK subprogram will support projects that integrate innovative WEC components into prototype systems and test and validate these innovative prototype systems through open water demonstrations and testing. Significant improvements in system performance are necessary to achieve a doubling of the absorbed power of MHK devices, a key element of MHK device cost-competitiveness in early entry markets. This effort builds on previous program technology research and development efforts, such as the Systems Performance Advancement projects. Components targeted for systems integration and testing within this area include Advanced Controls; Advanced Power Take-Off (PTO); and Optimized Structures.

Having accurate and cost-effective monitoring instrumentation will be a key element in acquiring MHK environmental permits in a predictable and timely manner and reducing overall project costs. Existing instruments are challenged by the high energy, often low light conditions of MHK settings, as well as by the limited availability of automated data processing tools for the large amounts of information collected. In FY 2016, the MHK subprogram will build upon its work initiated in FY 2015 to develop and test new environmental monitoring instrumentation. Successful tests and demonstrations in laboratory and controlled environments will be followed by open-water tests in conjunction with the deployment of MHK devices, where possible.

A Water Technology Program "Incubator" funding opportunity will invest 5 percent of Water Technology Program funding toward new off-roadmap innovative technologies and solutions that can help meet existing goals but are not represented in a significant way in the current portfolio or technology roadmaps. Successful Incubator projects will reduce the risk associated with potentially breakthrough approaches and technologies so they may be "on-ramped" to future program roadmaps and the program portfolio.

Within the FY 2016 Budget Request, the Water Power Program supports one Departmental Crosscut: Energy-Water Nexus. The Energy-Water Nexus crosscut is an integrated set of investments and cross-program collaborations that: (1) support a national data, modeling, and analysis platform to improve understanding and inform decision-making for a broad range of users and at multiple scales; (2) strategically target crosscutting technology opportunities within the system of water and energy flows that offer the greatest opportunity for positive impact; and 3) are informed, supported, and strengthened by focused policy analysis and stakeholder engagement. These investments position DOE to contribute strongly to the Nation's transition to more resilient energy and coupled energy-water systems.

**FY 2016 Crosscuts ($K)**

| | Energy-Water Nexus | Total |
|---|---|---|
| **Water Power** | **1,000** | **1,000** |

**Water Power**
**Funding ($K)**

| | FY 2014 Enacted[1] | FY 2014 Current[2] | FY 2015 Enacted | FY 2016 Request | FY 2016 vs FY 2015 |
|---|---|---|---|---|---|
| **Water Power** | | | | | |
| Hydropower Technologies | 17,290 | 16,973 | 19,200 | 25,500 | +6,300 |
| Marine and Hydrokinetic Technologies | 41,275 | 40,861 | 41,100 | 40,800 | -300 |
| NREL Site-Wide Facility Support | 0 | 0 | 700 | 700 | 0 |
| **Total, Water Power** | **58,565** | **57,834** | **61,000** | **67,000** | **+6,000** |

SBIR/STTR:

- FY 2014 Transferred: SBIR $640,000; STTR $91,000
- FY 2015 Enacted: SBIR $880,000; STTR $121,000
- FY 2016 Request: SBIR $1,071,000; STTR $161,000

[1] FY 2014 Enacted funding reflected the contractor foreign travel rescission of $34,956.
[2] Funding reflected the transfer of SBIR/STTR to the Office of Science.

**Water Power**
**Explanation of Major Changes ($K)**

| | FY 2016 vs FY 2015 |
|---|---|
| **Hydropower Technologies:** The increase is due to an expanded focus of the new HydroNEXT Initiative to leverage existing water infrastructure (Non-Powered Dams) and undeveloped steams for increased hydropower generation. Specifically for non-powered dams, investments will focus on: (a) standardized modular powertrain technologies; and (b) standardized site engineering designs and approaches. Regarding undeveloped streams, the key focus will be on innovations in structural materials and construction methodologies that reduce costs and environmental disturbance. | **+6,300** |
| **Marine and Hydrokinetic Technologies:** No significant change in funding. | **-300** |
| **Total, Water Power** | **+ 6,000** |

**Description**

Encompassing the breadth of the Hydropower Technologies subprogram, the new overarching HydroNEXT Initiative is a comprehensive technology development-to-deployment strategy across the three hydropower resource classes: (1) Existing Water Infrastructure; (2) Undeveloped Streams; and (3) Pumped-Storage Hydropower (PSH). Although the timeline and horizon of the HydroNEXT initiative is different for each resource class, the Hydropower Technologies subprogram is committed to investing in R&D that explores technology pathways to ensure sustainability, lower costs, and lower environmental impacts of hydropower.

Today, existing U.S. hydropower assets provide 50 percent of all renewable generation and, on average, provide 7 percent of annual electricity generation. As a result of extensive research identifying areas of opportunity in the hydropower sector, the Hydropower Technologies subprogram is extremely well positioned to invest in R&D activities that could improve the energy, capacity, value, and security services that the hydropower sector contributes to the nation's electricity future. Working under a memorandum of understanding (MOU) between DOE, the Department of Interior (DOI), and Department of Defense (DOD) for hydropower research, the Hydropower Technologies subprogram developed databases that support a comprehensive and shared understanding of the age, condition, design characteristics, and energy contributions of the entire 78 GW of hydropower and 22 GW of pumped-storage units currently installed in the U.S., including those within the Federal fleets of the Army Corps of Engineers, Bureau of Reclamation, and Tennessee Valley Authority. The Hydropower Technologies subprogram has also completed technical resource assessments for non-powered dams and undeveloped streams including information on water availability, environmental sensitivity, and development feasibility. The Hydropower Technologies subprogram will use these key foundational resources to inform future R&D priorities.

Within the Existing Water Infrastructure resource class, the capacity, energy, and value of hydropower from existing and non-powered dams (NPD) can be developed, maximized, and sustained with technology advancements that reduce environmental footprints, lower hydropower replacement and production costs, and enable more robust management of increasingly complex and competing water uses. Roughly half of the hydroelectric units in the U.S. have major components that are over 50 years old, with a preponderance of small, privately-owned machines that require innovative material, rehabilitation, and environmentally sound mitigation technologies to sustain their capability and value. To address these needs, the subprogram will focus on advancing standardized low-cost add-on modular powertrain technologies and standardized site engineering designs and approaches. The first part of this effort will invest in innovative technology solutions that achieve scalability through module demonstrations to develop a well-defined and standardized profile of safety and environmental requirements with a goal of reducing soft costs. The second part of this effort will target the creation of pre-approved, technology-agnostic site design packages that reduce or eliminate the risks of unforeseen safety, environmental, or regulatory design changes for NPD development.

Undeveloped streams – those segments of natural waterways outside the physical footprint of existing water infrastructure – represent over 60 GW (340 TWh/year) of technical hydropower resource potential. The subprogram's focus on the Undeveloped Streams resource class will invest in developing powertrain and component technologies with low-impact, low-cost potential. Efforts in FY 2016 will address challenges associated with: (1) high-cost Balance of Plant (BoP) components (civil infrastructure and associated equipment not-included in the powertrain); and (2) environmental concerns of establishing new permanent structures in previously undeveloped stream reaches. Construction, installation, and civil works account for more than half of baseline costs and can have significant environmental impacts when developing new streams for hydropower, yet innovation in this area has been slow to develop. In FY 2016, the Hydropower Technologies subprogram will focus on hydraulic, structural, materials, and construction innovations and prototype testing to reduce the cost, footprint, and environmental disturbance of siting, supporting, installing, and operating advanced powertrain technologies identified in FY 2015.

In FY 2016, the Hydropower Technologies pumped storage subprogram will continue to investigate the dependencies of cost, risk, and revenue streams on modular Pumped Storage size and capacity. The program will continue to explore the benefits of modularizing PSH technology with low-cost, highly-standardized compact components that can be aggregated to meet capacity and storage requirements of a specific development opportunity. Investments in FY 2016 initiate small-scale modular PSH technology R&D, and will include a small scale modular PSH conceptual design and feasibility analysis. Finally,

the subprogram will invest in a North American Variable Grid Integration Study to understand the future opportunities for hydropower to contribute to a future energy system with higher concentrations of variable sources of generation.

Finally, in order to serve as an environmental steward for all hydropower resource class R&D activities, the Hydropower Technologies subprogram will integrate cross-cutting market acceleration and deployment activities that can be applied to all new technology, independent of the resource class application. In FY 2016, the subprogram will identify and leverage existing Federal, university, or industry hydromechanical test facilities with the water flow capacity and water pressure capability to support full-scale performance and reliability testing of low-impact low-cost technologies for undeveloped streams.

In order to address environmental concerns associated with unvalidated turbines or operation methods, the Hydropower Technologies subprogram will fund research as needed to improve biological design tools used in the development of hydropower turbine units. This work will be coordinated with private turbine developers and partner Federal agencies, and can benefit both systems installed at new projects as well as upgrades and retrofits at existing hydropower facilities. The Hydropower Technologies subprogram will also leverage National Laboratory, university, and Federal partners with ecological and environmental science research capabilities to focus specifically on predicting and validating the response of the aquatic environment to low-impact technology deployment. Research will include physical experiments to validate computational models as well as establishment of laboratory and field testing protocols to validate the low-impact status of new technologies. These studies and validation tools will be crucial for ensuring the sustainability of these new systems as defined by community, environmental, and regulatory stakeholders.

Efforts to support regulatory process improvements, in coordination with a suite of Federal partners, will build upon FY 2015 work to develop and improve the RAPID (Renewable Energy Application and Permitting Desktop) Toolkit for hydropower. While DOE is not an active participant in regulatory and permitting processes for hydropower, DOE's mission to promote the development of renewable energy technologies requires that DOE address all barriers to development, including regulatory and permitting issues. Maintaining an active understanding and awareness of regulatory challenges, facilitating conversations amongst regulatory agencies, and providing useful data and information, enables DOE to meet its mission. The RAPID Toolkit will positively impact two significant cost uncertainties faced by the hydropower industry by increasing transparency and access to information about hydropower regulatory processes, and reducing the time associated with permitting new projects. This effort will be coordinated with other Federal partner agencies (FERC, Army Corps of Engineers, Bureau of Reclamation, NOAA, FWS, etc.) and will leverage similar ongoing projects within EERE's Geothermal and Solar Technologies Programs.

In coordination with other DOE research focused on the Energy-Water Nexus, in FY 2016 the Hydropower subprogram will initiate work to expand the number and diversity of hydropower systems represented in integrated assessment models, with the aim of identifying their potential effects and benefits to other water and energy systems (such as thermal generation units). This is important for evaluating the complex interrelationships associated with long-term, systems-level changes like major infrastructure improvements or changes in water availability or allocation.

**Hydropower Technologies**
**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **Hydropower Technologies $19,200,000** | **$25,500,000** | **+$6,300,000** |
| • Initiate the HydroNEXT initiative to focus on accelerating the use of hydropower through program activities to lower the cost, improve the performance, and reduce the environmental impacts of hydropower:<br>▪ Release a Funding Opportunity to develop technology associated with undeveloped streams such as civil works and powertrain technologies.<br>▪ Initiate a competitive project to develop hydropower development cost model, including LCOE analysis.<br>▪ Continue the development of tools and technologies to improve the environmental performance of new and existing hydropower systems, and initiate collaborations to support regulatory process improvements for accelerated permitting.<br>▪ Continue Clean Energy Manufacturing Initiative activities for the research and advancement of innovative manufacturing processes that can be used to develop lightweight materials for hydropower turbines to drive down LCOE from reduced equipment and powerhouse costs.<br>▪ Support Incubator activities that will enable introduction of off-roadmap, transformational new energy technologies into the EERE portfolio, dramatically increasing the rate of technology innovation.<br>▪ Fund efforts to evaluate feasibility of small-scale, modular Pumped Storage Hydropower through a technology and cost-benefits analysis. | • Under the HydroNEXT initiative, solicit and competitively select multiple projects focusing on new hydropower technology for non-powered dams. This effort will identify and demonstrate new technologies associated with powertrain and civil works that will minimize construction costs and environmental impacts.<br>• Issue a solicitation and competitively select multiple projects that will advance conceptual designs for modular and small PSH. This effort will focus on the ability to use Commercial Off-the-Shelf (COTS) pumps, turbines, piping, tanks, and valves to achieve reductions in PSH deployment costs, and hybrid PSH technology designs combining water storage with other forms of energy storage within energy and water delivery and collection systems.<br>• Identify and leverage existing Federal, university, or industry hydromechanical test facilities for full-scale performance and reliability testing of low-impact powertrain and components testing.<br>• Support hydraulic, structural, materials, and construction design innovations that reduce the cost, footprint, and environmental disturbance of siting, supporting, installing, and operating promising powertrain technologies through a low-impact, low cost balance of plant design initiative.<br>• Validate the environmental performance and sustainability of new hydropower technologies. | • Launch a HydroNext initiative focused on powertrain and civil works deployment at existing water infrastructure and undeveloped streams. This FY 2016 solicitation will leverage previous year investments to expand and demonstrate the next generation of hydropower technologies.<br>• Initiate technology evaluation for innovative small and modular PSH leveraging FY 2015 analysis associated with small-scale pumped storage hydropower feasibility.<br>• Initiate a new North American Grid Integration Study to improve understanding of grid impacts due to high penetrations of variable renewable energy sources.<br>• Expand on FY 2015 efforts to assess and validate the environmental performance of new hydropower technologies under development by partnering with hydropower turbine original equipment manufacturers (OEMs) to develop and commercialize biological design tools. |

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes<br>FY 2016 vs FY 2015 |
|---|---|---|
| • Provide production incentive payments to new hydropower assets developed on NPD in support of Section 242 of the Energy Policy Act of 2005 (EPACT 2005). | | |

## Water Power
## Marine and Hydrokinetic Technologies

**Description**

Marine and Hydrokinetic Technologies (MHK) capture the energy of waves and currents (e.g., tides, ocean current, or in-stream river flows). A cost-effective MHK industry could provide a substantial amount of electricity for the Nation due in large part to its unique advantages as a source of energy, including its vast resource potential, its close proximity to major coastal load centers, and its predictability and forecastability. The Water Power Program completed national assessments of U.S. wave, tidal, ocean-thermal, and river in-stream hydrokinetic energy resources in FY 2012; based on the quantitative estimates of resource and deployment potential resulting from these assessments, the MHK subprogram will place priority focus on technology development for wave energy devices while continuing to support key tidal and ocean current energy developments.

The objective of the MHK subprogram is to compress technology development timelines of MHK devices with the goal of reducing the LCOE for these devices. By 2020, these goals include reaching costs of $0.35 per kilowatt-hour (kWh) for wave, $0.21 per kWh for tidal, and $0.19 per kWh for current energy. By 2030, the prices associated with wave, tidal, and current energy will see further reductions to be cost-competitive with local coastal hurdle rates of $0.12-$0.15 per kWh. The MHK subprogram will accomplish these goals through a series of core activities, including: technology advancement and demonstration to prove technical credibility and optimize performance; testing infrastructure and instrumentation to strengthen MHK device quality and reliability; computational modeling and analysis to catalyze device design evolution at reduced time and cost to developers; environmental research and risk mitigation to boost investor confidence and reduce regulatory barriers; and resource characterization to quantify and classify physical conditions and reduce siting risk.

In order to reach cost competitiveness goals, MHK devices must attain both cost reductions and increased energy capture. The MHK subprogram's Technology Advancement and Demonstration (TA&D) focus area will address these needs in FY 2016 through component advancement and system innovations. By pursuing technology improvements at the sub-system and system level through component and device research and demonstrations, the MHK subprogram can decrease the time scale for technology development and accelerate the integration of these improved components into more complex system deployments.

Through this TA&D work, the MHK subprogram will fund efforts in FY 2016 to further validate and integrate innovative components into advanced WEC systems. This effort builds upon work conducted in FY 2014 and FY 2015 that identified advanced controls, power take offs, and optimized structures as key components necessary to achieve significant cost and performance improvements in WEC devices. Research conducted in FY 2016 will build on this initial work by integrating lab-tested and validated components into complete systems for further and expanded validation of results. These systems will be selected through a competitive effort and installed and tested at key wave energy test sites, such as the Navy Wave Energy Test Site in Hawaii.

In addition, the MHK subprogram will continue to leverage DOE core capabilities to cultivate new technology concepts for adoption by industry. The Structured Innovation Initiative takes a new approach by developing WEC system design concepts defined by requirements rather than a particular technology solution. Once validated in future years, the initiative will deliver MHK device designs that are resilient, efficient, and cost-effective. Applied research in FY 2016 will also continue to directly support MHK demonstrations through design review, design consultation and collaborative development of technologies that increase the performance and reliability of devices. The subprogram will also fund critical tidal energy component or system demonstrations.

The establishment of shared testing infrastructure in FY 2016 ($5.0 million) will accelerate development and deployment of MHK technologies as they progress through Technology Readiness Levels by: (1) reducing technical and financial risks; (2) reducing the cost of testing for the industry; and (3) reducing the time-to-market. The MHK industry has parallels with the wind industry where the value of testing and certification has been critical towards accelerating technology development and viability. MHK testing infrastructure must be available to test designs across the span of technology readiness levels, and needs to include highly instrumented laboratory facilities capable of providing controlled and repeatable test conditions, drivetrain simulators for component testing, and open-water test berths testing individual devices and arrays. Currently, there are significant gaps to adequately support this emerging industry in a manner that best accelerates U.S.

technology innovation, evolution, commercialization and deployment. Access to world-class test facilities and associated instrumentation will accelerate technology evolution while substantially reducing technology development and demonstration costs to the industry.

The FY 2016 Budget includes $5 million to complete front end engineering and design of an open-water test facility. The results of this completed engineering and design phase will be used to support a programmatic go/no-go decision on further facility construction funding. Fully-energetic open-water testing berths are high priority to demonstrate and test every WEC component and system at full scale under all operating conditions. Full scale open water grid connected test facilities have been proven internationally (European Marine Energy Center, Orkney Islands Scotland) to reduce time to market while reducing the development and permitting cost of MHK technologies. Furthermore, these facilities provide the testing rigor and instrumentation to collect the data that will enable cost reduction and reliability improvements in the next generation wave energy converters. A U.S. test facility is critical in providing our domestic industry with these capabilities to mature and reduce the cost of their technologies to become globally competitive. Work in relation to this facility began in FY 2013 with evaluating site locations. In FY 2016, DOE will move from continued preliminary design work completed in FY 2015 into a detailed front and engineering and design for a facility with 4 test berths at depths greater than 50 meters. The annual average power density at the site will be greater than 30 kW/m to allow for survivability tests. This project will leverage the results from the MHK subprogram's FY 2013 ($1.5 million) and FY 2015 ($3.0 million) awards focused on evaluating site locations and delivering preliminary designs and cost estimates for such a facility.

Computational device design tools are an efficient and cost effective means of optimizing device designs in terms of power production, and device survivability in extreme conditions. As devices are tested and performance data is generated, the MHK subprogram will continue to develop and validate open source advanced engineering and physics-based design tools for extreme conditions modeling and improved controls. The open source nature of these tools spurs innovation and collaboration in the MHK technology development community. Further, activities in computation modeling and analysis benefits all WEC developers established as well as new entrants.

The development and validation of open source design tools in FY 2016 will support the wave energy industry to improve device operational performance and survivability, which are two foundational drivers of device costs and performance life. FY 2016 efforts will validate an extreme conditions tool that will predict and characterize extreme device loads using only a fraction of the developer resources that would be required without the tool (i.e., computing hours, engineer input, and tank testing). This effort will leverage the broader engineering community for existing data, tools, and best practices and will be made available to developers at no cost. In addition, FY 2016 efforts related to advanced controls for WECs will continue, building upon work conducted in prior fiscal years. Specifically, this effort will map the full range of control strategies and model complexities to their resulting performance improvements, providing the guidance necessary for developers to understand the cost and performance improvement tradeoffs associated with investing in increasingly complex control systems.

The MHK subprogram aims to minimize key risks to deployment to reduce the cost and time associated with permitting and deploying MHK projects. In FY 2016, the MHK subprogram's Market Acceleration and Deployment (MA&D) work focuses on addressing many different barriers to the development, deployment, and evaluation of these systems. This includes undertaking research and developing new instruments to identify, mitigate and prioritize environmental risks; providing data to accelerate permitting timeframes and drive down costs; and engaging in ocean planning processes to ensure that MHK is considered in the nation's marine spatial plans. In FY 2016, the MHK subprogram will continue support of environmental research and data collection, the development and testing of environmental monitoring instrumentation, and the aggregation, analysis, and dissemination of environmental research data. This work will be rooted in existing, proven interagency and international collaborations which allow the MHK subprogram to both leverage the work occurring internationally and ensure that information provided meets the needs of MHK policy and permitting decision makers. These efforts will help reduce the time and cost associated with siting and permitting MHK projects, currently a critical barrier in the technology development cycle. Core activities include the continuation of the international Annex IV collaboration to aggregate, analyze, and disseminate research occurring throughout the world, housing that data in the Office's Tethys database, and the continued development of instrumentation to more efficiently and cost-effectively
Monitor potential environmental effects of MHK deployments. Existing instruments are challenged by the high energy, often low light conditions of MHK settings, as well as by the limited availability of automated data processing tools.

## Marine and Hydrokinetic Technologies
## Activities and Explanation of Changes

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **Marine and Hydrokinetic Technologies $41,100,000** | **$40,800,000** | **-$300,000** |
| • Continue preliminary development of an open water, fully energetic wave test facility.<br>• Improve energy capture, reliability, and survivability through advanced controls, power take off (PTO) components, and innovative structures efforts by industry awardees. This is the second effort in the System Performance Advancement initiative: a 5 year strategy to optimize MHK components in preparation for commercial-ready system integration. Improvements of 50% increase in absorbed power and 25% load reduction will be achieved.<br>• Advance reliability and survivability of systems with high potential to be cost competitive (high energy capture potential). Reduce system failure rate and design factors of safety while maintaining performance through computational modeling and either laboratory or open water testing.<br>• Develop new environmental monitoring instrumentation, conduct research that addresses key environmental uncertainties and develops strategic information-sharing partnerships.<br>• Continue efforts to develop open-source advanced design tools. | • Complete detailed front end engineering and design of a multi-berth, full-scale grid-connected open water wave test facility. The results of this completed engineering and design phase will be used to support a programmatic go/no-go decision on further facility construction funding.<br>• Award two competitive MHK subprogram demonstrations with advanced component systems integration in collaboration with the U.S. Navy's Wave Energy Test Site in Hawaii.<br>• Continue structured innovation R&D to define the requirements for wave energy devices to become cost-competitive and continue a competition began in FY 2015 to develop and test next-generation wave devices to quantify and demonstrate improved performance.<br>• Coordinate with relevant Federal agencies to continue environmental research, the development and testing of at least five new sets of instruments for environmental monitoring, and the aggregation, analysis, and dissemination of environmental research data. These efforts will help reduce the time and cost associated with siting and permitting MHK projects, currently a critical barrier in the technology development cycle.<br>• Validate open source advanced design tools for extreme conditions modeling, greatly reducing engineering time required to obtain confidence in robust system design.<br>• Validate two-fold improvement of absorbed power of wave energy capture devices in the laboratory with controls technology. | • Competitively select one Open Water Wave Energy Test Facility project in FY 2016. Detailed engineering and design activities will be completed and used to support a programmatic go/no-go decision for further facility construction funding.<br>• Initiate competitive MHK demonstrations to be conducted as a follow on initiative to the prior year's System Performance Advancement initiatives to increase MHK subprogram system performance and reduce costs.<br>• Launch a new Structured Innovation Initiative to complement the Wave Energy Prize Industry solutions by applying Techniques of Innovative Problem Solving (TIPS) to ensure delivery of technoeconomically viable solutions.<br>• Transition activities from development to validation of open source advanced design tools. |

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| | • Complete and release a wave classification scheme to enable design of technology products for resource classes rather than individual designs for specific sites. | |

## Water Power
## NREL Site-Wide Facility Support

**Description**

In FY 2016, EERE programs will continue to directly fund NREL site-wide facility costs that are not included in the Facilities and Infrastructure budget rather than fund those costs as laboratory overhead. This approach is consistent with Generally Accepted Accounting Practices and DOE management at other National Laboratories. EERE began this practice in FY 2014 to effectively control NREL's labor rate multiplier. One outcome has been reducing the cost of accessing unique NREL capabilities (such as facilities and staff expertise) by industry and academia. This practice also makes site operating costs more transparent in order to facilitate cost control and planning. In FY 2014, this practice resulted in a reduction in the Lab-wide direct labor multiplier of approximately 15 percent compared to FY 2013. The proposed FY 2016 Budget Request continues the approach applied in 2014 and 2015.

The NREL Site-Wide Facility Support subprogram funding supports research programs by providing basic site services, functions, and infrastructure for site operations, which includes: management, building operations, building and grounds maintenance, fire and emergency response, engineering and construction support, minor construction projects, electrical safety program, utilities, facilities planning support; and activities within the Sustainability and Environmental Health and Safety (EHS) portfolios. These activities and their costs are relatively fixed and only vary significantly based upon variations in commodities, construction activity, emergencies, weather patterns, etc. They are considered to be the core functions for site operations, safety, environmental compliance, and sustainability at NREL. In FY 2016, this funding will continue to support more than 60 full time equivalents that manage and provide support for these core functions. It will also fund site-wide subcontracts such as janitorial services, refuse and recycling, and subcontracts for minor construction. Additionally, this funding will support site-wide costs associated with maintaining NREL's leadership position, such as: maintaining International Organization for Standardization, American Association for Laboratory Accreditation, and other lab-wide accreditations, managing facilities to enable mission goals, improving sustainability, pollution prevention, waste minimization, improving energy efficiency, reducing water use, and maintaining an effective emergency management system.

The FY 2016 Budget Request remains consistent with the method EERE developed in FY 2015. This approach is a more precise, equitable, and economically neutral method that ensures a predictable net-zero impact on programs' funding. For each program, the contribution to direct funding for site-wide facility support is equivalent to the estimated contribution the program otherwise would have made through overhead charges. This method is based upon each program's level of funding to NREL, adjusted to account for anomalies from large capital expenditures and major subcontracts.

**NREL Site-Wide Facility Support**
**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **NREL Site-Wide Facility Support $700,000** | **$700,000** | **$0** |
| • Fund NREL site-wide facility support costs that are not included in the Facilities and Infrastructure budget rather than continue to fund these costs in the laboratory overhead rate. | • Directly fund NREL site-wide facility support costs that are not included in the Facilities and Infrastructure budget rather than continue to fund these costs in the laboratory overhead rate. | • No change. |

In accordance with the GPRA Modernization Act of 2010, the Department sets targets for, and tracks progress toward, achieving performance goals for each program.

| | FY 2014 | FY 2015 | FY 2016 |
|---|---|---|---|
| Performance Goal (Measure) | **2015-2016: Marine & Hydrokinetic (MHK) - Demonstrate component improvements that will allow increase in wave energy conversion system power-to-weight ratio (PWR) of 100 percent (baseline for wave is 0.25kW/ton).**<br><br>**2014: Reduce the cost of energy from Marine & Hydrokinetic technologies (cents/kWh).**<br><br>**2011 - 2013: Test marine and hydrokinetic devices and components to determine baseline cost, performance, and reliability (all targets cumulative).** | | |
| Target | $0.60/kWh | 50 percent increase in power-to-weight ratio | 100 percent increase in power-to-weight ratio |
| Result | N/A | N/A | TBD |
| Endpoint Target | Competitive with local coastal hurdle rates by 2030 | | |

## Geothermal Technologies

### Overview

Geothermal energy—a relatively untapped domestic energy resource from the heat of the earth—represents a clean and nearly inexhaustible energy source. The current U.S. installed capacity is 3.4 gigawatts (GW), with vast additional potential: a mean estimated 30 GW of new undiscovered hydrothermal resources and 100+ GW of new geothermal energy accessible through Enhanced Geothermal Systems (EGS). The mission of the Geothermal Technologies Program is to accelerate the deployment of domestic electricity generation from geothermal resources by investing in transformative research, development, and demonstration-scale projects that will catalyze commercial adoption. Successful efforts will promote a stronger, more productive economy; provide valuable, stable, and secure renewable energy to power the U.S.; and support a cleaner environment.

To achieve these benefits, the program's technology portfolio prioritizes two closely related geothermal categories, balancing near-term growth with long-term sector transformation: hydrothermal and EGS.[1] New exploration technologies and tools can reduce the near-term cost and risk of developing undiscovered hydrothermal systems, as well as EGS located in or near existing hydrothermal fields. These technologies will also advance the development of greenfield EGS in the long-term.[2] Additionally, the investments in co-produced resources and systems analysis identify opportunities for reducing deployment costs (e.g., developing revenue streams from geothermal brines, streamlining regulatory processes).

The geothermal industry operates in a harsh subsurface environment with unique technical and operational challenges. Foremost among those challenges is that the resource is "out of sight" at a depth of approximately 2 to 5 kilometers, in hard, abrasive rock formations at elevated temperatures and pressures well beyond those typically encountered in oil, gas, or other subsurface operations. Furthermore, market adoption is a critical issue for the geothermal sector, given its small size and traditionally risk-averse nature. Consequently, DOE involvement in applied research provides the geothermal sector with critical access to cutting-edge technologies and research that expands potential for domestic geothermal energy growth and future production in new regions.

### Highlights of the FY 2016 Budget Request

The Geothermal Technologies Program will pursue the following major activities in FY 2016:

- Initiate Phase 3, and full implementation of the Frontier Observatory for Research in Geothermal Energy (FORGE). and advance that effort towards actual field operations at the final, down-selected FORGE site.
- Accelerate geothermal Play Fairway Analysis (PFA), which is an assessment of exploration risk and the probability of finding new resources on a regional scale, through the analysis and integration of diverse geologic datasets. The objective is to quantitatively identify the most prospective areas for new geothermal exploration and development. The PFA mapping leverages and modifies practices from traditional oil and gas analysis, and is a first-of-its-kind endeavor for geothermal mapping in both the U.S. and internationally. The resulting maps and studies will reduce overall exploration costs and increase geothermal development by providing more targeted exploration and drilling opportunities, leading to a more accurate assessment of exploration risk in a region and reducing finding-and-development costs. The FY 2016 Budget will advance the PFA initiative towards field validation, through the drilling of select and specifically-located wells in high-potential "Blind" geothermal resources areas.
- Conduct feasibility studies of low-temperature deep-well geothermal systems coupled with advanced direct use applications and cascaded surface technologies whose applications extend the reach of geothermal beyond the western U.S. The FY 2016 Budget will identify and assess these new geothermal resource opportunities.

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[1] Hydrothermal resources are found where there is sufficient temperature, permeability, and fluid in the subsurface such that fluids can flow naturally at economic rates for power generation. EGS reservoirs require rock stimulation and fluid injection to allow commercial-scale fluid flow. The Hydrothermal subprogram encompasses innovative exploration technologies, low-temperature resources, co-produced resources (i.e., concurrent with oil and gas or material extraction from geothermal brines), direct use and both identified and undiscovered conventional hydrothermal resources.

[2] A Greenfield site is where no previous geothermal development has occurred.

- Implement the Subsurface Engineering crosscut (SubTER) in coordination with the Office of Fossil Energy and Office of Nuclear Energy The Geothermal Technologies Program will advance innovative technology R&D to reduce the cost and risk of geothermal exploration and development.
- A Geothermal Technologies Program 'Incubator' will invest 5 percent of Geothermal Technologies Program funding toward new off-roadmap innovative technologies and solutions that could help meet existing goals but are not represented in a significant way in the current portfolio or technology roadmaps. Successful Incubator projects will reduce the risk associated with potentially breakthrough approaches and technologies so they may be 'on-ramped' to future program roadmaps and the program portfolio.

The goal of the Geothermal Technologies Program is to make geothermal energy a fully competitive, widely available, and geographically diverse component of the national energy mix. Geothermal Technologies subprogram objectives include technology development that will drive industry deployment of a targeted 30 GW of new undiscovered hydrothermal resources (nearly 10 times the current level of geothermal power deployment) and 100+ GW of EGS. The pathway for achieving these objectives includes developing new exploration tools and techniques to lower the upfront risk of geothermal resource exploration, reducing the Levelized Cost of Electricity (LCOE) of newly developed geothermal systems—including EGS—from current costs of 22.4 cents/kilowatt hour (kWh) to 6 cents/kWh (market prices) by 2030 (see Figure 1), conducting RD&D on technologies to harness available lower temperature resources more effectively, and developing improved methods to create new EGS reservoirs. As shown in Figure 1, a number of geothermal resource categories have become cost-competitive, which allows the program to target RD&D efforts on lowering the cost and risk of developing greenfield EGS, both blind and known hydrothermal resources, as well as greenfield low temperature.

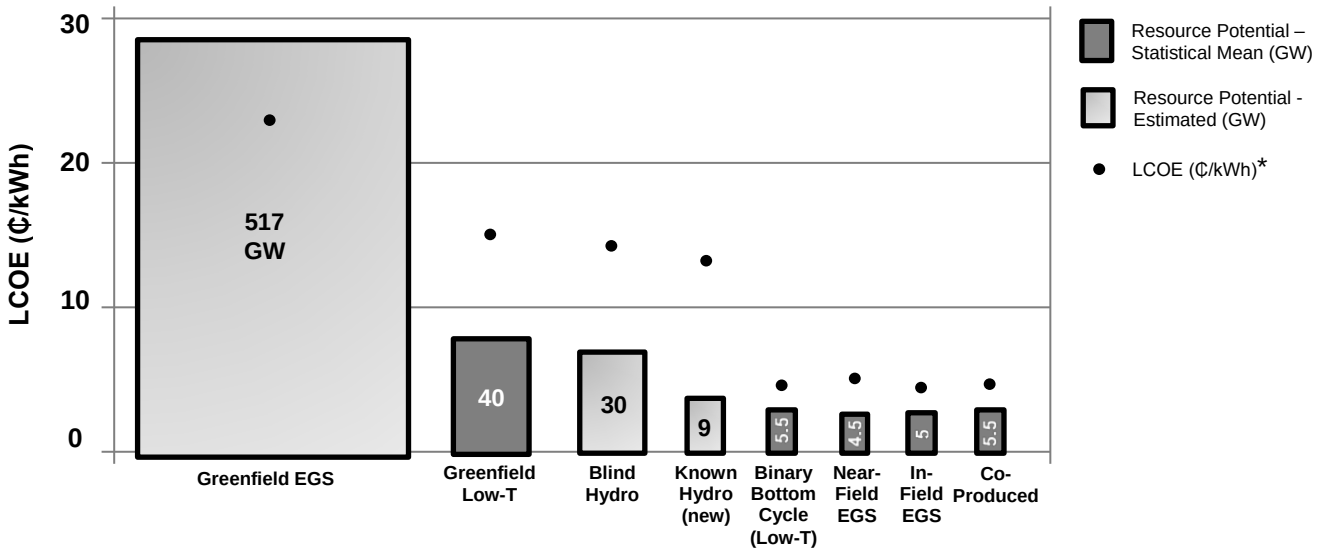


**Figure 1: Resource potential (GW) and 2014 modeled levelized cost of electricity, by geothermal resource category.**

Within the FY 2016 Budget, the Geothermal Technologies Program supports three Departmental Crosscuts: Supercritical Carbon Dioxide ($sCO_2$) in Electric Power Generation, Subsurface Engineering, and Energy-Water Nexus.

The mission of the $sCO_2$ crosscut is to reduce the technical barriers and risk to comercialization of the $sCO_2$ power cycle. The $sCO_2$ crosscut is structured around a common objective to establish a 10 MWe scale Supercritical Transformational Electric Power (STEP) pilot scale facility for evaluating power cycle and component performance over a range of operating conditions. This will enable the development of more efficient, lower-cost energy systems which, in turn, save energy and reduce our carbon footprint. Geothermal Technologies will support this crosscut through R&D focused on further testing and demonstration of $CO_2$ as a geothermal working fluid.

The goal of the Subsurface Engineering crosscut is to address the grand challenges in the subsurface through highly focused and coordinated research in wellbore integrity, subsurface stress state, permeability manipulation and subsurface signals to ensure enhanced energy security, material impact on climate change via $CO_2$ sequestration, and dramatically mitigated environmental impacts from energy related activities and operations. Geothermal Technologies supports this crosscut by focusing research on subsurface stress and induced seismicity, permeability manipulation, and new subsurface signals.

The goal of the Energy-Water Nexus crosscut is to: (1) support a National data, modeling, and analysis platform to improve understanding and inform decision-making for a broad range of users and at multiple scales; (2) strategically target crosscutting technology opportunities within the system of water and energy flows that offer the greatest opportunity for positive impact; and (3) be informed, supported, and strengthened by focused policy analysis and stakeholder engagement. Geothermal Technologies supports this crosscut by contributing to regional water resources assessments and development of brine treatment technology.

**FY 2016 Crosscuts ($K)**

| | Supercritical $CO_2$ | Subsurface Engineering | Energy-Water Nexus | Total |
|---|---|---|---|---|
| **Geothermal Technologies** | **500** | **71,000** | **3,750** | **75,250** |

## Geothermal Technologies
## Funding ($K)

| | FY 2014 Enacted[1] | FY 2014 Current[2] | FY 2015 Enacted | FY 2016 Request | FY 2016 vs FY 2015 |
|---|---|---|---|---|---|
| **Geothermal Technologies** | | | | | |
| Enhanced Geothermal Systems | 27,084 | 26,536 | 32,100 | 45,000 | +12,900 |
| Hydrothermal | 10,285 | 9,956 | 12,500 | 36,500 | +24,000 |
| Low Temperature and Coproduced Resources | 4,708 | 4,612 | 6,000 | 9,000 | +3,000 |
| Systems Analysis | 3,698 | 3,698 | 3,900 | 5,000 | +1,100 |
| NREL Site-Wide Facility Support | 0 | 0 | 500 | 500 | 0 |
| **Total, Geothermal Technologies** | **45,775** | **44,802** | **55,000** | **96,000** | **+41,000** |

SBIR/STTR:

- FY 2014 Transferred: SBIR $851,000; STTR $122,000
- FY 2015 Enacted: SBIR $626,000; STTR $86,000
- FY 2016 Request: SBIR $2,475,000; STTR $371,000

[1] FY 2014 Enacted funding reflected the contractor foreign travel rescission of $27,000.
[2] Funding reflected the transfer of SBIR/STTR to the Office of Science.

**Geothermal Technologies**
**Explanation of Major Changes ($K)**

| | FY 2016 vs FY 2015 |
|---|---|
| **Enhanced Geothermal Systems:** The increased funding reflects the commencement of Phase 3 of the Geothermal Technologies Program's highest, priority, the FORGE initiative, which will focus on R&D and field operations at the single site. Phase 3 activities include further subsurface characterization, drilling of wells, and technology R&D and complementary EGS R&D funded through the National Laboratories Annual Operating Plan (AOP) process. | **+12,900** |
| **Hydrothermal:** Implement SubTER in coordination with the Office of Fossil Energy and Office of Nuclear Energy, The Geothermal Technologies Program will advance innovative technology R&D to reduce the cost and risk of geothermal exploration and development. | **+24,000** |
| **Low Temperature and Coproduced Resources:** This increased funding reflects a slightly expanded Low Temperature and Coproduced Resources subprogram to include advancements in co-produced Strategic Materials, as well as additional funding for advanced direct use and cascaded surface technologies, whose applications will extend the distribution of geothermal well beyond the western U.S. | **+3,000** |
| **Systems Analysis:** The increase in funding is requested to reflect the System Analysis subprogram's focus on larger, collaborative R&D projects to overcome barriers to "speed and scale" adoption of geothermal in the U.S. and validate technical progress across the geothermal sector. This also represents advancement of a collaborative geothermal vision study with industry and other stakeholders, which will be a future-looking analysis and view of sustainable domestic geothermal power based upon new technologies developments. | **+1,100** |
| **Total, Geothermal Technologies** | **+41,000** |

**Description**

Enhanced Geothermal Systems (EGS) are engineered reservoirs, created where there is hot rock but little to no natural permeability or fluid saturation present in the subsurface. To develop an EGS, fluid is injected into the subsurface at low to moderate pressures under a safe, controlled, environmentally responsible and well-engineered stimulation process, causing pre-existing fractures or weaknesses in the rock fabric to open. The pressure increase causes displacements along the fracture planes and zones of rock heterogeneity, which results in increased permeability and allows fluid to circulate throughout the rock. Via a production well, this fluid then transports heat to the surface where electricity can be generated. In the long term, EGS success would potentially enable the utilization of an enormous, geographically diverse energy resource on the order of 100+ GW.

Operational data and research experience to date indicate that overcoming the challenges in EGS technology development requires a broad-based, multidisciplinary approach. Critical to advancing EGS (and other subsurface energy related sectors) are technologies that facilitate characterization of local stress, chemical constituents, and fluid and thermal pathways evolution through time. Economic access to the subsurface thermal resource, while ensuring wellbore integrity over multi-decadal timeframes, is another challenge. A final overarching hurdle is sustainable operation, which involves achieving sufficient productivity for commercial EGS power generation without excessive pressure build up or localization and decrease of flow.

To address critical challenges to EGS development, in FY 2016 the EGS subprogram will pursue the development of innovative technology solutions with a focus on Phase 3 of the Frontier Observatory for Research in Geothermal Energy (FORGE), the Geothermal Program's highest priority activity in FY 2016. FORGE is a dedicated EGS field laboratory where novel technologies and techniques will be tested, with a primary focus on EGS optimization and validation. FORGE is a critical step toward creating a commercial pathway to EGS; it will promote transformative and high-risk science and engineering that the private sector is not financially or operationally equipped to undertake. FORGE is a collaborative and inclusive effort involving a diverse group of geothermal and subsurface stakeholders; participation and contribution from industry, National Laboratories, and academia is integral to its success. In addition, the EGS subprogram will have a smaller focus on advancing strategic R&D that is not performed at FORGE.

Testing of new technologies and methodologies in the deep rock environment accessed at FORGE will allow the geothermal sector to gain a fundamental understanding of the key mechanisms controlling coupled thermo-mechanical-chemical-hydrologic processes at depth. For the geothermal industry, critical and detailed knowledge of fracture mechanics and heat transfer in low permeability rock formations will inform the design and testing of a methodology for reproducing large-scale, economically sustainable heat exchange systems. A pivotal aspect of creating a repeatable development methodology involves the consideration of various well and rock stimulation configurations, to determine which design most efficiently and effectively exploits in-situ stress directions, rock physics and properties, and resultant fracture orientations. Equally essential to informing the future direction of EGS is the comprehensive capture of high-fidelity data from both surface and subsurface instrumentation, which ensures a deep understanding of system-level engineering and reproducibility in a variety of geologic environments. Concurrently, real-time dissemination of technical data to all stakeholders will revolutionize the geothermal community's understanding of EGS creation and evolution, and pave the way for a rigorous and reproducible methodology that reduces industry development risk.

- In Phase 1 of FORGE, the program selected up to ten teams, which were required to develop comprehensive geologic models of their prospective sites. At the conclusion of Phase 1, a down-select occurred, where (up to) three teams were authorized to move into the subsequent phase. By the end of Phase 2, these teams were down-selected to one site and operational team that had completed a robust site characterization effort; finalized the National Environmental Policy Act (NEPA) and environmental requirements including the development of an Induced Seismicity Mitigation Plan; initiated dynamic reservoir modeling of the target reservoir, and developed and deployed a National Geothermal Data System (NGDS)-compatible, mechanism (FORGE Data System/Node) for real-time data-sharing of all baseline site characterization and monitoring data.

- Phase 3 activities launched in FY 2016 will involve full implementation of FORGE by the winning Site Management Team (SMT) including full-scale reservoir development and tasks specific to the solicitation, selection, testing and evaluation of new and innovative EGS tools and techniques.
  - In Phase 3, the SMT, in collaboration with DOE, will commence design and drilling of two or more operational, full sized wells; stimulate the target formation; and test reservoir connectivity through flow-testing efforts with a target of increasing performance per well (up to 5 megawatts (MW) realized at prior EGS field demonstrations). Drilling, stimulation, and testing activities in Phase 3 will include optimizing wells to the in-situ stress field conditions through techniques such as highly deviated or fully horizontal medium radius configurations and new approaches for implementing monitoring multi-zone/multi-stage simulations under extremely hot geothermal conditions. To improve understanding of thermal depletion and coupled processes within heterogeneous formations these, or auxiliary wells may be used for testing of fluid and heat transport properties at less than full reservoir scale, thereby easing the transition into large-scale operations planning.
- In addition, the SMT, in collaboration with DOE, will design and initiate drilling of the first FORGE well and any auxiliary wells that may be utilized for complementary R&D efforts, including those that are off-ramping from projects funded under our FY 2014 EGS R&D funding opportunity announcement (FOA) and FY 2015 AOP projects.

- The FORGE SMT will continuously monitor microseismic activity and other geophysical and geochemical signatures at FORGE, throughout Phase 2 and 3. The SMT will make all characterization and monitoring data available to the community via the FORGE Data System/Node in real-time, a first-in-the-world initiative, and will utilize ongoing reservoir modeling efforts to dynamically inform drilling and stimulation design and other fundamental R&D decisions.

Competitively selected Phase 3 R&D projects will follow the lifecycle of FORGE:
- Reservoir characterization (coupled imaging, drilling for interrogation and monitoring, high-temperature tools and sensors);
- Reservoir creation (formation access, fracture characterization, zonal isolation, permeability enhancement technologies); and
- Reservoir sustainability (long-term testing, monitoring, and operational feedback).

In FY 2016, the FORGE R&D solicitation will focus on reservoir characterization technologies, as the site will require the collection and compilation of robust characterization data to inform the predictive stimulation models that are currently under development. Ten to 20 projects will be competitively selected from proposals by the broader scientific and technical community and may include collaborations on crosscutting R&D with other DOE offices engaged in complementary subsurface energy research.

Although the majority of the EGS subprogram's R&D will be conducted at FORGE, new R&D in highly strategic topical areas remains a key and fundamental part of the EGS subprogram and will run in parallel with the implementation of FORGE. Because of the lengthy development timeline for subsurface technologies and methodologies, the EGS subprogram seeks to maintain investment in R&D that feeds into FORGE operations, such that new technologies are properly positioned for field testing at the site, aligned with sequencing of the multi-year FORGE technical implementation strategy.

In FY 2016, the EGS R&D will continue to address key identified challenges through new, competitively selected R&D focused on large, collaborative projects that utilize a systems approach to understand and design effective reservoir stimulation methodologies and to understand and predict reservoir sustainability. The EGS subprogram will continue to support successful FY 2015 work in lab scale fracture characterization, innovative tracer technology development, and joint geophysical methods for reservoir imaging. In addition, in support of the $sCO_2$ crosscut, this activity will fund further testing of $CO_2$ as a geothermal working fluid, including demonstration of the viability of the thermo-siphon effect, and associated analysis that represent proof-of-concept for efficiently coupling $CO_2$ sequestration with geothermal energy production.

In addition, funds may be used to support efforts such as peer reviews, data collection and dissemination, technology assistance, and technology-to-market activities.

**Enhanced Geothermal Systems**
**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **Enhanced Geothermal Systems $32,100,000** | **$45,000,000** | **+$12,900,000** |
| • Complete down-select of up to ten Phase 1 teams to up to three potential FORGE sites and complete cooperative agreement negotiations with the Phase 2 awardee(s).<br>• Finalize Environmental Information Volume for submission to DOE and appropriate regulatory agencies to initiate the NEPA process for FORGE activities.<br>• Initiate site characterization and monitoring activities at FORGE including development and deployment of high-resolution surface and subsurface seismic monitoring systems.<br>• Complete initial R&D topic scoping in collaboration with the final FORGE team, and develop / release the first R&D Request for Proposal (RFP) for projects at FORGE.<br>• Mission-critical R&D (funded through the Annual Operating Plans and competitively selected FY 2014 R&D FOA awards) focused on addressing EGS barriers will continue to feed out-year activities at FORGE. Topics will focus on zonal isolation, novel stimulation methodologies, and unique well designs and configurations.<br>• First-of-its-kind super-critical phase $CO_2$ EGS field pilot test, through the continuation of a competitively-selected project focused on the design of an innovative, water-free, heat extraction methodology for EGS. | • EGS subprogram activities independent of the Subsurface Engineering crosscut:<br>▪ Finalize design and initiate drilling of the first FORGE well and any auxiliary wells that may be utilized for complementary R&D efforts, such as monitoring, characterization, and tracer analysis.<br>▪ Continue any further characterization of the in-situ stress field needed, utilizing various techniques and further characterization of fluid content and composition at depth.<br>▪ Incorporate field testing of methodologies/tools/procedures developed through the EGS subprogram's FY 2014 Integrated EGS R&D solicitation (12 awards), depending on the sequencing of the FORGE multi-year R&D strategy.<br>▪ Continue micro-seismic and other geophysical and geochemical signature monitoring initiated in Phase 2 and input all data into ongoing dynamic reservoir modeling efforts.<br>▪ Upload all characterization and monitoring data collected throughout the initial year of Phase 3 to the FORGE Data System/Node in real-time.<br>▪ Issue first FORGE R&D solicitation, on research and technology testing related to site characterization technologies and other topics defined by the collaboratively developed FORGE multi-year R&D strategy. Select 10-20 projects, based on | • EGS subprogram activities independent of the Subsurface Engineering crosscut:<br>▪ Initiate first drilling at FORGE;<br>▪ Issue the first of the annual R&D solicitations associated with the FORGE R&D strategy; and<br>▪ Incorporate field testing of methodologies/tools/procedures originally developed through the EGS subprogram's FY 2014 EGS Integrated R&D solicitation, as was originally planned.<br>▪ Support the final phases of competitively selected AOP projects focused on increasing the precision and accuracy of subsurface parameters critical to EGS development and sustainability.<br>• Seismic response simulations and risk models, as part of the Subsurface Engineering crosscut |

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes<br>FY 2016 vs FY 2015 |
|---|---|---|
| | appropriations.<br>• Advance R&D (funded through the Annual Operating Plan and performed by National Laboratories and industry or academic partners) focused on larger scoped, collaborative projects that utilize a systems approach to understand and design effective reservoir stimulation methodologies, induced seismicity, and to understand and predict reservoir sustainability.<br>• Support critical laboratory-scale work and first-of-their-kind feasibility studies on fracture characterization, innovative tracer technology development, and joint geophysical methods for reservoir imaging will continue through the down select of FY 2014 EGS R&D FOA projects.<br>• The EGS subprogram will develop and implement seismic response simulations and risk models, as part of the subsurface stress state/induced seismicity topical pillar within the SubTER. | |

**Description**

The U.S. Geological Survey's (USGS) 2008 Geothermal Resource Assessment estimated that 30,000 MW (range from a P95 of 7,900 MW to a P5 of 73,000 MW) of undiscovered hydrothermal resources could still be found in the western U.S. alone. However, the technical feasibility of discovering and developing this resource potential depends on innovative approaches to subsurface characterization. Hydrothermal resources are defined by the presence of three key elements associated with geologically active areas: heat, fluid, and permeability (the ability for fluid to flow through rock). However, given the stage of geothermal development in the U.S., most of these remaining resources are now categorized as being either undiscovered or in so-called "blind" systems (i.e., showing little to no surface expression). These blind systems require new and innovative approaches to exploration. The risks and costs associated with successful geothermal exploration and development in these poorly characterized areas are high, and the sector's inability to consistently drill economically viable wells is therefore a major barrier to near-term capacity expansion.

The Hydrothermal subprogram is focused on supporting the research and development of technologies necessary to effectively find and access "blind" resources at lower cost, enabling them to be developed and brought online by the private sector. The Hydrothermal subprogram's goal is to reduce the cost of electricity generated from currently undiscovered hydrothermal resources to 10 cents/kWh by 2020. To find "blind" hydrothermal systems, scientists need to identify geochemical and geophysical signatures of hot fluid and unique rock properties that are up to 10,000-15,000 feet underground. This is a major challenge, particularly since hot water alone does not provide a unique geophysical signature; its presence has to be inferred by other detected features, for instance, unique sub-surface attributes or geophysical properties (e.g., resistivity, magnetic, gravity, or seismic responses). Many of the current geothermal exploration technologies were originally developed to detect hydrocarbons and have been adapted to the higher temperature and pressure of geothermal environments.

The Hydrothermal subprogram targets opportunities to leverage relevant advances in other subsurface sectors for use in geothermal environments. The energy sectors operating in the subsurface have many separate and distinct technical challenges, but there exist many shared elements in the research, development, and field demonstration of pathways to overcome common challenges. The Hydrothermal subprogram pursues opportunities to adopt and advance leading subsurface practices for geothermal, doing so most recently in FY 2014 with the launch of the Play Fairway Analysis effort, a first-of-its-kind mapping effort for geothermal, borrowing proven methodologies from the oil and gas sector. The geothermal sector is a relatively small player among the industries that operate in the subsurface and is therefore positioned to benefit greatly from strategic collaborations to accelerate the development of undiscovered hydrothermal resources and optimize the management of operational reservoirs.

To effectively coordinate efforts across subsurface sectors, DOE has established intra-agency collaboration on subsurface technology and engineering. This crosscutting effort intends to address common technical RD&D challenges confronting the Geothermal Technologies Program as well as other DOE offices. In addition, this effort has initiated collaboration and outreach within the Federal Government that will continue in FY 2015, particularly with the USGS and the National Science Foundation, to ensure cost effective and logical identification and funding of subsurface research. The DOE collaboration has also commenced an in-depth outreach and consultation initiative with industry, which will be ongoing. While the program will benefit from key advances in the Wellbore Integrity R&D jointly proposed by the DOE offices of Nuclear Energy and Fossil Energy, no funding is proposed by the Geothermal Technologies Program for this component of the crosscut.

To address critical challenges to the development of undiscovered hydrothermal, FY 2016, the Hydrothermal subprogram will continue to focus on the advancement of the Play Fairway Analysis through the completion of a Phase I down-select of awardees. Discussions with the private industry and the Hydrothermal subprogram's exploration technologies roadmapping indicated that industry needs better tools to accurately predict heat and permeability in the subsurface, as well as reduce the overall risk of geothermal exploration, resulting in the FY 2014 Play Fairway Analysis FOA. In FY 2015, the Hydrothermal subprogram advanced projects from the FY 2014 funded Play Fairway Analysis awards, to collect data and perform initial mapping of prospective areas on a regional basis. This is a first-in-the-world initiative. A key objective of this effort is to generate maps and risk assessments that industry can use to more reliably explore for and develop geothermal resources.

Further, integral to this effort was identification of critical data gaps, where the mapping in highly ranked areas (see Figure 2) could be materially enhanced through additional, select data collection such as slim holes, temperature gradient wells, and targeted geophysical data collection. Based on exploration plans submitted in Phase 1, Phase 2 will consist of additional geophysical exploration data gathering by conducting seismic, gravity, magnetotelluric and or remote sensing surveys along with geochemical and geothermometry studies and temperature gradient and or slimhole drilling within the newly proposed prospective areas.

In conjunction with Phase I down-select, the Geothermal Technologies Program will explore collaborative work with USGS as a drilling partner to conduct regional data gathering based on the results of the Play Fairway Analysis FOA. These regional exploration efforts will provide critical informational tools and techniques that allow developers to more successfully target exploration areas, improve the accuracy of prospect maps, augment the probability of success and certainty of resource size, and economically develop resources (see Figure 2).

The Hydrothermal subprogram will issue an industry-focused Play Fairway Analysis FOA to target exploration slim hole and/or temperature gradient well drilling to confirm and characterize in more detail prospective geothermal areas derived from industry performed exploration activities similar to those conducted in the Play Fairway Analysis Phase I awards.

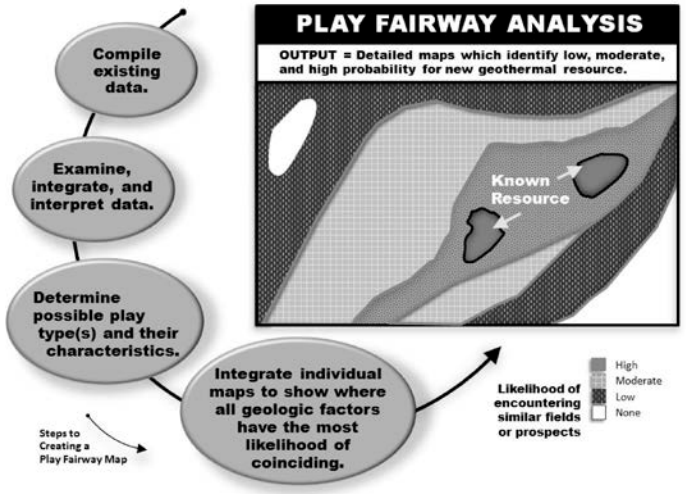


**Figure 2: Illustrative Example of Geothermal Play Fairway Map**

In FY 2016, Hydrothermal R&D will more aggressively leverage and transition select oil and gas exploration, drilling, and completion technologies to the geothermal industry, as well as incorporate mining technology transfer. Specifically, these technologies will be modified and advanced for use in the unique high-temperature geothermal subsurface environment via laboratory-focused R&D funding. These funds will also support advanced blind resource characterization, downhole completion tool development, and technologies for geochemical and isotope signals that can also constitute important indicators for the presence of hidden or "blind" geothermal systems. Success in tool and methodology development will provide greater consistency and reliability, and lower costs for geothermal development.

In FY 2016, the Hydrothermal subprogram proposes a coordinated RD&D effort, Subsurface Engineering Crosscut (see figure 3), with the overarching goal of promoting "Subsurface Control for a Safe and Effective Energy Future." This is a critically important area as it is central to increased domestic energy production and supply, enhanced environmental protection, and risk mitigation. Furthermore, core economic and social benefits include job creation, increased public confidence and U.S. leadership, and improved U.S. energy security.

The overarching pathway for pursuing this goal is to advance select technologies that provide for effective, adaptive and safe control of fractures and fluid flow. Four complementary pillars of research all contribute to this effort (see Figure 3), of

which the following three are targeted in the Hydrothermal subprogram request: Subsurface Stress and Induced Seismicity, Permeability Manipulation, and New Subsurface Signals.

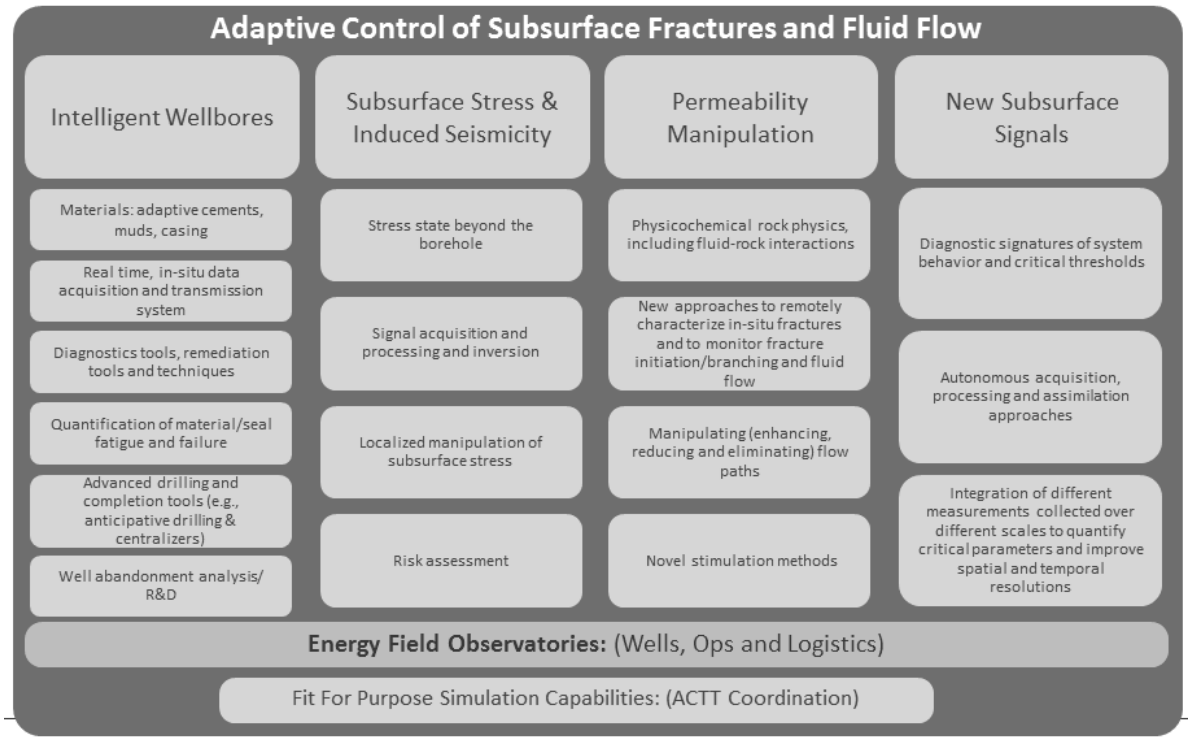


**Figure 3: Identified RD&D Priorities within the Four Subsurface Crosscut Pillars**

- Subsurface Stress and Induced Seismicity

  Proposed activities will include R&D efforts to establish baselines for assessing the state of stress at key scales and developing new tools and methodologies to push the boundaries of dynamic stress characterization near the wellbore and in the far field. Specifically, opportunities may include high-temperature wireline logging for continuous stress measurements in deep settings, methodologies for extracting improved source mechanisms from microseismic events and stress changes from ambient noise seismic interferometry, and advanced methods for monitoring and interpreting aseismic slip. Importantly, the proposed R&D will accelerate overall advancement in the ability to evaluate subsurface stress conditions in order to mitigate the potential for induced seismicity associated with subsurface operations.
  FY 2016 will also lay the foundation for public-private industry partnerships, to create a virtual data site to make key field and laboratory data and R&D accessible to the broader scientific community. DOE will also launch a "design and build" phase for ultra-high density seismometer arrays for out-year deployment at existing operational sites, to better understand and characterize new subsurface seismic signals, and mitigate against unwanted events.

  In FY 2016, $5 million from the EGS subprogram will be allocated to develop and implement seismic response simulations and risk models, as part of the subsurface stress state/induced seismicity topical pillar within the Subsurface Engineering cross-cutting initiative. This work will build on existing efforts to simulate earthquake initiation, crustal wave propagation, and shaking risk at the surface. The new tasks will focus on the coupling of these simulation tools to accurate soil geomechanical and geophysical models (non-linear, non-elastic) and surface infrastructure interactions (Buildings) to produce robust, quantified risk profiles applicable to structures and human health. This work will directly address the risks of induced seismicity associated with subsurface activity, a significant technical challenge to development and deployment of advanced energy production, storage technologies, and high consequence facilities that are critical to meeting climate change, infrastructure, and national security goals.

- Permeability Manipulation
  Proposed activities will focus on accelerating research in developing new technologies for enhancing fluid flow through novel techniques such as using environmentally benign energetic agents or propellants. This research not only has the potential to facilitate more effective management of geothermal reservoirs to sustain the necessary high flow rates throughout the reservoir lifetime, it also has the potential to dramatically reduce water use while enhancing permeability. Research will also be targeted at developing new methods for remotely characterizing and monitoring fluid flow in the subsurface, and improving the fundamental understanding of coupled physicochemical processes during fluid-rock interactions, which is a critical aspect of sustaining geothermal reservoirs.

- New Subsurface Signals
  Proposed activities will include advancing state-of-the-art imaging technologies for subsurface interrogation from the wellbore into adjacent rock bodies, in order to accurately image fractures and measure rock properties away from the wellbore. R&D will also be directed toward new techniques to interpret seismic and other geophysical signals that can be measured from the surface. A pivotal R&D emphasis will be the development of inexpensive and small, high-performance sensors for broad scale deployment in geothermal reservoirs.

**Hydrothermal**
**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **Hydrothermal $12,500,000** | **$36,500,000** | **+$24,000,000** |
| • The subprogram will focus on Play Fairway analysis through the completion of Phase 2 of eleven previously funded competitive awards.<br>• Targeted R&D for Blind Geothermal Resources and Leveraging Oil and Gas (O&G)/Mining Technologies focused on blind resource characterization and exploration, downhole completion tool development, and oil and gas drilling/completion transfer. | • Hydrothermal subprogram activities independent of the Subsurface Engineering crosscut:<br>▪ The Hydrothermal subprogram will launch Phase 2 validation effort for Play Fairway Analysis in FY 2016, rather than in FY 2015, to allow for well-structured timing between Phase 1 and Phase 2. In addition the Phase 2, industry-focused, FOA will target exploration slim hole and/or temperature gradient well drilling similar to those conducted in the, non-industry focused, Play Fairway Analysis Phase I awards.<br>▪ Targeted R&D for Blind Geothermal Resources and Leveraging Oil and Gas (O&G)/Mining Technologies that will work to more aggressively transfer select oil and gas exploration, drilling, and completion technologies as well as incorporating mining technology transfer to the geothermal industry.<br>• Full implementation of the Subsurface Engineering crosscut, a critical effort for advancing innovative RD&D under the Hydrothermal subprogram to reduce the cost and risk of geothermal development, by targeting opportunities to leverage advances in other subsurface sectors. The geothermal proposal focuses on geothermal-specific R&D in Subsurface Stress and Induced Seismicity, Permeability Manipulation, and New Subsurface Signals, and the cross-cutting nature of these topics aims to result in outcomes that are accretive across multiple DOE Offices. | • The requested funding increase reflects full implementation of the Subsurface Engineering crosscut.<br>• Hydrothermal subprogram R&D, independent of the Subsurface Crosscut, will support the Play Fairway Validation initiative. |

## Geothermal Technologies
## Low Temperature and Coproduced Resources

**Description**

The Low Temperature and Coproduced Resources subprogram supports targeted RD&D on technologies applicable to geothermal resources below a temperature of 300°F (150°C); as well as geothermal resources, including high-value material extraction and hybrid power designs that can be co-developed with existing well-field infrastructure and other clean energy technologies. Although these low-temperature resources have a lower power conversion efficiency than other geothermal resources—due to the lower temperature fluids—these resources are abundant; highly accessible across the U.S.; and as in the case of co-produced fluids, have much of the necessary infrastructure in place, attributes that lower the effective LCOE. Improving the efficiency of lower temperature geothermal systems, and expanding their utility through value-added commercial opportunities (i.e., Mineral Recovery, Desalination); can enable near-term development of innovative geothermal technologies in more geographically diverse areas of the U.S. The Low Temperature and Coproduced Resources subprogram also supports R&D of the direct use of thermal resources for process and space heating applications.

Certain valuable elements, such as lithium and manganese, are relatively plentiful in geothermal brines. Rare earth elements (REE) such as neodymium can also be present in these fluids. These REE and other high-value materials are of national importance given their role in manufacturing, clean energy development, and strategic stockpiles. Mineral recovery is a potential value-added pathway to improve low-temperature geothermal system project economics. By collaborating with geothermal and mineral industry stakeholders to develop additional revenue streams from geothermal brines, the economic viability of geothermal projects will increase, concurrently expanding the potential geographic distribution of this base-load energy resource. In FY 2016, the Low Temperature and Coproduced Resources subprogram will expand upon the low temperature mineral recovery initiative begun in FY 2014 with a new competitive FOA to transition the most successful feasibility studies to technology prototype development or field demonstration project(s). This FOA will bridge the gap between applied R&D and commercial adoption of geothermal mining technologies by allowing cost-shared development of pilot scale extraction technologies at geothermal mining and power production sites. The USGS, due to its expertise in mineral deposits and subsurface geochemistry, is a valuable partner in this effort. Additional collaboration will be undertaken with the Critical Materials Hub (Ames National Laboratory) and its complementary research on critical material applications.

In FY 2016, the Low Temperature and Coproduced Resources subprogram will continue to dedicate targeted RD&D to innovative energy conversion, additional revenue-stream creation, and further advancement of both traditional and newly developed power cycles. This is based upon prior strategic planning, such as the Low Temperature and Coproduced Program Roadmap, which indicated these areas should continue to be supported by the Low Temperature and Coproduced Resources subprogram. Specific developments in this area will include renewable power hybrid cycles, compressed air energy storage (CAES) in conjunction with geothermal power generation, and power system improvements—with the goal of steadily increasing the value of geothermal resources. Additionally, in support of the Energy-Water Nexus crosscut, the subprogram will fund geothermal desalination technologies that will move into a pilot-scale stage. These R&D activities will promote the expansion of the geothermal market through the development of technologies that increase the brine effectiveness (efficiency) of produced fluids.

The Low Temperature and Coproduced Resources subprogram will issue a competitive funding solicitation to conduct feasibility studies for assessment and evaluation of prospective direct use/low temperature systems in geologically distinct parts of the country that currently lack geothermal development. As opposed to ground source heat pumps (GSHP), which perform heating and cooling duties using a near surface constant temperature profile, geothermal direct use harvests the heat from geothermal brines and uses it to directly heat (or cool) buildings, as well as for other beneficial thermal processes. By displacing high-temperature power generation with low-to-medium temperature geothermal, significant energy conservation gains can be achieved from end-use processes, with moderate temperature requirements. Direct use is

widely used throughout the world, most notably in Iceland, where nearly 90 percent of the country's heating is provided by geothermal direct use.[1]

Direct use geothermal applications have the potential to provide cost-effective, renewable energy in large portions of the country. Many of these opportunities will exist in sedimentary basins, where legacy oil and gas drilling data can provide valuable technical information to identify and confirm direct use targets. Further, since direct use geothermal can replace the need for conventional high-temperature power generation for the relatively modest temperature requirements of heating and cooling, it may assist in valuable grid management by providing utilities with effective demand management and demand reduction. This effort will be a first-of-its-kind, large-scale feasibility and resource assessment for direct use applications in the U.S., and could ultimately benefit large energy users such as college and university campuses, business districts and complexes, and similar large-scale applications. Importantly, many of these opportunities will have existing in-place infrastructure, thereby lowering the cost of energy transformation.

Direct use applications in the U.S. are currently concentrated almost exclusively in the western U.S. Excluding geothermal heat pumps; the majority of applications involve space and district heating, agricultural applications, aquaculture and some industrial uses. Direct use applications provide the potential to extend geothermal deployments nearer to the more densely populated regions in the central and eastern U.S.

This direct use initiative could also lead to dramatically expanded geothermal development in the central and eastern U.S. through a combination of deep wells, coupled with advanced low temperature electricity generation units and cascaded-use surface technologies. If the results of the initial feasibility studies are positive, there is potential for the line-of-sight direct use market to grow in size to approximate that of geothermal heat pumps, displacing a considerable amount of conventional electricity, which will result in significant reduction of greenhouse gas emissions.

In addition, funds may be used to support efforts such as peer reviews, data collection and dissemination, technology assistance, and technology-to-market activities.

[1]Orkustofnun, National Energy Authority Iceland, http://www.nea.is/geothermal/direct-utilization/.

**Low Temperature and Coproduced Resources**
**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **Low Temperature and Coproduced Resources** | | |
| **$6,000,000** | **$9,000,000** | **+$3,000,000** |
| • Initiation of Phase II of the Low Temperature Mineral Recovery FOA will occur via planning activities to include – stakeholder workshop and request for information release.<br>• Continuing from FY 2014 funded efforts, transition the most successful feasibility studies to technology prototype development or field demonstration project(s).<br>• Fund cost-shared demonstrations of extraction technologies at geothermal mining and power production sites.<br>• Demonstrate a commercial-ready hybrid cycle binary power plant in cooperation with National lab and industry partners.<br>• Through the use of Metal Organic Heat Carriers (MOHCs) in a commercial binary plant, improve the heat transfer coefficients in the plant's heat exchanger by at least 5 percent.<br>• Successfully demonstrate that the thermal energy in low-temperature geothermal fluid is sufficient to drive a Forward Osmosis water purification process.<br>• Initiation of Direct Use FOA to identify and assess new geothermal resource opportunities via planning activities to include two shareholder workshops and a request for information release. | • To allow for well-structured timing between the completion of the nine Phase 1 projects and an open call for Phase 2projects, the Low Temperature and Coproduced Resources subprogram will release the Phase 2 FOA and award projects for the Low Temperature Mineral Recovery initiative in FY 2016.<br>• The Low Temperature and Coproduced Resources subprogram will launch the Direct Use FOA to identify and assess new geothermal resource opportunities in FY 2016. It is anticipated that six to ten feasibility and assessment projects will be awarded.<br>• The program will continue funding targeted R&D of value-added technologies, to include at least one pilot-scale demonstration(s) of geothermal water purification processes. | • The increase funds a follow-on opportunity that leverages successful FY 2014 Mineral Recovery projects, and the completion of Phase 1 of the funding opportunity for innovative direct use. |

## Geothermal Technologies
## Systems Analysis

**Description**

The goal of the Systems Analysis subprogram is to identify and address barriers to geothermal adoption in the U.S., and validate and assess technical progress across the geothermal sector. The Systems Analysis subprogram takes a holistic analytical approach across the program's technology portfolio to evaluate trends, conduct impact analyses, identify best practices, and provide resources and tools that will reduce costs and risk for geothermal developers. The Systems Analysis subprogram primarily conducts analyses in the following areas: the environmental impacts of geothermal; the policy and regulatory barriers to development and deployment; economic modeling and validation of geothermal technologies; and, collecting and disseminating data for public use to spur geothermal development. Lessons learned resulting from these analyses are subsequently incorporated into the program's Multi-Year Program Plan and either validate or refine the program's overall strategic direction. The Systems Analysis subprogram conducts these activities in partnership with the National Labs, Federal agencies, academic institutions, and industry stakeholders.

In FY 2016, the Systems Analysis subprogram will fund activities to support specific EGS, Hydrothermal, and Low Temperature and Coproduced Resources strategic, market and techno-economic analysis projects, as well as projects that remove deployment barriers including:

- A robust, forward-looking analysis of the future state of geothermal deployment in 2030 and 2050 for EGS, Hydrothermal, Low Temperature and Coproduced Resources, and cascading geothermal technologies as well as economic and environmental benefits of these deployments. This will be a critical analysis that engages the geothermal industry, academia, National Labs, and government stakeholders.
- Support data collection and dissemination across all Geothermal Technologies subprograms, such as assisting FORGE Teams in deploying a node on the NGDS tailored to researcher data requirements, which will expedite EGS research results by leveraging data collection efforts-to-date. In addition, the Systems Analysis subprogram will help to deploy integrated datasets from the Play Fairway Analysis effort into the NGDS to maximize the number of mapping tools that can utilize the data, thereby reducing the cost of determining geothermal potential. Techno-economic analysis and validation of the impact of investments on the geothermal sector, including tracking the commercialization of funded R&D investments.
- Evaluation of the potential for direct use to tap the full range of geothermal resources, including utilizing EGS technologies, to provide direct thermal heating of campuses/installations/communities across the country. Electrical power may be provided to the grid while electricity formerly required for heating and cooling is displaced by direct use geothermal.
- Continued regional water resources assessments, integrating data from program-funded projects, in support of the Energy-Water Nexus crosscut.
- Regional modeling and analysis of power generation, as well as commercial geothermal resources ("geothermal reserves") that will allow us to develop updated assessment of resource targets in the U.S., which complements the program's Play Fairway Analysis initiative.
- Educational activities will be supported through the Systems Analysis subprogram, and will include a student competition and fellowship opportunities with The American Association for the Advancement of Science (AAAS) and Oak Ridge Institute for Science and Education's (ORISE) Science and Technology Policy program.

**Systems Analysis**
**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **Systems Analysis $3,900,000** | **$5,000,000** | **+$1,100,000** |
| • The subprogram will continue to conduct analyses and develop tools to reduce development and deployment barriers to geothermal development in the U.S.; as well as conduct cross-cutting analysis to identify, validate, and assess progress being made across the geothermal sector. Proposed work under this budget request include:<br>▪ Two environmental analyses that continue to assess the lifecycle greenhouse gas and water use impacts of geothermal systems, incorporating the latest data on EGS;<br>▪ Policy and regulatory analysis, in the form of the Regulatory Roadmap and five inter-agency technical working papers on environmental issues relevant to geothermal technologies.<br>▪ Updated assessment of financial policies and market drivers affecting the geothermal sector, as part of NREL's Strategic Analysis.<br>▪ Techno-economic analysis including an impact assessment study of the emerging and commercialized technologies initially funded by the R&D portfolio (GT-Mod and GETEM); and<br>▪ Data collection and tools development including development of a node-in-a-box repository for public sharing of data resulting from the FORGE initiative. | • The Systems Analysis subprogram will continue to conduct analyses and develop tools to reduce development and deployment barriers to geothermal development in the U.S.; as well as conduct cross-cutting analysis to identify, validate, and assess progress being made across the geothermal sector. Proposed work under this budget request include:<br>▪ A robust, forward-looking Vision Study to illustrate the geothermal potential and impacts in 2020, 2030 and 2050, based on scenarios within a geothermal continuum addressing the valuation of a full spectrum of geothermal technologies.<br>▪ Support data collection and dissemination across GTO subprograms, specifically the EGS FORGE, Low Temperature Mineral Recovery, and the Hydrothermal Play Fairway Analysis initiatives.<br>▪ Techno-economic analysis and validation of the impact of investments on the geothermal sector, including tracking the commercialization of funded R&D investments.<br>▪ A continued regional water resources assessment, integrating data from program-funded projects, in support of the Energy-Water Nexus crosscut.<br>▪ Evaluation of the potential for direct use applications to utilize the full range of geothermal resources, including EGS technologies.<br>▪ Regional modeling and analysis of power generation, as well as commercial geothermal resources ("geothermal | • Minimal change in funding is requested to reflect the Systems Analysis subprogram's continued focus on analysis and tools that help to reduce barriers to "speed and scale" adoption of geothermal in the U.S. and validate and assess technical progress across the geothermal sector. |

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| | reserves") that will allow us to develop updated assessment of resource targets in the U.S., to complement the Geothermal Technology Program's Play Fairway Analysis initiative. | |

## Geothermal Technologies
## NREL Site-Wide Facility Support

**Description**

In FY 2016, EERE programs will continue to directly fund NREL site-wide facility costs that are not included in the Facilities and Infrastructure budget rather than fund those costs as laboratory overhead. This approach is consistent with Generally Accepted Accounting Practices and DOE management at other national laboratories. EERE began this practice in FY 2014 to effectively control NREL's labor rate multiplier. One outcome has been reducing the cost of accessing unique NREL capabilities (such as facilities and staff expertise) by industry and academia. This practice also makes site operating costs more transparent in order to facilitate cost control and planning. In FY 2014, this practice resulted in a reduction in the lab-wide direct labor multiplier of approximately 15 percent compared to FY 2013. The proposed FY 2016 budget continues the approach applied in 2014 and 2015.

This subprogram funding supports research programs by providing basic site services, functions, and infrastructure for site operations, which includes: management, building operations, building and grounds maintenance, fire and emergency response, engineering and construction support, minor construction projects, electrical safety program, utilities, and facilities planning support; and activities within the Sustainability and Environmental Health and Safety (EHS) portfolios. These activities and their costs are relatively fixed and only vary significantly based upon variations in commodities, construction activity, emergencies, weather patterns, etc. They are considered to be the core functions for site operations, safety, environmental compliance, and sustainability at NREL. In FY 2016, this funding will continue to support more than 60 FTEs that manage and provide support for these core functions. It will also fund site-wide subcontracts such as janitorial services, refuse and recycling, and subcontracts for minor construction. Additionally, this funding will support site-wide costs associated with maintaining NREL's leadership position, such as: maintaining International Organization for Standardization (ISO), American Association for Laboratory Accreditation (A2LA), and other lab-wide accreditations, managing facilities to enable mission goals, improving sustainability, pollution prevention, waste minimization, improving energy efficiency, reducing water use, and maintaining an effective emergency management system.

The FY 2016 budget allocation remains consistent with the method EERE developed in FY 2015. This approach is a more precise, equitable, and economically neutral method that ensures a predictable net-zero impact on programs' funding. For each program, the contribution to direct funding for site-wide facility support is equivalent to the estimated contribution the program otherwise would have made through overhead charges. This method is based upon each program's level of funding to NREL, adjusted to account for anomalies from large capital expenditures and major subcontracts.

In addition, funds may be used to support efforts such as peer reviews, data collection and dissemination, technology assistance, and technology-to-market activities.

**NREL Site-Wide Facility Support**
**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **NREL Site-Wide Facility Support $500,000** | **$500,000** | **$0** |
| • Directly fund NREL site-wide facility support costs that are not included in the Facilities and Infrastructure budget rather than continue to fund these costs in the laboratory overhead rate. | • Directly fund NREL site-wide facility support costs that are not included in the Facilities and Infrastructure budget rather than continue to fund these costs in the laboratory overhead rate. | • No Change. |

## Geothermal Technologies
## Performance Measures

In accordance with the GPRA Modernization Act of 2010, the Department sets targets for, and tracks progress toward, achieving performance goals for each program.

| | FY 2014 | FY 2015 | FY 2016 |
|---|---|---|---|
| Performance Goal (Measure) | **Reduce the LCOE from newly developed geothermal systems (cents/kWh)** | | |
| Target | 22.4 | 22.3 | 22.2 |
| Result | Met - 22.4 | N/A | N/A |
| Endpoint Target | 6 cents/kWh by 2030 | | |

## Advanced Manufacturing

### Overview

Manufacturing is critical to future U.S. innovation, global economic competitiveness, and job growth, particularly the manufacture of clean energy products. Manufacturing is the use of energy, equipment, information, services, and capital to convert raw materials, components, and parts into goods that meet market expectations. As an economic sector, manufacturing generates 12 percent of U.S. Gross Domestic Product (GDP)[1] and employs 12 million Americans.[2] While being a key sector underlying long-term economic growth, manufacturing also has an annual energy bill of about $200 billion and uses roughly one-third of the primary energy (and related GHG emission) in the U.S.[3] With opportunities to improve energy efficiency in specific manufacturing processes by 25 percent or more, the development and deployment of manufacturing technologies has multiple benefits in reducing both the energy footprint and associated GHG emissions from manufacturing as well as supporting the competitiveness in the manufacturing of new clean energy products. U.S. manufacturing can particularly benefit from technologies for energy efficiency across the board, as industry must continually improve productivity and efficiency to remain globally competitive.

There is also a large opportunity to improve the cost effective manufacture of products that reduce energy consumption in their distribution, use, and disposal. New or improved materials, technologies, and processes can drive forward the U.S. manufacturing of products at globally competitive costs while achieving significant energy, carbon and economic benefit across the economy—ensuring that technologies invented in the US ultimately result in the manufacture of high-quality clean energy products in the U.S.

The Program's research, development, demonstration, and deployment (RDD&D) investments bring together manufacturers, research institutions, suppliers, and universities to advance high-impact technologies for energy efficiency in the manufacturing sector in addition to foundational, cross-cutting manufacturing and materials technologies critical to efficient and competitive domestic manufacturing of clean energy products. The Program addresses these clean energy manufacturing challenges using three primary modalities of support: research and development of early stage manufacturing technologies through the support of individual R&D projects, pre-commercial technology development through facilities and manufacturing consortia, and technology assistance through manufacturing partnership participation, assessment and evaluation tools. These modalities are represented by the three sub-programs: Advanced Manufacturing R&D Projects, Advanced Manufacturing R&D Facilities, and Industrial Technical Assistance.

Work in these three sub-programs focuses on manufacturing issues in two categories: (1) energy cost reduction and efficiency for the nation's most energy-intensive and energy-dependent industries and (2) materials and enabling technologies with cross-cutting impact for cost reduction and performance improvement broadly applicable to the manufacturing of clean energy products. The Program identifies topical thrusts within each of these two categories and uses them as organizing priorities for existing and proposed technical work. These thrusts are identified through extensive consultation with private sector firms, non-profit, university and National Laboratory partners, as well as coordination across the department through the clean energy manufacturing activities to ensure high potential for impact to multiple technology offices, and are selected on the basis of potential energy, environmental, and economic impacts. In addition to these forward looking engagement efforts, the projected benefits and impacts of these areas are quantitatively investigated through analytic tools such as energy bandwidth studies, life-cycle energy and materials flow analysis. Once identified, they are pursued through the establishment and implementation of well-designed multi-year program plans. The program will revisit the list of thrusts regularly to ensure continued relevancy.

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[1] "GDP by Industry / VA, GO, II, EMP," 2013, Bureau of Economic Analysis; available from: http://www.bea.gov/industry/xls/GDPbyInd_VA_NAICS_1997-2013.xlsx

[2] "GDP by Industry / VA, GO, II, EMP," 2013, Bureau of Economic Analysis; available from: http://www.bea.gov/industry/xls/GDPbyInd_VA_NAICS_1997-2013.xlsx

[3] Annual Energy Outlook 2014: Reference Case Data, U.S. Energy Information Administration, available from: *http://www.eia.gov/forecasts/aeo/data.cfm*

Over the past year, a set of twelve high priority technical thrust areas have been identified and are aligned to address the broad mission of the Program's RDD&D. They are intended to be broad enough to comprehensively address the range of advanced manufacturing challenges faced by clean energy manufacturing, while being focused to ensure technical leadership in each thrust area. This portfolio organization is structured to be cross-cutting without picking specific industry sectors, while maintaining support for longstanding Program technical priorities. Individual industrial sectors, such as steel, combined heat and power (CHP), natural gas, and water-energy benefit from these cross-cutting technologies.

For materials and technologies broadly applicable to the manufacturing of clean energy products, identified thrusts are:

- Advanced Materials Manufacturing – Technologies for the accelerate development and qualification of new materials broadly applicable to clean energy products (including steels, lightweight metals, and nanomaterials).
- Critical Materials – Materials essential to the production of clean energy products for which there is potential for supply chain disruption with few alternatives (including rare-earth materials).
- Advanced Composites and Lightweight Materials – Materials and processes for the cost-effective and low energy-intensive production of high strength and low weight materials, broadly applicable to clean energy products ranging from fuel efficient vehicles and long blade wind turbines to high pressure natural gas tanks.
- Additive 3D Manufacturing – Manufacturing processes capable of directly achieving net-shape production of metals, polymers, and ceramic materials. New technologies to drive down cost, increase the quality, and maximize the throughput of these processes have the potential to broadly impact clean energy products ranging from electric vehicles and fuel cells to gas turbines and heat exchangers.
- Roll-to-Roll 2D Manufacturing – Manufacturing processes capable of continuously and reliably producing complex two-dimensional multi-material material assemblies and structures used in clean energy products ranging from solar photovoltaic and energy storage batteries to chemical process membranes and fuel cells.
- Wide Bandgap Power Electronics – Semiconductor and semiconductor products based on energy efficient wide bandgap semiconductors such as Silicon Carbide and Gallium Nitride. Power electronics based on these semiconductors have the potential to reduce energy losses in electrical systems ranging from data centers and lighting systems to electric vehicles and electric grid power control and management.
- Next Generation Electric Machines – Advanced electro-mechanical motor and generator systems coupling torque to electrical energy. Leveraging advances in materials and electronics technologies, new electric machines have the potential to reduce energy loss, lower costs and increase functionality in systems ranging from electric vehicles and wind turbines to natural gas compressor systems and chemical process units.

For energy efficiency technologies applicable to energy-intensive and energy-dependent industries, identified thrusts are:

- Smart manufacturing – Advanced sensors, controls, platforms, and models (including high performance computing modelling) as a suite of validated tools enabling real-time operational energy efficiency improvements in manufacturing ranging from unit processes to factory-wide integration to enterprise-wide energy management. Potential impacts for cost effective energy efficiency and energy management in both existing infrastructure (steel, aluminum, chemical and pulp/paper production) as well as new facilities (biochemical, carbon and glass fiber production).
- Chemical process intensification – Equipment and method technologies intended to cost effectively reduce the size and energy intensity of chemical processes through higher reaction efficiency, novel mixing and separation technologies and low thermal budget heating and cooling technologies. Potential impact for production of biochemicals, conversion of stranded flare gas, separation and cleaning of manufacturing waste and energy efficient water purification.
- Grid and resource integration, including CHP – Technologies to cost effectively improve the effective and efficient integration of manufacturing into the grid and other energy related fuel and feedstock resources (natural gas). Includes new technologies for high efficiency CHP, distributed generation, and real time manufacturing demand response.
- Sustainable manufacturing – Technologies and processes for cost effective utilization of new and sustainable fuels and feedstocks that reduce long range impact of manufacturing, for instance, through the use of low cost natural gas, cost effective recycling of energy-intensive materials or high efficiency use of water.
- Emergent topics for clean energy manufacturing – New technologies not otherwise addressed with the potential to significantly impact energy efficiency in the manufacture of clean energy products.

These technical thrust areas will be addressed through a combination of technology development based on the nature of the specific gaps identified and the degree to which a comprehensive industry-wide collaboration would accelerate

development and promote competitiveness. Continuing input from Industry, university, national laboratory, and non-profit partners will be solicited, and all technology development activities will be selected through merit based competitive processes.

**Highlights of the FY 2016 Budget Request**

The Program's FY 2016 Budget Request supports several key initiatives that contribute to achieving the goal of developing cross-cutting technologies for the manufacturing of clean energy products and energy efficiency in manufacturing:

- Advanced Manufacturing R&D Projects ($133 million): The Program's FY 2016 request supports up to six new individual competitive funding opportunity announcements (FOAs), plus an additional Advanced Manufacturing Incubator FOA that will be released in the Program's priority thrust areas. Thrust area topics to be considered include:
  - Grid and resource integration – Grid integration of manufacturing through combined heat and power, including waste heat recovery, advanced insulation materials, and integration of energy infrastructure (grid and natural gas);
  - Smart manufacturing – Including high performance computer simulation of energy-intensive and energy-dependent manufacturing processes;
  - Advanced materials manufacturing - (including advanced steels and nanomaterials manufacturing);
  - Next generation electric machines - (including ultraconductive materials);
  - Sustainable manufacturing - (including water-energy); and
  - Emergent topics for clean energy manufacturing – Including technologies with strong potential for dramatic improvement in energy efficiency and manufacturing competitiveness. (Incubator FOA).
- In areas where high-impact research and development project opportunities are identified that are strongly complementary to existing program-supported Manufacturing Innovation Institute, or other program-supported consortium, but are at a lower level of technical maturity, the project based individual FOA efforts will be tightly coordinated with these consortia to ensure leveraging of existing support without overlap. In addition, the Program will make competitively selected investments in a broad range of the technologies that can meet program goals with no predetermination about specific pathways to allow the business community to propose ideas that may revolutionize the field of advanced manufacturing.
- Advanced Manufacturing R&D Facilities ($241 million): The Program's FY 2016 Request will support the full funding of two new Clean Energy Manufacturing Innovation Institutes and will also support ongoing advanced manufacturing R&D facilities including four Clean Energy Manufacturing Innovation Institutes.
  - Wide Bandgap Power Electronics Institute ($14 million, started FY 2013)
  - Advanced Composite Materials and Structures Institute ($14 million, started FY 2014)
  - Smart Manufacturing Institute ($14 million, started FY 2015]
  - Clean Energy Manufacturing Innovation Institute #4 ($14 million, started FY 2015)
  - Two new fully-funded Clean Energy Manufacturing Innovation Institutes ($140 million, to be started in FY 2016)
  - One Energy Innovation Hub (Critical Materials Institute [$25 million, started in 2012])
  - One Manufacturing Demonstration Facility (Additive Manufacturing Demonstration Facility [$20 million, started in 2012])

Furthermore, as part of its ongoing support of the Wide Bandgap Semiconductor Power Electronics Institute, the Program will continue to coordinate with the Office of Science to implement technical training focused on wide bandgap power electronics that will consist of a mixture of classroom and project based practical experience. These Clean Energy Manufacturing Innovation Institutes are part of the Administration's vision for a larger multi-agency National Network for Manufacturing Innovation (NNMI). Potential topics and technical metrics for the two new institutes will be finalized through engagement with industry through requests for information and public workshops, will align with the program's technology thrusts, and will follow the same process as previously awarded Institutes. Recent workshops included investigation of (1) Advanced Materials Manufacturing; (2) High Efficiency Modular Chemical Process Intensification; and (3) Two-Dimensional Roll-to-Roll Processing, with the findings of such workshops published.[1]

[1] "New Request for Information (RFI) on Clean Energy Manufacturing Topic Areas" http://www.energy.gov/eere/amo/articles/new-request-information-rfi-clean-energy-manufacturing-topic-areas, September 2014.

- An Advanced Manufacturing "Incubator" FOA will invest no less than 5 percent of Advanced Manufacturing R&D project funding toward new off-roadmap innovative technologies and solutions that can help meet existing goals but are not represented in a significant way in the Program's current priority thrust areas or project portfolio. Successful Incubator projects will reduce the risk associated with potentially breakthrough approaches and technologies so they may be 'on-ramped' to future Program roadmaps and the Program portfolio.
- Industrial Technical Assistance ($30 million): the Program will continue to partner with industry by providing technical assistance by investing in cost-effective energy efficiency solutions through the Better Plants program, Superior Energy Performance (SEP) certification program, Industrial Assessment Centers (IACs) program, Combined Heat and Power Technical Assistance Partnerships (CHP TAPs) and related efforts. This assistance offers manufacturers the opportunity to establish energy savings targets and improve energy management with significant energy savings. Efforts include identifying and publishing best practices, energy assessments for small and medium-sized manufacturers, technical assistance for efficient on-site distributed generation, and catalyzing the use of energy management and assessment tools. Effective industrial strategic energy management includes standardized energy management tools and protocols. They enable established and emerging industries to identify and invest in energy efficiency improvements; comply with international energy management standards (ISO 50001); adopt new flexible/adaptable processes and materials; and educate, re-train and certify the U.S. workforce.

The Program's Advanced Manufacturing R&D Projects and Industrial Technical Assistance support the Energy-Water Nexus crosscut in the FY 2016 budget. The goal of the Energy-Water Nexus crosscut is an integrated set of investments and cross-program collaborations that contribute to the Nation's transition to more resilient energy and coupled energy-water systems. The Program will support this crosscut by collaborating with water supply and wastewater treatment plants through a combination of targeted technical assistance and a small amount of competitive awards to fund water and wastewater advanced energy efficiency R&D that aligns with the crosscut.

The Program provides foundational capabilities to support the Department-wide Clean Energy Manufacturing Initiative (CEMI), a comprehensive DOE-wide approach to enhance U.S. competitiveness in clean energy manufacturing while advancing progress toward the nation's energy goals. The DOE Clean Energy Manufacturing Initiative supports research, development, and addressing market barriers that will help companies competitively manufacture clean energy technologies in the U.S., and help companies across the manufacturing sector become more competitive by leveraging energy efficiency measures to increase their energy productivity. The Program will also collaborate across DOE through CEMI in targeted investment in: (1) advanced materials manufacturing for core materials design and qualification capabilities, and (2) foundational 3D additive manufacturing capabilities to achieve customized composition and structure for tailored materials as well as optimized, higher performance / lower cost clean energy system components. These are technical areas where the Program is supporting the development of foundational capabilities; the cross-cutting impact will be through partnership with technology offices across the department.

**FY 2016 Crosscuts ($K)**

| | Energy-Water Nexus | Total |
|---|---|---|
| **Advanced Manufacturing** | **4,300** | **4,300** |

[1] "Manufacturing Innovation Multi-Topic Workshop" http://www.energy.gov/eere/amo/downloads/manufacturing-innovation-multi-topic-workshop, October 2014.

**Advanced Manufacturing**
**Funding ($K)**

| | FY 2014 Enacted[1] | FY 2014 Current[2] | FY 2015 Enacted | FY 2016 Request | FY 2016 vs FY 2015 |
|---|---|---|---|---|---|
| **Advanced Manufacturing** | | | | | |
| Advanced Manufacturing R&D Projects | 76,971 | 74,508 | 84,000 | 133,000 | +49,000 |
| Advanced Manufacturing R&D Facilities | 81,500 | 78,892 | 92,500 | 241,000 | +148,500 |
| Industrial Technical Assistance | 22,000 | 22,000 | 23,500 | 30,000 | +6,500 |
| **Total, Advanced Manufacturing** | **180,471** | **175,400** | **200,000** | **404,000** | **+204,000** |

SBIR/STTR:

- FY 2014 Transferred: SBIR $4,437,000; STTR $634,000
- FY 2015 Enacted: SBIR $5,119,000; STTR $706,000
- FY 2016 Request: SBIR $11,220,000; STTR $1,683,000

[1] FY 2014 Enacted funding reflected the contractor foreign travel rescission of $107,720.
[2] Funding reflected the transfer of SBIR/STTR to the Office of Science.

**Advanced Manufacturing**
**Explanation of Major Changes ($K)**

| | FY 2016 vs FY 2015 |
|---|---|
| **Advanced Manufacturing R&D Projects:** The increase in funding will enable an expanded number of FOAs in high-impact foundational technology areas, allowing up to six (an increase of three) new fully front-funded advanced manufacturing R&D project FOAs aligned with the Program's strategic priority thrusts. | **+49,000** |
| **Advanced Manufacturing R&D Facilities**: The increase in funding will support the Additive Manufacturing Demonstration Facility for the final year of its intended five year federal funding profile, complete the five-year funding for the Critical Materials Hub, provide support for previous commitments to four existing Clean Energy Manufacturing Innovation Institutes, and enable the program to award two new fully front-funded Clean Energy Manufacturing Innovation Institutes. | **+148,500** |
| **Industrial Technical Assistance**: The increase in funding will expand the Better Plants program, including support for the supply chain and water savings efforts; enhance support for and comprehensively review the impacts of the IACs, as well as support research by IACs relating to industrial energy efficiency; and support the continued growth, including tools and training, for the SEP program, as well as increase the emphasis on strategic energy management within the Better Plants, CHP TAPs, and IAC program elements. | **+6,500** |
| **Total, Advanced Manufacturing** | **+204,000** |

**Description**

Through competitively-selected R&D investments in foundational energy-related advanced manufacturing technologies, the Program will increase the impact of its work in thrust areas relevant to energy-intensive and energy-dependent industries as well as materials and technologies widely applicable across multiple clean energy manufacturing industries. The Advanced Manufacturing R&D Projects subprogram will support innovative manufacturing projects at American companies and research organizations that focus on specific high-impact manufacturing technology and process challenges in order to increase energy productivity. These projects will fund the development of next generation production technologies. Development will also take into account down-stream challenges to better facilitate the ultimate transition of these technologies into domestic industrial production facilities.

In FY 2016, up to six new individual R&D project funding opportunity announcements (FOAs) of approximately $15-20 million each ($113 million) will be released in specific foundational manufacturing technology areas. These specific areas will be selected from the results of technology analyses and workshops, and by soliciting input from stakeholders through requests for information prior to planning of the FOAs. Candidate topics will fit within one or more of the Program's technology thrust areas and will be selected based on the consideration of potential energy, environmental, and economic impacts. The impacts include: (1) reducing the energy intensity of production and producing items which reduce life cycle energy use; (2) additionality relative to existing public and private sector investments; (3) degree of technical uncertainty and risk which limit potential private sector investment; (4) potential for catalyzing influence of public sector investment; and (5) opportunity for long term impact on domestic manufacturing.

Two technology thrust areas with clear potential that the program may support through specific topical FOAs in FY 2016:

- Chemical process intensification: Replacements for current high-temperature materials processing for producing and/or recovering materials offer significant potential savings across a broad set of applications. Example applications include water-based selective extraction of critical materials from low-grade ores, obsolete electronic equipment, and waste landfills and low-temperature/high-efficiency chemical or electrochemical processes. Opportunities for alternate thermal processes include new applications of electromagnetic energy such as microwave, radio frequency, ultra-violet or electron-beam processing to heat selected materials. Improved reactions and separations can enable energy and cost savings, reduced water usage and a lower carbon footprint in energy-intensive industries such as desalination, chemical production, food processing, helium extraction, and oil refining. Innovative membranes with higher selectivity and low fouling characteristics have the potential to reduce energy requirements by up to 20 percent for high-demand chemicals, including oxygen and nitrogen.
- Smart manufacturing: New information technologies with broad applicability to manufacturing processes can reduce energy consumption as well as the use of materials and related costs, for instance through the integration of robust sensors, high fidelity process models and process to enterprise wide integration information platforms. Sensors and advanced process controls to automate processes also offers significant energy savings. High performance computer simulation of energy-intensive and energy-dependent manufacturing processes offers significant productivity improvement opportunities.

Other topics under strong consideration for FY 2016 FOAs include those that address the following thrust areas: grid and resource integration (including advanced combined heat and power, waste heat recovery, advanced insulation materials, and integration of energy infrastructure (grid and natural gas)); next generation electric machines (including ultraconductive materials); sustainable manufacturing (including water-energy); and emergent topics. Projects will be evaluated for selection through the competitive FOA process. In cases where R&D project opportunities are identified in specific topical areas complimentary to an existing manufacturing institute, the Programs will be coordinated to ensure leveraging of existing support without overlap.

The Advanced Manufacturing Incubator activity ($20 million) will make competitively selected investments in a broad range of the technologies that can meet the goals of the Program with no predetermination about specific technological pathways to allow the industry and research community to propose ideas that may revolutionize the field of advanced manufacturing. These R&D projects will focus on the most fundamental of applied R&D projects that could have significant

energy, environmental, and economic gains. This activity provides the incentive for small- and medium-size manufacturing companies to pursue emerging high-risk, high-impact technology developments that they otherwise would not pursue.

In addition, funds may be used to support efforts such as peer reviews, data collection and dissemination, and technology-to-market activities.

**Advanced Manufacturing R&D Projects**
**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **Advanced Manufacturing R&D Projects $84,000,000** | **$133,000,000** | **+$49,000,000** |
| • Through competitively selected R&D projects, funding will address core technical issues for foundational technologies that will enable U.S. manufacturers to realize significant gains in energy productivity, environmental performance, product yield, and economic growth. Three or four FOAs will be supported in FY 2015 to address specific topical opportunities in several technology thrust areas including next generation electric machines and advances in combined heat and power. Each FOA will provide approximately $20 million to support R&D projects in that area. In addition, an Advanced Manufacturing Incubator for High-Impact Foundational Technology FOA will supplement the individual targeted FOAs and is planned at approximately $14 million. | • Through competitively selected R&D projects, funding will continue to address core technical issues for foundational technologies that will enable U.S. manufacturers to realize significant gains in energy productivity, environmental performance, product yield, and economic growth. Up to six FOAs will be supported in FY 2016, potentially targeting specific topical opportunities in the following thrust areas: chemical process intensification, advanced materials manufacturing, smart manufacturing, grid and resource integration, next generation electric machines, sustainable manufacturing, and emergent topics. Each FOA will invest approximately $15-20 million to support R&D projects in that area. In addition, an Advanced Manufacturing Incubator for High-Impact Foundational Technology FOA will supplement the individual targeted FOAs and is planned at approximately $20 million. | • The increased funding will enable an expanded number of funding opportunities in specific high-impact foundational technology areas, allowing up to six new R&D project FOAs at approximately $19 million each. The amount of funding available for the Advanced Manufacturing Incubator activity will be increased slightly to broadly seek potentially revolutionary manufacturing advances. |

**Description**

The Advanced Manufacturing R&D Facilities subprogram supports public-private R&D partnership facilities and consortia for clean energy manufacturing technology research and development. Through these facilities, the subprogram also helps facilitate the transition of innovative next generation material processes and production technologies to industry. The Program's facilities include Clean Energy Manufacturing Innovation Institutes, the Critical Materials Hub, and the Manufacturing Demonstration Facility, and are designed to accelerate the development and implementation of cutting-edge energy efficiency technologies applicable to energy-intensive and energy-dependent industries and materials and technologies broadly applicable to the manufacturing of clean energy products. The topics of Institutes have broad application and are focused on getting technologies ready for a production environment whereas R&D Projects often have a more focused application and solve research problems that have to be overcome prior to production scale-up. Program activities help the U.S. position itself as a world leader in manufacturing by bringing together manufacturers, research institutions, suppliers, and universities. The benefits from these Clean Energy Manufacturing Innovation Institutes and other advanced manufacturing R&D facilities will be spread broadly across multiple industries and improve U.S. competitive advantage, especially for small- and medium-sized enterprises (SMEs). Further, the investments with universities and SMEs contribute to developing national capabilities that enable future global leadership.

The FY 2016 funding ($241 million) will support the full funding of two new Clean Energy Manufacturing Innovation Institutes ($70 million each) and will also provide annual support for four existing Institutes ($14 million each). These Institutes are part of the President's vision for a larger multi-agency National Network for Manufacturing Innovation (NNMI). The NNMI model[1] will induce collaboration and spread risk,[2] complement university research, and support innovation to increase competitiveness of U.S. manufacturers. The Clean Energy Manufacturing Innovation Institutes are designed to focus on specific technologies that are broadly applicable and pervasive in multiple industries and markets with potentially transformational technical and manufacturing productivity impact. Institutes are partnerships among government, industry, and academia, supported with cost-share funding from Federal and non-Federal sources. Within 5 years of its launch, each institute is expected to be financially independent and sustainable using only private-sector and other sources without further federal funding. Multi-year award agreements and funding profiles for the institutes will reflect this expectation.

The new institutes will be competitively selected in FY 2016 through an FOA. They will focus on one of the following priority technology thrust areas: (1) advanced materials manufacturing; (2) two-dimensional roll-to-roll manufacturing; (3) high efficiency modular chemical processes; and (4) other emergent topics in clean energy manufacturing. These were identified for consideration at the Design for Impact workshop, requests for information, and technical topic specific workshops.[3] The outputs from these broadly attended technical workshops are publicly disseminated to ensure a high level of feedback from industry and technical communities.[4] Additional workshops with industry, academia, and other government organizations will be held on each of these topics to refine their suitability for an institute FOA, including development of quantitative technical goals and metrics. Topics will be prioritized based on the consideration of potential energy, environmental, and economic impacts of technology (including reducing the energy intensity of production and producing items which reduce life cycle energy use); additionality relative to existing public and private sector investments in such facilities; technical uncertainty and risk which limit potential private sector investment; potential for catalyzing influence of public sector investment; and opportunity for long range impact on domestic manufacturing. Each new institute will be fully funded by the $70 million requested in FY 2016. The two new institutes therefore will not incur out-year commitment.

[1] Executive Office of the President National Science and Technology Council Advanced Manufacturing National Program Office, "National Network for Manufacturing Innovation: A Preliminary Design", March 2013.
[2] Massachusetts Institute of Technology, "A Preview of the MIT Production in the Innovation Economy Report", February 2013.
[3] http://www1.eere.energy.gov/manufacturing/resources/workshops.html.
[4] "Manufacturing Innovation Multi-Topic Workshop" http://www.energy.gov/eere/amo/downloads/manufacturing-innovation-multi-topic-workshop, October 2014

In FY 2016, $14 million will be provided for the fourth of 5 total years of support to the Next Generation Power Electronics Manufacturing Innovation Institute, focused on wide bandgap semiconductor technology. The Next Generation Power Electronics Manufacturing Innovation Institute was selected through an FOA issued in FY 2013, was established in FY 2014, and was funded at $14 million in each of FY 2013, FY 2014, and FY 2015, for a total of $42 million through FY 2015. Assuming availability of appropriations, this Institute will be funded for an additional $14 million in FY 2017; this Institute thus has a total out-year commitment of $14 million.

$14 million will also be provided for the third of 5 total years of support for the Advanced Composites Manufacturing Innovation Institute. This Institute was selected through an FOA issued in FY 2014, and was funded at $14 million in each of FY 2014 and FY 2015, for a total of $28 million through FY 2015. Assuming availability of appropriations, this Institute will be funded for an additional $14 million in each of FY 2017 and 2018; this Institute thus has a total out-year commitment of $28 million.

$14 million will be provided for the third of 5 total years of support for the Smart Manufacturing Innovation Institute. This Institute was funded for $14 million in each of FY 2014 and FY 2015, for a total of $28 million through FY 2015. Assuming availability of appropriations, this Institute will be funded for $14 million in each of FY 2017 and FY 2018; this Institute thus has a total out-year commitment of $28 million.

$14 million will be provided for the 4$^{th}$ DOE Clean Energy Manufacturing Institute, which will be selected through FOAs issued in FY 2015. The 4$^{th}$ Institute is funded at $14 million in FY 2015, its first year of funding. Assuming availability of appropriations, this Institute will be funded for $14 million in each of FY 2017, FY 2018, and FY 2019; this Institute thus has a total out-year commitment of $42 million.

The Advanced Manufacturing R&D Facilities subprogram will track and assess the impact of all Clean Energy Manufacturing Innovation Institutes and, in cooperation with Department of Defense, the National Additive Manufacturing Innovation Institute (America Makes, the initial pilot National Network for Manufacturing Innovation institute). It will ensure that supported facilities and activities contribute significantly to the program's clean energy, energy productivity, and manufacturing competitiveness goals. These institutes will be actively managed as public-private partnerships through cooperative agreements, to ensure timely achievement of all technical, operational, organizational and partnership goals. This active management will explicitly include inputs and reviews from public and private sector experts to ensure the institutes are of high value to both public and private sector interests. FY 2015 is the final year of Energy Efficiency and Renewable Energy (EERE) support for America Makes. No funds are included for America Makes in the FY 2016 budget.

In FY 2016, the Critical Materials Hub ($25 million)—competitively awarded in FY 2013 to a team led by the Ames National Laboratory—will focus on technologies that will enable American manufacturers to make better use of the critical materials to which they have access, as well as to reduce or eliminate the need for materials that are subject to supply disruptions. These critical materials, including many rare earth elements, are essential for American competitiveness in the clean energy manufacturing and other strategic industries like defense. This fifth year of funding for the Critical Materials Hub will enable it to continue to integrate scientific research, engineering innovation, and manufacturing and process improvements to provide holistic solutions to critical materials challenges facing the Nation. EERE first funded the Critical Materials Hub in FY 2012, and has funded it for a total of $90 million through FY 2015. FY 2016 is the final year of EERE funding commitment for the Critical Materials Hub.

In FY 2016, the Advanced Manufacturing R&D Facilities subprogram will continue to fund the Oak Ridge National Laboratory (ORNL) led Manufacturing Demonstration Facility (MDF) with an additional $20 million for the final year of the planned period of funding. The MDF is a facility for industrial research partnerships related to additive manufacturing. Its work is supported through a combination of cost-shared cooperative research and development agreements focusing on specific manufacturing challenges, as well as competitively awarded research and development projects. The activities of the MDF are managed as an overall facility to ensure highly leveraged research and developments efforts consistent with the Advanced Manufacturing mission, without duplication or overlap with complementary facilities elsewhere such as America Makes. During FY 2015, the subprogram will develop assessment criteria for a full review at the end of five years, including technical and non-technical criteria to evaluate the MDF model. One element of the assessment criteria for the MDF will be the potential for application of additive manufacturing technologies developed through the facility to clean energy

manufacturing challenges across the DOE enterprise, including both EERE and non-EERE offices. EERE first funded the MDF in FY 2013, and has funded it for a total of $41 million through FY 2015. FY 2016 is expected to be the final year of EERE funding for the MDF; the MDF therefore has no out-year commitment.

In addition, funds may be used to support efforts such as peer reviews, data collection and dissemination, technology assistance, and technology-to-market activities.

**Advanced Manufacturing R&D Facilities**
**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **Advanced Manufacturing R&D Facilities $92,500,000** | **$241,000,000** | **+$148,500,000** |
| • Supports the creation of at least one new Clean Energy Manufacturing Innovation Institute, that will be part of the President's vision for a larger, multi-agency National Network of Manufacturing Innovation. Provides annual and forward-funded support for the existing Institutes. Supports $25 million of investment in the Critical Materials Hub. | • Supports the full funding of two new Clean Energy Manufacturing Innovation Institutes, as part of the President's vision for a larger, multi-agency National Network of Manufacturing Innovation. DOE is planning to invest $70 million over 5 years into each new Institute. Supports $56 million for four existing Institutes, $25 million of investment in the Critical Materials Hub, and $19.9 million for the Manufacturing Demonstration Facility. | • The increase in funding will allow the program to award two additional fully funded Institutes, as well as provide support for the existing Institutes and other facilities that were awarded in previous years. |

## Advanced Manufacturing
## Industrial Technical Assistance

**Description**

The Industrial Technical Assistance subprogram is implemented through the CHP deployment activities including CHP TAPs, formerly known as Clean Energy Application Centers (CEACs); the Better Buildings Better Plants program; IACs; and the SEP International Organization for Standardization (ISO)/American National Standards Institute (ANSI) Certification. Through these activities, the Industrial Technical Assistance subprogram's goals are to assist in the deployment of 40 gigawatts (GW) of new, cost-effective CHP by 2020, demonstrate the technical and economic viability of improved energy management approaches, and support a reduction in manufacturing energy intensity by 25 percent over ten years.

The $30 million budget for the Industrial Technical Assistance subprogram is critical to the deployment of existing and future advanced energy efficiency technologies and practices. Advanced Manufacturing's CHP efforts support Executive Order 13624, which sets a national goal of 40 GW of new CHP by 2020. The cornerstone of the program's efforts is the CHP TAPs, which promote and assist in transforming the market for CHP, waste heat to power, and district energy with CHP technologies and concepts throughout the U.S. CHP TAP services include: market assessments for CHP, such as critical infrastructure; education and outreach that provide information on the benefits and applications of CHP to state and local policy makers, regulators, energy end-users, trade associations, and others; and technical assistance to energy end-users and others to help them consider CHP as a viable technical and economic opportunity for them. FY 2016 funding for these activities provides both ongoing support for the existing CHP TAP awards and $7 million for competitively awarded technical assistance to help States and regions to increase CHP deployment, including through the design of regulations, policies, or other actionable strategies informed by best practices.

The Better Buildings Better Plants program offers technical assistance and informational resources to manufacturers to help them identify and pursue opportunities to implement cost-effective energy efficiency improvements that save money, create jobs, and strengthen their competitiveness. The program will continue efforts to add more companies and members of their supply chains to the Better Buildings Better Plants program as industrial partners. The program will also continue efforts to add more companies that will take on water savings targets, along with their energy savings targets. Finally, the program will work with water treatment and wastewater treatment facilities to enable greater savings in this energy-intensive industry. All Better Plants partners establish energy savings targets and report annually on attainment towards the goals, as well as have opportunities to share critical information on what approaches are working for them in achieving results. Better Plants assists partners to invest in energy management and ISO 50001 processes to better identify and manage energy use as a long-term approach to efficiency that includes goals, tracking, and reporting. The program is advancing strategic energy management best practices through the Better Plants program and as well as through SEP, an industry-led certification program that provides industrial facilities with a transparent, globally accepted system for verifying energy performance improvements and management practices. A central element of SEP is implementation of the global energy management standard, ISO 50001, with additional requirements to achieve and document third-party verification of energy performance improvements. DOE provided support for the development of this standard. Now that standards development is complete, DOE is coordinating the ANSI-accredited SEP certification bodies; recruiting and recognizing the early adopter facilities to build and expand the SEP market; and integrating the facility-level SEP certification process with Better Buildings Better Plants corporate partners' efforts to drive continual energy performance improvement using the ISO 50001 energy management standard.

FY 2016 funding supports IACs ($7 million), which conduct energy efficiency, productivity improvement, and waste reduction assessments for small- and medium-sized manufacturer at no cost to them. The IACs utilize major university-based engineering faculty and engineering students to do the assessments and teach the students hands on skills and knowledge of industrial process systems, plant systems, energy systems, and energy management practices. DOE will also work with the IACs on the refinement and dissemination of an Accreditation Board for Engineering and Technology (ABET) accredited undergraduate energy engineer degree offering. Finally, the IACs coordinate with the nation's Manufacturing Extension Partnerships, state energy offices, and electric, natural gas and water utilities to maximize the savings potential for the small- and medium-sized clients. FY 2016 funding completes the current five-year funding cycle for the IACs, and it includes funds to assess the performance, nationwide impact, and overall benefit of the program, as well as promote industrial energy efficiency research by Center Directors and Assistant Directors.

In addition, in FY 2016, $1 million will be used to conduct a comprehensive Technical Assistance program review to evaluate programmatic and cost effectiveness as well as other factors necessary to improve program planning and impact. Funds may be used to support efforts such as peer reviews, data collection and dissemination, technology assistance, and technology-to-market activities.

**Industrial Technical Assistance**
**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **Industrial Technical Assistance $23,500,000** | **$30,000,000** | **+$6,500,000** |
| • The program supports CHP deployment activities including the seven CHP TAPs; the Better Buildings Better Plants Program, with more than 150 Partners; 24 IACs located at ABET-accredited engineering departments; and more than 25 SEP ISO/ANSI Certified facilities. These efforts work together to drive a corporate culture of continuous improvement and wide-scale adoption of technologies to reduce energy use and costs in the industrial sector. | • The program continues to support CHP deployment activities including the CHP TAPs and expanded market analysis and outreach resources; increase the number of Better Buildings Better Plants Program Partners to at least 165; enhance support for the 24 IACs with an increased emphasis on energy management systems and water-related issues; and expand the number of SEP ISO/ANSI Certified facilities to between 40 to 50. These efforts work together to drive a corporate culture of continuous improvement and wide-scale adoption of technologies, such as CHP, to reduce energy use and costs in the industrial sector. | • The program will expand the Better Buildings Better Plants program, especially the supply chain and water savings efforts; enhance support for the IACs, including a comprehensive review the impacts of the program and support for research efforts by the IACs relating to industrial energy efficiency; and support to expand the SEP program into water facilities as well as produce tools and training that emphasize strategic energy management within all Technical Assistance program elements. |

**Advanced Manufacturing**
**Performance Measures**

In accordance with the GPRA Modernization Act of 2010, the Department sets targets for, and tracks progress toward, achieving performance goals for each program.

| | FY 2014 | FY 2015 | FY 2016 |
|---|---|---|---|
| Performance Goal (Measure) | **Demonstrations – Number of Clean Energy Manufacturing Innovation Institute(s) selected for negotiation to demonstrate advanced material and process technologies, leading to commercialization.**<br>**2014 & 2015: Number of Clean Energy Manufacturing Innovation Institute(s) established to demonstrate advanced material and process technologies, leading to commercialization.** | | |
| Target | 1 | 2 | 1 |
| Result | Met – 1 | Not Applicable | Not Applicable |
| Endpoint Target | 8 Manufacturing Innovation Facilities by 2017 | | |

## Federal Energy Management Program

### Overview

As America's largest single energy consumer, the Federal Government has a tremendous opportunity and responsibility to lead by example in cutting energy waste and advancing America's clean energy future. With more than 500,000 buildings and a 600,000 vehicle fleet, the Federal Government can serve as a model for successful approaches, stimulate private markets, and make a significant contribution to our national energy and environmental goals.

Federal energy use is significant. In 2013, the Federal Government used 1.6 quads of primary energy (1.7 percent of total U.S. energy use) at a cost of $24 billion. Federal greenhouse gas (GHG) emissions in 2013 totaled almost 90 million metric tons (1.3 percent of the Nation's total), which were primarily from energy use. Buildings and facilities represent about 42 percent of these totals, with vehicles and equipment accounting for the other 58 percent.

The Federal Government is pursuing—and making substantial progress toward—a number of challenging energy and sustainability goals established through Executive Order and statute[1]. Leadership by the Federal Government is a critical element of the President's Climate Action Plan. The DOE's Federal Energy Management Program (FEMP) assists and enables Federal agencies to meet these energy and sustainability goals and provide energy leadership as. FEMP tools and guides are beneficial to both Federal and non-Federal organizations. FEMP is uniquely positioned within the Office of EERE to coordinate innovative technologies and expertise from the other programs to bear upon the goals and aspirations of the Federal Government. Based on the unified knowledge and expertise available in EERE, FEMP is able to directly improve the sustainability, energy and water use of the Federal Government, which will facilitate the Government's ability to Lead by Example--encouraging establishment of energy goals, facilitating innovative technologies and creating change in the energy sphere.

### Highlights of the FY 2016 Budget Request

The FEMP FY 2016 Budget Request supports key initiatives to better assist Agencies in meeting aggressive energy, water, GHG and other sustainability goals, as well as share solutions, such as best practices, tools, and process improvements, more broadly throughout the economy to provide the greatest impact for its efforts. In FY 2016, four of FEMP's subprograms were combined into the Federal Energy Management subprogram. The goal of this restructuring is to allow FEMP to better respond to the dynamic needs of Federal agencies across major areas such as building energy efficiency, renewable energy, fleet vehicle energy use, and the use of performance contracting.

The overall FEMP Budget Request in FY 2016 increased by $16 million compared to the FY 2015—most of which is directed toward the Federal Energy Efficiency Fund (FEEF), also known as Assisting Federal Facilities with Energy Conservation Technologies (AFFECT) program. In FY 2016, FEMP will expand AFFECT from approximately $3 million in FY 2015 to $15 million in FY 2016 to assist agencies fund and invest in priority projects for efficiency and renewables with the greatest impact. By providing direct funding to leverage cost sharing at Federal agencies for capital improvement projects and other initiatives to increase energy efficiency, conserve water, and increase renewable energy investments at Federal agency facilities, AFFECT provides a mechanism for FEMP to ensure the best projects are funded and stay on schedule. This investment fund provides greater opportunities for agencies to develop and fund projects that they may not otherwise be able to implement, and provides another avenue for FEMP to partner with other EERE programs and national laboratories that can provide the expertise to help the Federal government lead in the adoption of innovative technologies and lead by example.

Out of the $120 million in investment leveraged by AFFECT in FY 2014, FEMP enabled approximately $73 million of investment in projects that would not have occurred without the added FEMP support. This revitalized assistance fund gave nine Federal agencies the ability to add scope to existing projects, streamline projects, and combine appropriations with privately financed performance contracts to increase investment possibilities. Participation in the program also requires agencies to be accountable for faster project implementation and reporting best practices to be shared with other sites.

[1] http://energy.gov/eere/femp/laws-and-requirements-0

In FY 2016, FEMP will continue to support the President's Performance Contracting Challenge (PPCC) by assisting agencies to successfully meet the $4 billion goal for investing in energy efficiency and renewable energy projects by the end of 2016 and helping agencies to continue their acceleration of using performance contracts to meet future energy investment needs and goals. FEMP will also share and rely on best practices from the PPCC to partner with other government and private sector stakeholders/partners to accelerate their use of performance contracts.

FEMP will also continue to lead the DOE Better Buildings Data Center Challenge (BBDCC), a voluntary leadership challenge to improve Federal data center consolidations and efficiency, a significant source of Federal energy use – in addition to data center efficiency more broadly throughout the public and private sectors. Based on the initial success of this challenge in recruiting more than twenty partners, including thirteen Federal partners to date, FEMP will work with Federal agencies to expand participation and success of its BBDCC partners. As the BBDCC achieves further success, FEMP may look for ways to use and potentially expand this platform to additional challenges.

**Federal Energy Management Program**
**Funding ($K)**

| | FY 2014 Enacted | FY 2014 Current | FY 2015 Enacted | FY 2016 Request | FY 2016 vs FY 2015 |
|---|---|---|---|---|---|
| **Federal Energy Management Program** | | | | | |
| Federal Energy Management | 0 | 0 | 0 | 27,288 | +27,288 |
| Federal Energy Efficiency Fund/AFFECT | 3,000 | 3,000 | 2,850 | 15,000 | +12,150 |
| DOE Specific Investments | 2,509 | 2,509 | 2,160 | 0 | -2,160 |
| NREL Site-Wide Facility Support | 0 | 0 | 800 | 800 | 0 |
| Project Financing | 9,558 | 9,558 | 9,500 | 0 | -9,500 |
| Technical Guidance and Assistance | 6,224 | 6,224 | 6,317 | 0 | -6,317 |
| Planning, Reporting and Evaluation | 5,569 | 5,569 | 4,073 | 0 | -4,073 |
| Federal Fleet | 1,388 | 1,388 | 1,300 | 0 | -1,300 |
| **Total, Federal Energy Management Program** | **28,248** | **28,248** | **27,000** | **43,088** | **+16,088** |

**Comparability Matrix ($K)**
**Proposed FY 2016 Budget Structure**

| | Federal Energy Management Program | | | Total |
|---|---|---|---|---|
| | Federal Energy Management | Federal Energy Efficiency Fund | NREL Site-Wide Facility Support | |
| **Federal Energy Management Program** | | | | |
| Project Financing | 11,270 | 0 | 0 | 11,270 |
| Technical Guidance and Assistance | 10,343 | 0 | 0 | 10,343 |
| Planning, Reporting and Evaluation | 4,050 | 0 | 0 | 4,050 |
| Federal Fleet | 1,625 | 0 | 0 | 1,625 |
| Federal Energy Efficiency Fund | 0 | 15,000 | 0 | 15,000 |
| NREL Site-Wide Facility Support | 0 | 0 | 800 | 800 |
| **Total, Federal Energy Management Program** | **27,288** | **15,000** | **800** | **43,088** |

**Federal Energy Management Program**
**Explanation of Major Changes ($K)**

| | FY 2016 vs FY 2015 |
|---|---|
| **Federal Energy Management:** All activities under Project Financing; Technical Guidance and Assistance; Planning, Reporting and Evaluation; and Federal Fleet have moved to Federal Energy Management. FY 2016 activities include the full utilization of the eProject Builder National Energy Savings Performance Contract database to make performance contracts standard practice by standardizing the collection, calculation, and reporting of performance data for ESPCs across Government; assisting agencies achieve $4 billion of Performance Contracting investment through 2016; and continuing support for the BBDCC. As the BBDCC achieves further success, FEMP may look for ways to use and potentially expand this platform to additional challenges. | **+27,288** |
| **Federal Energy Efficiency Fund:** Efforts under FEEF or AFFECT will be significantly expanded from approximately six projects in FY 2015 to approximately 30 projects in FY 2016. The AFFECT awards are focused on providing direct funding to support the best available agency projects and leverage cost sharing at Federal agencies for capital improvement projects and other initiatives to increase energy efficiency, conserve water, and increase needed renewable energy investments at Federal agency facilities. | **+12,150** |
| **DOE Specific Investments:** No funding is requested for this subprogram in FY 2016 due to the transfer of funding, functions and full-time employees of the Sustainability Performance Office to the Under Secretary for Management and Performance in order to align those duties under the DOE-Designated Senior Sustainability Officer. The $2.2 million reduction for DOE Specific Investments activities in the FEMP Budget Request is offset by a corresponding increase in the Budget Request for the Office of Management to support the Under Secretary for Management and Performance. | **-2,160** |
| **Project Financing:** Activities for Project Financing have moved to Federal Energy Management. In FY 2016, the FEMP budget structure was realigned to reduce the administrative overhead of managing the program and also allow FEMP to better respond to the dynamic needs of Federal agencies. FEMP will continue to support Federal agencies in identifying and implementing energy projects using performance contracting under the FEM subprogram**.** | **-9,500** |
| **Technical Guidance and Assistance:** Activities for Technical Guidance and Assistance have moved to Federal Energy Management. In FY 2016, the FEMP budget structure was realigned to reduce the administrative overhead of managing the program and also allows FEMP to better respond to the dynamic needs of Federal agencies. FEMP will continue to Support technical assistance on energy efficiency and renewable energy technologies results in accelerated Federal sector acceptance of these technologies. | **-6,317** |

| | FY 2016 vs FY 2015 |
|---|---|
| **Planning, Reporting and Evaluation:** Activities for Planning, Reporting and Evaluation have moved to Federal Energy Management. In FY 2016, the FEMP budget structure was realigned to reduce the administrative overhead of managing the program and also allows FEMP to better respond to the dynamic needs of Federal agencies. FEMP will continue tracking the Government's record in energy achievement; ensuring the program's capabilities are a known resource for energy management; coordinating the program's strategic planning, budgeting, and evaluation; and supporting public access to Federal energy data under the FEM subprogram. | **-4,073** |
| **Federal Fleet:** Activities for Federal Fleet have moved to Federal Energy Management" In FY 2016, the FEMP budget structure was realigned to reduce the administrative overhead of managing the program and also allows FEMP to better respond to the dynamic needs of Federal agencies. FEMP will continue assisting agencies with meeting or exceeding requirements for reducing fleet petroleum consumption. | **-1,300** |
| **Total, Federal Energy Management Program** | **+16,088** |

## Federal Energy Management Program
## Federal Energy Management

**Description**

The Federal Energy Management (FEM) subprogram assists agencies in achieving the goals and objectives set forth by the Energy Policy Act of 2005 (EPAct 2005), Executive Order (E.O.) 13423, the Energy Independence and Security Act of 2007 (EISA 2007), and E.O. 13514. The Federal Government is the largest energy consumer in the U.S. As such, the Federal Government carries significant responsibility to lead by example in achieving aggressive Federal energy goals through the successful development and implementation of high-impact or new programs. This leadership manifests itself into goals that are established by statute and executive order. FEMP is the primary and lead organization within the Federal government tasked with helping other agencies achieve these goals by developing implementation guidance, providing high-impact tools and programs, and assisting all Federal agencies in meeting these goals. To provide this leadership FEMP facilitates technical services, project financing services and customer-driven services to agencies that need support or assistance.

Current mandated goals that must be achieved by the Federal Government include:

- Improve energy efficiency of each agency through the reduction of energy intensity by 3 percent annually, or 30 percent by the end of FY 2015, relative to the baseline of the agency's energy use in FY 2003 (EISA 2007);
- Reduce Government-wide scope 1 and 2 (direct) GHG emissions from targeted sources by 28 percent in FY 2020 compared to FY 2008 (E.O.13514);
- Ensure that at least 7.5 percent of Federal electricity consumption is generated from renewable sources in FY 2014 and 20 percent by 2020 (EPAct 2005, President's Climate Action Plan);
- Ensure that at least half of the statutorily required renewable energy consumed by the agency in a fiscal year comes from new renewable sources (after 1999) and, to the extent feasible, the agency implements renewable energy generation projects on Federal or Indian property for agency use (E.O. 13423);
- Reduce water consumption intensity by 2 percent annually, or 26 percent by the end of FY 2020 as compared to the FY 2007 base year (E.O. 13514);
- Reduce the motor vehicle fleet's total consumption of petroleum products by 2 percent annually through the end of FY 2020, relative to their approved baselines from FY 2005 (E.O. 13514); and
- Increase alternative fuel consumption by 10% through the end of FY 2015 as compared to a FY 2005 baseline (E.O. 13423, EISA 2007).

FEMP helps Federal agencies Lead by Example, by providing assistance to Federal agencies through project financing, technical guidance and assistance, planning reporting and evaluation, and Federal fleet support.

Congress authorized Federal agency use of performance contracts to help Federal agencies achieve energy conservation and sustainability goals through energy efficiency, renewable energy, and water efficiency improvements in Federal facilities. By using performance contracts such as ESPCs and Utility Energy Service Contracts (UESCs), the Government is able to engage a third-party (private sector energy service company) to invest in needed energy projects and pay for the investment through the energy, water, and operations and maintenance (O&M) savings achieved over the life of the contract. Federal ESPC and UESC projects include energy and water-efficiency improvements, renewable energy technologies, renewable alternative fuel (biomass/landfill), combined heat and power, advanced metering, and power management. These projects must improve site or system-wide energy efficiency and be life-cycle cost effective in order to guarantee the savings needed to pay for the project.

In December 2011, as part of the DOE Better Buildings Challenge, President Obama signed a Presidential Memorandum entitled "Implementation of Energy Savings Projects and Performance-Based Contracting for Energy Savings," challenging Federal agencies to enter into $2 billion worth of energy savings performance contracts for Federal buildings within two years. As of July 15, 2014, Federal agencies developed a pipeline of about $2.3 billion in projects. To continue this strategy for saving energy, reducing GHG emissions and saving taxpayer dollars, in 2014, the Administration expanded the Challenge by an additional $2 billion. Agencies work closely with FEMP to assist them in achieving their individual Challenge targets and as of July 15, 2014 have identified a total of $3.98 billion in project investments to be awarded through the end of 2016.

The FY 2016 funding request will enable the FEM subprogram to continue to use its Federal financing expertise to assist agency staff and management with initial decision making on the scope of performance contracts; project facilitators to guide agencies through the ESPC and UESC project development and implementation process; provide beginning and advanced training for Federal personnel in project financing; and track project implementation and performance. Further, the FEM subprogram will continue to offer the ESPC ENABLE program which offers a standardized and streamlined process for agencies with small Federal facilities to install energy conservation measures typically needed for a building that size. Performance contracting assistance also includes the development and use of the eProject Builder National ESPC & UESC database–a cutting-edge tool developed by FEMP for Federal and non-Federal entities to standardize the collection, calculation, and reporting of performance data for all performance contracts and to have better access and availability of project data across Government and the private sector. With over 100 users to date, the expansion of the use of the eProject Builder to include all performance based contracts will provide a best practice and valuable benchmarking information to improve the performance of all Federal contracts.

FEM will also provide a broad range of technical guidance and assistance to help Federal agencies implement projects and practices that reduce energy bills and promote the use of water conservation, energy efficiency, and renewable energy. The broad range of assistance includes the following:

- Direct technical assistance on capital projects;
- Targeted customer service for agencies;
- Renewable energy technical assistance;
- Sharing best practices on sustainability;
- Support to meet water efficiency goals;
- Development of Federal agency efficiency standards;
- Specification of energy-efficient products for agency procurement;
- New technology deployment;
- Training courses;
- Energy assessments; and
- Other assistance to help other agencies develop comprehensive planning and internal processes to reduce their energy use and to achieve Federal water consumption goals.

The FEM subprogram will continue to support voluntary challenges across the Federal agencies to spur progress in reducing energy intensity in energy-intensive facilities and other areas to help share effective solutions broadly across the economy. Specifically, it supports data center efficiency and optimization initiatives by encouraging Federal agencies to adopt best practices, construct and manage energy-efficient core data centers, and educate energy managers and information technology professionals. To accelerate progress in this area and the development of relevant technical knowledge, FY 2016 funding supports the ongoing efforts of the BBDCC to improve partners' data center efficiency by 20 percent over 10 years. As the BBDCC achieves further success, FEMP may look for ways to use and expand this platform to additional challenges.

For renewable energy, FEM provides project assistance and expertise in project assessment and implementation areas to help Federal agencies identify and implement renewable energy technologies, provides a collection of resource maps and assessment tools to help Federal agencies screen for potential renewable energy projects, and consults with agencies on available options to purchase renewable power and renewable energy certificates to meet energy regulatory requirements and goals. In particular, the renewable energy program is focused on agency achievement of the 20 percent renewable energy by 2020 requirement.

Through Planning, Reporting, and Evaluation, FEM provides tools and data to agencies to effectively track the Government's progress and status in energy and related goal achievement; ensures the program's capabilities are a known resource for energy management; and coordinates the program's strategic planning, budgeting, and evaluation. Specifically, the activity compiles annual reports from all Federal agencies on energy consumption and management within Federal facilities, prepares an annual report to Congress, and conducts interagency collaboration. In addition, this activity facilitates and coordinates data collection to track Federal facility compliance with energy and water evaluations, project implementation measures, and benchmarking requirements per Section 432 of the EISA 2007. Furthermore, through communications and

interagency coordination, this activity shares the program's technical resources with both the public and private sector. Finally, this activity also supports the program's strategic planning activities—ensuring that funding supports strategic goals.

The National Energy Conservation Policy Act (NECPA) (as amended by EISA 2007) requires DOE to collect, verify and report on Federal agencies' progress (including DOE) toward their goals to address energy efficiency in facilities. In FY 2016, the program will continue to collect and publish data for the Section 432 Annual Report to Congress and respond to inquiries to help ensure accuracy in reporting and analysis of trends. In addition, through its awards program, the activity recognizes energy efficiency and renewable energy champions at Federal agencies; and through the new FEMP Veterans Intern program, provides opportunities for veterans to learn energy management, while helping agencies meet their goals. In FY 2014 FEMP, through the Oak Ridge Institute for Science and Education conducted a pilot program for eight interns to be located at Federal agencies to help agencies achieve their energy management goals as well as build the skill set for future energy managers.

The Federal fleet is comprised of 635,000 vehicles worldwide and annually consumes an amount of energy equivalent to 383 million gallons of gasoline (47.9 trillion Btu), or 5 percent of the Federal Government's total energy consumption. The FEM subprogram assists and enables Federal agencies to meet or exceed requirements for reducing fleet petroleum consumption. FEM provides direct technical assistance and tools to agencies for achieving this goal, including the following:

- A fuel consumption dashboard that identifies locations and volumes of missed opportunities for dual-fuel vehicles to use alternative fuel, and synthesizes monthly fuel use in emails that enable better management of driver fuel consumption behavior;
- A web-based tool that enables fleet managers and vehicle operators to locate nearby alternative fuel infrastructure; Analysis of fueling patterns to inform alternative fuel vehicle and infrastructure deployment that would displace the most petroleum consumption through both regional technical assistance workshops in partnership with Vehicle Technologies Office and technical assistance reports to agencies;
- Training and communication on mandates and best practices; and
- Analysis of agency reported data in the Federal Automotive Statistical Tool (FAST) for compliance with Federal mandates to reduce petroleum consumption, increase alternative fuel use, acquire sufficient volumes of alternative fuel vehicles, and install onsite alternative fuel infrastructure.

FEM also provides guidance and assistance to help implement Federal legislative and regulatory requirements that mandate reduced petroleum consumption and increased alternative fuel use for the Federal fleet. Efforts include assisting agencies with implementing and managing energy-efficient and alternative fuel vehicles, facilitating a coordinated effort to reduce petroleum consumption and increase alternative fuel use, and tracking and reporting Federal progress annually. FEM provides information and resources for Federal requirements, technology resources, technical assistance on infrastructure development, and data analysis and trends, as well as coordination of INTERFUEL, an interagency working group that provides a forum for Federal fleet managers to learn about new/pending sustainability requirements, alternative fuel and vehicle technologies, and activities and tools developed by FEMP and other partners to help Federal agencies achieve regulatory compliance with mandates related to energy/fuel use, vehicle acquisitions, reporting, and others. FEM also provides resources for Federal fleet management, including publications, online tools, and related links on vehicles, alternative fuels, and fleet management deployment strategies. Federal agencies must report vehicle acquisitions and alternative fuel consumption annually. The program outlines reporting requirements and processes, including regulations, timelines, and tools to help Federal agencies meet annual requirements.

In addition, funds may be used to support efforts such as peer reviews, data collection and dissemination, technology assistance, and technology-to-market activities.

**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **Federal Energy Management $0** | **$27,288,000** | **+$27,288,000** |
| • This subprogram did not exist in FY 2015. The new FEM subprogram will reduce the administrative overhead of managing the program and also allows FEMP to better respond to the dynamic needs of Federal agencies. | • This is a new subprogram in FY 2016 that incorporates Project Financing; Technical Guidance and Assistance; Planning, Reporting and Evaluation; and Federal fleet. | • All work has been moved from Project Financing; Technical Guidance and Assistance; Planning, Reporting and Evaluation; and Federal fleet. |
| • Through project financing, support Federal agencies in identifying and implementing energy projects using performance contracting and expand marketing, streamline processes, expansion of the GSA schedule use for equipment replacements, and create a new protocol for measurement and verification of ESPCs. | • Continue to support Federal agencies in identifying and implementing energy projects using performance contracting and assist agencies achieve $4 billion of Performance Contracting investment through 2016. FY 2016 funding also supports the full utilization of the eProject Builder National Energy Savings Performance Contracts database designed to standardizing the collection, calculation, and reporting of performance data for ESPCs across Government. | • Increased support for Federal agencies in identifying and implementing energy projects using performance contracting and assist agencies to successfully meet the $4 billion goal for investing in energy efficiency and renewable energy projects by the end of 2016 and support for the full utilization of the eProject builder National Energy Savings Performance Contracts database a cutting-edge tool developed by FEMP for Federal and non-Federal entities to standardize the collection, calculation, and reporting of performance data for all ESPCs and having better access and availability of project data across Government. |
| • Support technical assistance on energy efficiency and renewable energy technologies which results in accelerated Federal sector acceptance of these technologies. Supports data center efficiency and optimization initiatives by encouraging Federal agencies to adopt best practices; and help agencies achieve energy management goals including using 20 percent renewables by 2020. | • Expanded technical assistance on energy efficiency and renewable energy technologies results in accelerated Federal sector acceptance of these technologies. In particular, the renewable energy program is focused on agency achievement of the 20 percent renewable energy by 2020 requirement. FY 2016 funding supports the ongoing efforts of the BBDCC, improve partner's data center efficiency by 20 percent over 10 years. | • Expanded technical assistance on energy efficiency and renewable energy technologies results in accelerated Federal sector acceptance of these technologies. In particular, the renewable energy program is focused on agency achievement of the 20 percent renewable energy by 2020 requirement. FY 2016 funding supports the ongoing efforts of the BBDCC, improve partner's data center efficiency by 20 percent over 10 years. As the BBDCC achieves further success, FEMP may look for ways to use this planform and may expand to additional challenges. |

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| • Through planning, reporting and evaluation continue tracking the Government's record in energy achievement; ensuring the program's capabilities are a known resource for energy management; coordinating the program's strategic planning, budgeting, and evaluation; and supporting public access to Federal energy data. | • Continue to track the Government's record in energy achievement; ensuring the program's capabilities are a known resource for energy management; coordinating the program's strategic planning, budgeting, and evaluation; and supporting public access to Federal energy data. | • No significant change. |
| • Continue assisting agencies with meeting or exceeding requirements for reducing fleet petroleum consumption. | • Continue assisting agencies with meeting or exceeding requirements for reducing fleet petroleum consumption. | • No significant change. |

**Federal Energy Management Program**
**Federal Energy Efficiency Fund**
**AFFECT**

**Description**

The FEEF or AFFECT program focuses on providing direct funding to support the best available agency projects, enable implementation of projects, and leverage cost sharing at other Federal agencies for capital improvement projects and other initiatives to increase energy efficiency, conserve water, and increase renewable energy investments at Federal facilities. The AFFECT program drives projects forward and forces schedule accountability. Many AFFECT-funded projects have been jointly funded with appropriations and private investment through performance based contracts, while some have been fully supported with appropriated funds. This investment fund provides greater opportunities for agencies to develop and implement good projects that may not otherwise get off the ground and provides another avenue for FEMP to partner with other EERE programs to help the Federal government adopt innovative technologies and lead by example.

AFFECT grants are awarded after a competitive assessment of the technical merits and economic effectiveness of each agency proposal, which considers a number of factors including: a cost benefit analysis; the life-cycle cost-effectiveness of the project; the amount of energy and cost savings anticipated; the amount of funding committed to the project by the proposing agency; and the extent that a proposal leverages financing from other non-Federal sources. AFFECT is a front-end management tool to encourage projects that are well designed with impactful and replicable results. Other programs within FEMP provide support as projects are evaluated and implemented, and to ensure replicability and track progress. The increase in funding for AFFECT will help agencies implement energy and water-saving projects faster and cheaper (if direct appropriations are used) and should result in better projects.

Section 152(f) of the EPAct of 1992, Public Law 102-486, authorized the Secretary of the DOE to establish a Federal Energy Efficiency Fund with the stated purpose of providing grants to Federal agencies to assist them in meeting the energy management requirements of the NECPA (42 U.S.C. 8256(b)).

In addition, funds may be used to support efforts such as peer reviews, data collection and dissemination, technology assistance, and technology-to-market activities.

## Federal Energy Efficiency Fund

**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **Federal Energy Efficiency Fund $2,850,000** | **$15,000,000** | **+$12,150,000** |
| • Through FEEF/AFFECT, award approximately six projects focused on providing direct funding to support the best available agency projects and leverage cost sharing at other Federal agencies for capital improvement projects and other initiatives to increase energy efficiency, conserve water, and increase renewable energy investments at Federal agency facilities. | • Through FEEF/AFFECT, award approximately 30 projects focused on providing direct funding to support the best available agency projects and leverage cost sharing at other Federal agencies for capital improvement projects and other initiatives to increase energy efficiency, conserve water, and increase renewable energy investments at Federal agency facilities. | • Efforts under FEEF will be significantly expanded resulting in the award of at least 24 more projects than in 2015 focused on providing direct funding to support the best available agency projects and leverage cost sharing at other Federal agencies for capital improvement projects and other initiatives to increase energy efficiency, conserve water, and increase renewable energy investments at Federal facilities. |

## Federal Energy Management Program
## DOE Specific Investments

**Description**

The DOE Specific Investments subprogram supports activities that help ensure achievement of Federal and Departmental sustainability goals within DOE. These goals are driven by mandates from statutes, including EPAct 2005 and EISA 2007, and related E.O., including E.O. 13653 and 13423.

DOE is committed to meeting its sustainability goals and requirements, including reducing scope 1 and 2 GHG emissions by 28 percent and scope 3 emissions by 13 percent by 2020. DOE will strive to achieve this goal through its efforts to reduce; reduce water use intensity by 26 percent from FY 2007 through FY 2020; and use at least 20 percent of electricity from renewable sources by FY 2020. In FY 2013, DOE reduced scope 1 and 2 (direct) GHG emissions by 34.1 percent relative to an FY 2008 baseline—placing DOE on track to meet its FY 2020 scope 1 and 2 GHG reduction goals (28 percent reduction). In addition, DOE reduced water use intensity 23.8 percent from a FY 2007 baseline. In FY 2013, DOE's use of renewable electric energy was 17.7 percent of total electricity use, exceeding the interim target and placing the Department on track to meet the FY 2020 20 percent goal.

The DOE Sustainability Performance Office (SPO) manages the DOE Specific Investments subprogram and coordinates implementation of sustainability goals at DOE, on behalf of the DOE Senior Sustainability Officer, and is responsible for data collection, analysis, and the reporting of Departmental progress. The SPO completes required reporting on behalf of the Department to Congress and OMB, including the Strategic Sustainability Performance Plan, the Annual Energy Report, the Greenhouse Gas Inventory, the DOE Climate Change Adaptation Plan, and the OMB Energy/Sustainability scorecard. The SPO collaborates with DOE's Under Secretaries, Program Secretarial Offices, corporate offices, and DOE sites and National Laboratories to achieve the Department's sustainability goals and objectives.

In FY 2016, DOE proposes to transfer the SPO to the Under Secretary for Management and Performance in order to align those duties under the DOE-Designated Senior Sustainability Officer. This move will help DOE to better support Administration priorities such as the President's Performance Contracting Challenge, the 2020 Renewable Energy goal and to meet its GHG emission reduction goals, while continuing the relationship with EERE and FEMP for technical expertise and assistance. In addition, funds may be used to support efforts such as peer reviews, data collection and dissemination, technology assistance, and technology-to-market activities.

## DOE Specific Investments

**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **DOE Specific Investments $2,160,000** | **$0** | **-$2,160,000** |
| • Continue to provide technical assistance and support to DOE sites and National Laboratories to meet Departmental sustainability requirements. | • No funding requested within the FEMP account. | • Reduction in the Request is offset by a corresponding increase in the Budget Request of the Departmental Administration, Office of Management for support to the Under Secretary for Management and Performance. |

## Federal Energy Management Program
## NREL Site-Wide Facility Support

**Description**

In FY 2016, EERE Programs will continue to directly fund the National Renewable Energy Laboratory (NREL) Site-Wide Facility Support subprogram costs that are not included in the Facilities and Infrastructure budget rather than fund those costs as laboratory overhead. This approach is consistent with Generally Accepted Accounting Principles and DOE management at other National Laboratories. EERE began this practice in FY 2014 to effectively control NREL's labor rate multiplier. One outcome has been reducing the cost of accessing unique NREL capabilities (such as facilities and staff expertise) by industry and academia. This practice also makes site operating costs more transparent in order to facilitate cost control and planning. In FY 2014, this practice resulted in a reduction in the Lab-wide direct labor multiplier of approximately 15 percent compared to FY 2013. The proposed FY 2016 Budget Request continues the approach applied in FY 2014 and FY 2015.

The NREL Site-Wide Facility Support subprogram funding supports research programs by providing basic site services, functions, and infrastructure for site operations, which includes: management, building operations, building and grounds maintenance, fire and emergency response, engineering and construction support, minor construction projects, electrical safety program, utilities, facilities planning support; and activities within the Sustainability and Environmental Health and Safety portfolios. These activities and their costs are relatively fixed and only vary significantly based upon variations in commodities, construction activity, emergencies, weather patterns, etc. They are considered to be the core functions for site operations, safety, environmental compliance, and sustainability at NREL. In FY 2016, this funding will continue to support more than 60 full time equivalents that manage and provide support for these core functions. It will also fund site-wide subcontracts such as janitorial services, refuse and recycling, and subcontracts for minor construction. Additionally, this funding will support site-wide costs associated with maintaining NREL's leadership position, such as: maintaining International Organization for Standardization, American Association for Laboratory Accreditation, and other lab-wide accreditations, managing facilities to enable mission goals, improving sustainability, pollution prevention, waste minimization, improving energy efficiency, reducing water use, and maintaining an effective emergency management system.

The FY 2016 Budget Request remains consistent with the method EERE developed in FY 2015. This approach is a more precise, equitable, and economically neutral method that ensures a predictable net-zero impact on programs' funding. For each program, the contribution to direct funding for site-wide facility support is equivalent to the estimated contribution the program otherwise would have made through overhead charges. This method is based upon each program's level of funding to NREL, adjusted to account for anomalies from large capital expenditures and major subcontracts.

## NREL Site-Wide Facility Support

**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **NREL Site-Wide Facility Support $800,000** | **$800,000** | **$0** |
| • Directly fund NREL site-wide facility support costs that are not included in the Facilities and Infrastructure budget rather than continue to fund these costs in the laboratory overhead rate. | • Directly fund NREL site-wide facility support costs that are not included in the Facilities and Infrastructure budget rather than continue to fund these costs in the laboratory overhead rate. | • No Change. |

## Federal Energy Management Program
## Project Financing

**Description**

The Project Financing subprogram provides support for government-wide implementation of ESPCs and UESCs. Through these contracts, the Government pays back the third-party investment through energy, water, and operations and maintenance savings achieved over the project's life. In addition, funds may be used to support efforts such as peer reviews, data collection and dissemination, technology assistance, and technology-to-market activities. In FY 2016, all activities will be moved to the Federal Energy Management subprogram.

## Project Financing

**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **Project Financing $9,500,000** | **$0** | **-$9,500,000** |
| • Support Federal agencies in identifying and implementing energy projects using performance contracting and expand marketing, streamline processes, expansion of the GSA schedule use for equipment replacements, and create a new protocol for measurement and verification of ESPCs. | • All activities will continue to be conducted within the FEM subprogram. | • All work has been moved to the FEM subprogram. |

## Federal Energy Management Program
## Technical Guidance and Assistance

**Description**

The Technical Guidance and Assistance subprogram supports the program's mission by helping agencies implement projects and practices that reduce energy bills and promote the use of water conservation, energy efficiency, and renewable energy. The program's technical assistance on energy efficiency and renewable energy technologies results in accelerated Federal sector adoption of these technologies. The Technical Guidance and Assistance subprogram's assistance helps agencies reach the goals set forth by the EPAct 2005, E.O. 13423, the EISA 2007, and E.O. 13514. In addition, funds may be used to support efforts such as peer reviews, data collection and dissemination, technology assistance, and technology-to-market activities. In FY 2016, all activities will be moved to the FEM subprogram.

## Technical Guidance and Assistance

**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **Technical Guidance and Assistance $6,317,000** | **$0** | **-$6,317,000** |
| • Support technical assistance on energy efficiency and renewable energy technologies results in accelerated Federal sector acceptance of these technologies along with increased support for data centers, energy-efficient and sustainable building practices; technology deployment networks; and expanded renewable energy technical assistance. | • All activities will continue to be conducted within the FEM subprogram. | • All work has been moved to the FEM subprogram. |

## Federal Energy Management Program
## Planning, Reporting and Evaluation

**Description**

Through the Planning, Reporting, and Evaluation subprogram, FEMP tracks the Government's progress and status in energy and related goals' achievement; ensures the program's capabilities are a known resource for energy management; and coordinates the program's strategic planning, budgeting, and evaluation. Specifically, the activity compiles annual reports from all Federal agencies on energy consumption and management within Federal facilities, prepares an annual report to Congress, and conducts interagency collaboration. Furthermore, through communications and interagency coordination, this activity shares the program's technical resources with both the public and private sector. In addition, funds may be used to support efforts such as peer reviews, data collection and dissemination, technology assistance, and technology-to-market activities. In FY 2016, all activities will be moved to the FEM subprogram.

## Planning, Reporting and Evaluation

**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **Planning, Reporting and Evaluation $4,073,000** | **$0** | **-$4,073,000** |
| • Continue tracking the Government's record in energy achievement; ensuring the program's capabilities are a known resource for energy management; coordinating the program's strategic planning, budgeting, and evaluation; and supporting public access to Federal energy data. | • All activities will continue to be conducted within the FEM subprogram. | • All work has been moved to the FEM subprogram. |

## Federal Fleet

**Description**

The Federal Fleet subprogram assists and enables Federal agencies to meet or exceed requirements for reducing fleet petroleum consumption. The Federal Fleet subprogram provides direct technical assistance and tools to agencies for achieving this goal, including the following:

- A fuel consumption dashboard;
- A model that optimizes vehicle selection and location for maximum petroleum reduction;
- Identification of areas where new alternative fuel infrastructure would displace the most petroleum consumption;
- Training and communication on mandates and best practices; and
- Analysis of Federal fleet compliance with Federal mandates through reporting in the FAST.

In addition, funds may be used to support efforts such as peer reviews, data collection and dissemination, technology assistance, and technology-to-market activities. In FY 2016, all activities will be moved to the FEM subprogram.

## Federal Fleet

**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **Federal Fleet $1,300,000** | **$0** | **-$1,300,000** |
| • Continue assisting agencies with meeting or exceeding requirements for reducing fleet petroleum consumption. | • All activities will continue to be conducted within the FEM subprogram. | • All work has been moved to the FEM subprogram. |

## Federal Energy Management Program
## Performance Measures

In accordance with the GPRA Modernization Act of 2010, the Department sets targets for, and tracks progress toward, achieving performance goals for each program.

| | FY 2014 | FY 2015 | FY 2016 |
|---|---|---|---|
| Performance Goal (Measure) | **Investment - Total Federal Investment in Facilities Energy Conservation Measures Government-Wide ($Million)** | | |
| Target | N/A | 750 | 750 |
| Result | N/A | N/A | N/A |
| Endpoint Target | $8 Billion of total investment in Federal Facilities Energy Conservation Measures through FY 2025, or $750 Million annually through FY 2020 and $850 Million annually through 2025. | | |

## Building Technologies

### Overview

In 2013, residential and commercial buildings consumed more than 40 percent of the Nation's total energy and more than 73 percent of its electrical energy[1], resulting in an estimated annual national buildings energy bill of more than $430 billion.[2] This energy bill can be reduced by 20-50 percent through a variety of existing and emerging building energy efficiency technologies and techniques once these solutions are successfully developed, commercialized, and proven to be cost effective. EERE's Building Technologies Program will continue to develop and demonstrate advanced building efficiency technologies and practices to make buildings in the U.S. more efficient, affordable, and comfortable. The program uses a three-pronged strategy: (1) High Impact Technology Research and Development—research and development (R&D) targeting the greatest opportunities to develop high-impact new cost-effective energy efficiency products and solutions (i.e., the highest potential market and energy efficiency impact); (2) Technology-to-Market—validating and driving these technology products and solutions into the market by verifying and improving performance and cost, providing improved data and information, and partnering with manufacturers and users; and (3) Lock In Savings—where a government role is appropriate and justified, locking in the savings through market based (e.g., Energy Star) and regulatory (i.e., codes and standards) efforts that provide clear public and net economic benefits to both producers and consumers. The program invests in a balanced portfolio of activities that are determined to contribute optimally to national energy efficiency goals.

In order to develop and deploy energy efficient technologies and techniques that can make a sizeable reduction in building energy use and greenhouse gas (GHG) emissions, building system components and transactions must be improved and become more cost effective to building owners. Collectively, program activities will focus on the following high level goal that is in alignment with the President's Climate Action Plan and all-of-the-above approach to energy: the program will develop and promote the adoption of technologies and practices, that when fully deployed, would reduce U.S. building-related energy use by 50 percent from the 2010 Annual Energy Outlook baseline. Achieving this goal would decrease annual energy use by approximately 20 quads, which is equivalent to approximately 1 billion metric tons of $CO_2$, and save consumers and businesses roughly $200 billion in annual energy costs. Both the commercial and residential buildings integration and market transformation efforts (technology to market) accelerate technology adoption and realization of energy savings. These efforts demonstrate the additional savings available through effective integration of building systems, effective new building design, and retrofits of existing buildings. Further, the Building Technologies Program delivers energy savings to consumers across the country through Equipment and Buildings Standards and support of building energy codes that are adopted and implemented at the state and local level. Energy savings from the Equipment and Buildings Standards subprogram, from standards enacted or expected to be enacted between 2009 and 2016, will avoid at least 3 billion metric tons of carbon emissions through 2030, a key goal of the President's Climate Action Plan. Standards enacted since 2009 are projected to avoid a cumulative total of 2.2 billion metric tons of carbon emissions by 2030. State and local building codes regulate 70 percent of U.S. building energy use and represent the baseline for building energy efficiency: the associated cumulative energy savings through 2020, since program inception in 1992, are estimated to be 10.2 quads. Building energy codes are an existing solution that can provide between 20-30 percent whole building energy savings.

### Highlights of the FY 2016 Budget Request

The Emerging Technologies (ET) subprogram will continue its research efforts in five high-impact key technology areas: Solid State Lighting (SSL); Heating, Ventilation, & Air-conditioning (HVAC), including water heating and appliances; Windows and Building Envelope; Whole-Building Energy Modeling; and Sensors & Controls (including transactive controls).

In FY 2016, the program will continue its BENEFIT (Buildings Energy Efficiency Frontier and Innovation Technologies), BUILD (Buildings University Innovators and Leaders Development), and SSL (Solid State Lighting) Funding Opportunity Announcements (FOAs). These three FOAs are released annually to solicit and fund cutting-edge building energy technology

[1] Monthly Energy Review, Energy Information Administration, U.S. Department of Energy, November 2014, http://www.eia.gov/totalenergy/data/monthly/pdf/mer.pdf.
[2] Annual Energy Outlook, Energy Information Administration, U.S. Department of Energy, April 2014, http://www.eia.gov/forecasts/aeo/pdf/0383(2014).pdf.

research and development projects. The BENEFIT FOA includes multiple topics that vary depending on the FOA schedule provided in the ET Multi-Year Program Plan (MYPP). The topics are rotated among the technology areas every three years, with the exception of SSL, which offers an annual FOA. In FY 2016, the $23 million BENEFIT FOA topics will be water heating, air sealing/roofs, dynamic windows and films/daylighting technologies, and advanced building controls. The $2 million BUILD FOA targets universities as the lead institutions, and provides small seedling awards to multi-disciplinary university teams to develop building energy efficiency technologies that emphasize engineering design, manufacturing, and commercialization. The $12.5 million SSL FOA will continue its support of inorganic light-emitting diodes (LEDs) and organic light-emitting diodes (OLEDs) to improve their efficacy (lumens/W) and cost effectiveness (lumens/$).

Throughout its efforts, the Building Technologies program supports the Department's Clean Energy Manufacturing Initiative. The Clean Energy Manufacturing Initiative is a Department-wide approach to increase U.S. competitiveness in clean energy manufacturing while advancing progress toward the nation's energy goals. The DOE Clean Energy Manufacturing Initiative supports research, development, and addressing market barriers that will help companies competitively manufacture clean energy technologies in the U.S., and help companies across the manufacturing sector become more competitive by leveraging energy efficiency measures to increase their energy productivity. Clean Energy Manufacturing efforts in the Building Technologies program include manufacturing R&D for solid state lighting and tech-to-market activities. In addition, the ET subprogram will release a $30 million Advanced Building Energy Materials FOA in collaboration through the Clean Energy Manufacturing Initiative on materials manufacturing R&D, focusing on cost-effective next-generation materials for non-vapor-compression refrigeration systems and high performance building envelope materials. This approach will be carried out through public-private partnership will include the use of high-performance computing and high-throughput process experimentation, to develop validated models capturing the effects of manufacturing processes and end use to dramatically accelerate the development of these materials from the point of discovery through qualification and implementation.

In addition to R&D activities, the program will continue to pursue solutions identification and technology to market initiatives in both the Commercial Buildings Integration (CBI) and Residential Buildings Integration (RBI) subprograms to overcome market barriers to widespread adoption of cost-effective advanced building energy efficiency technologies and solutions. Existing market barriers include high first cost, fragmented market segments, lack of uniform data and data formats, and insufficient availability of objective consumer information, all of which result in building trades' limited acceptance and adoption of new technologies and practices. The CBI and RBI subprograms' approach to addressing these barriers includes partnerships with stakeholders to develop and share validated data and best practices, improvement of building design and audit tools, and the creation of reliable efficiency benchmarks and databases to facilitate energy efficiency financing and to define efficiency's value-add to consumers.

The CBI and RBI subprograms efforts will focus on developing, demonstrating, and releasing a suite of cost-effective technologies, specifications, tools, and solutions, as well as analyzing their ability to deliver the intended energy savings. These subprograms work with industry to promote voluntary activities to prime and support improved energy efficiency in the residential and commercial building sectors, with an emphasis on underutilized high-potential products that meet performance and cost hurdles for commercial building investment.

The Equipment and Buildings Standards subprogram will continue to generate cost-effective energy savings through the development of national appliance and equipment standards. Funding will support rulemakings and standards certification and enforcement in both commercial and industrial products, as well as assisting state and local jurisdictions to improve building energy code compliance rates. The program generates cost-effective energy savings through the development of national appliance and equipment standards. By setting minimum energy efficiency standards for covered products that are manufactured or imported into the U.S. and incrementally raising the e standards, the Equipment and Buildings Standards subprogram saves consumers money and energy, while updated codes, adopted by state and local jurisdictions, provide for minimum energy efficiency performance requirements for homes and buildings. Energy conservation standards and test procedures directly support national energy policy objectives, such as increasing energy savings and energy productivity and reducing carbon emissions.

A Building Technologies Program 'Incubator' funding opportunity will invest 5% of Building Technologies funding toward new off-roadmap innovative technologies and solutions that can help meet existing goals but are not represented in a significant way in the current portfolio or technology roadmaps. Successful Incubator projects will reduce the risk

associated with potentially breakthrough approaches and technologies so they may be 'on-ramped' to future program roadmaps and the program portfolio.

Within the FY 2016 Budget Request, the Building Technologies Program supports DOE's Grid Modernization crosscut. U.S. prosperity and energy innovation in a global clean energy economy depends on the modernization of the National Electric Grid. To support this transformation, the Department of Energy's Grid Modernization Initiative will create tools and technologies that measure, analyze, predict, and control the grid of the future; focus on key policy questions related to regulatory practices, market designs, and business models; and collaborate with stakeholders to test and demonstrate combinations of promising new technologies. In FY 2016, the Building Technologies Program will invest $18 million in research and development (R&D) on grid integration. In alignment with other EERE and DOE-wide activities centered on grid integration and modernization, ET will support efforts in sensing and measuring, including a sub-metering program and the development of low-cost sensors and the integration of devices into a larger distribution energy resource management system.

**FY 2016 Crosscuts ($K)**

| | Grid Modernization | Total |
|---|---|---|
| **Building Technologies** | **18,000** | **18,000** |

**Building Technologies**
**Funding ($K)**

| | FY 2014 Enacted[1] | FY 2014 Current[2] | FY 2015 Enacted | FY 2016 Request | FY 2016 vs. FY 2015 |
|---|---|---|---|---|---|
| **Building Technologies** | | | | | |
| **Emerging Technologies** | | | | | |
| Lighting R&D | 25,800 | 25,176 | 25,800 | 21,000 | -4,800 |
| Space Conditioning and Refrigeration R&D | 16,968 | 16,559 | 8,038 | 41,000 | +32,962 |
| Transactive Controls | 0 | 0 | 8,854 | 28,000 | +19,146 |
| Building Envelope | 10,094 | 9,853 | 2,611 | 13,700 | +11,089 |
| Analysis Tools | 3,000 | 2,925 | 2,437 | 5,300 | +2,863 |
| High-Impact Technology | 0 | 0 | 8,000 | 3,500 | -4,500 |
| **Total, Emerging Technologies** | **55,862** | **54,513** | **55,740** | **112,500** | **+56,760** |
| **Commercial Buildings Integration** | **30,782** | **30,438** | **27,643** | **32,000** | **+4,357** |
| **PSU Consortium for Building Energy Innovation** | **9,994** | **9,866** | **10,000** | **0** | **-10,000** |
| **Residential Buildings Integration** | **24,390** | **21,974** | **22,758** | **48,000** | **+25,242** |
| **Equipment and Buildings Standards** | **55,840** | **55,840** | **53,359** | **69,000** | **+15,641** |
| **NREL Site-Wide Facility Support** | **1,000** | **1,000** | **2,500** | **2,500** | **0** |
| **Total, Building Technologies** | **177,868** | **173,631** | **172,000** | **264,000** | **+92,000** |

SBIR/STTR:

- FY 2014 Transferred: SBIR $3,957,000; STTR $280,000
- FY 2015 Enacted: SBIR $2,610,000; STTR $360,000
- FY 2016 Request: SBIR $3,870,000; STTR $581,000

[1] FY 2014 Enacted funding reflects the contractor foreign travel rescission of $106,166.
[2] Funding reflected the transfer of SBIR/STTR to the Office of Science.

**Building Technologies**
**Explanation of Major Changes ($K)**

| | FY 2016 vs FY 2015 |
|---|---|
| **Emerging Technologies:** Increased funding for the annual BENEFIT FOA, which will focus on water heating, air sealing/roofs, dynamic windows/films and daylighting technologies, and sensor and controls. Emerging Technologies will undertake a new effort in building energy efficiency advanced materials R&D in support of the Administration's Materials Genome Initiative and DOE's Clean Energy Manufacturing Initiative, which will focus on the investigation and design of advanced non-vapor-compression refrigeration and building envelope materials, through the use of high-performance computing and high-throughput experimental testing to develop validated models that capture the effects of processing and end use to accelerate material development from the point of discovery through qualification. | **+56,760** |
| **Commercial Buildings Integration:** Increased funding will support a Commercial Buildings FOA on small and medium commercial buildings to extend demonstration and market transformation of technical and market solutions into self-sustaining programs and to replicate them in different climate zones and jurisdictions around the country. | **+4,357** |
| **PSU Consortium for Building Energy Innovation:** As originally proposed, FY 2015 was the last year of funding requested for the PSU Consortium for Building Energy Innovation, and therefore, there is no funding for this subprogram in FY 2016. | **-10,000** |
| **Residential Buildings Integration:** Increased funding will support a Building America FOA; an expanded residential building energy efficiency retrofit program supporting all residential building types and income levels; and a new competitive FOA focused on human behavior in the context of energy efficiency and consumption. | **+25,242** |
| **Equipment and Buildings Standards:** Increased funds will support a Commercial Energy Codes FOA. | **+15,641** |
| **Total, Building Technologies** | **+92,000** |

**Description**

The Emerging Technologies (ET) subprogram supports a broad array of high impact technologies that impact building energy consumption. These technologies include HVAC, water heating, building envelope, windows, SSL, sensors and control (S&C) including transactive controls, appliances like clothes washers and dryers, and building energy modeling. As a result of ET-sponsored research, the Building Technologies Program seeks to enable cost-effective technologies that will be introduced into the marketplace by 2030 or sooner to support the following goal: develop technologies enabling a 70 percent reduction in lighting energy use, 60 percent savings in water heating, 20 percent savings in HVAC, 20 percent savings in building envelope & windows, 20 percent savings in appliances, and 30 percent savings enabled by sensors & controls from the 2010 AEO baseline.

Funding is divided between core support for the DOE National Laboratories and competitive FOAs that invite all interested domestic entities (companies, universities, non-profits, as well as the National Laboratories) to conduct cost-shared research and development on building energy efficiency technologies. Requested FY 2016 activities include three competitive ET FOAs that are released annually and one new FOA focused on materials manufacturing.

First, the $12.5 million Solid State Lighting (SSL) FOA seeks to achieve >10 percent improvement in the manufacturing cost of warm-white Light-Emitting Diode (LED) packages relative to a 2010 baseline, to 160 lumens per dollar by 2020.

Secondly, multiple ET topics, rotated among the program's priority technology areas on a three-year cycle, will be solicited through the $23 million BENEFIT FOA. In FY 2016, the BENEFIT FOA will focus on water heating, controls, commercial roofing, air-sealing, dynamic windows/window films and daylighting topics, and include an open topic to address off roadmap technology R&D.

| Priority Technology Areas | Performance and Cost Targets to be Achieved by 2020 | Energy Savings Potential (Quad/year) Achieved by 2030 |
|---|---|---|
| Water Heating | • 25 percent increase in primary energy factor<br>• 50 percent decrease in installed cost | 0.8 |
| Controls | • Enable 45 percent increase in the fraction of the building load controlled | 1.1 |
| Air-Sealing | • Reduce uncontrolled air infiltration to 3 air changes per hour<br>• 40 percent reduction in installed cost for residential buildings | 1.6 |
| Daylighting | • Reduce lighting energy use from by 35 percent for a 50-ft floor plate<br>• Installed cost of $13/ft$^2$, including the cost of lighting controls | 0.17 |
| Commercial Roofs | • Energy use reduction that increases ASHRAE 90.1-2010 R-values by a factor of 1.5<br>• Installed cost increase limited to <$1/ft$^2$ relative to standard technology | 0.12 |
| Dynamic Windows and Window Films | • 0.4 change in SHGC between bleach and tinted states<br>• Installed cost premium $15/ft.$^2$ and $8/ft$^2$ for windows and window films, respectively | 0.4 |

The third annual Building Technologies FOA proposed in FY 2016 is the $2 million BUILD FOA, in which faculty-led multidisciplinary university teams develop building energy efficiency technologies with careful consideration for engineering design, manufacturing, and commercialization. Collaboration with external partners, especially manufacturers, is required, and involvement of undergraduate students is mandated. Each $200,000, 2-year project is expected to lead to the development and testing of a lab prototype, with the ultimate goal of developing a successfully commercialized technology. All topics relevant to building energy efficiency are solicited, but applicants must demonstrate an annual technical potential primary energy savings of at least 0.25 quads.

An additional FOA planned for FY 2016 is the $30 million Buildings Energy Efficiency Materials Manufacturing FOA. As part of the Department's Clean Energy Manufacturing Initiative and in support of the Materials Genome Initiative, this seeks to capitalize on advances in high-performance computing and high-throughput experimental techniques to rapidly design new and improved materials for (1) non-vapor-compression refrigeration systems; and, (2) high-performance envelope materials, through the development and use of validated models of these materials systems capturing the effects of processing and end-use performance. Non-vapor-compression refrigeration technologies eliminate the use of refrigerants and their potential impacts on global climate. An example of a non-vapor-compression technology is magnetocaloric refrigeration, in which the application or removal of a magnetic field causes magnetocaloric materials to heat up or cool down and thus achieve a heat pumping effect. These systems, however, are limited by the lack of suitable magnetocaloric materials with large temperature changes and heat removal rates, and with minimal presence of rare earth elements. Computational tools coupled with high-throughput materials synthesis and characterization would allow a more efficient search for better materials and development of better processing techniques for meeting target end-use performance, with one goal being to enable the development of a residential refrigerator that is 25 percent more efficient than the recently developed minimum efficiency standard.

In order to develop high-performance building envelope materials, it is critical to predict and characterize the transport of phonons, photons (ultraviolet, visible and infrared) and moisture through that material, properties that are often neglected in computational and characterization efforts. Ultimately, an improved understanding of these phenomena could be leveraged to actively control phonon, photon and moisture transport through a building envelope. This represents a transformative change in existing building envelope technologies that would minimize energy losses due to the envelope while maximizing the health and comfort of occupants. Potential applications resulting from these efforts include visibly transparent insulating film for windows, high-performance, moisture-tolerant insulation for building retrofits, thermally insulating membrane that can be activated to remove water and $CO_2$, building envelope with integrated sensors ($CO_2$, $H_2O$, temperature), and adsorption or absorption materials (solids or liquids) to control gas flow through the building envelope.

Approximately $20 million is requested for lab-directed funding, including core support and lab calls. Except for the sensors and controls subprogram, which conducted a merit review to select its lab-directed projects in FY 2015, in FY 2016 all of the ET lab-directed funding will be merit reviewed prior to project selection, to ensure identification and selection of the highest impact lab projects. Priorities for the lab-directed funding will be as follows:

- Develop or maintain key experimental facilities necessary for manufacturers (large and small) to develop building energy efficiency technologies, including lighting, HVAC, windows, and the building envelope;
- Provide support for continued development of software tools, including EnergyPlus, Radiance, WINDOW, and THERM;
- High impact national laboratory building energy efficiency R&D projects selected through a merit reviewed lab call; and
- Fill any technology gaps in the ET MYPP that are not being addressed through an ongoing or planned FOA project.

To address the grid integration issue in a holistic manner, EERE will implement an $18 million research investment within the program while working in close partnership with the Office of Electricity Delivery and Energy Reliability. The path to achieve advanced automated buildings (that cost effectively transact with the grid) involves several key topics for utilities, industry, and building designers, contractors, managers and owners to resolve data standards and interoperability; high resolution data and data analytics/tools; models; and an open architecture control systems.

Presently, the energy related components and systems within residential and commercial buildings are controlled with methodologies that deliver suboptimal energy operations. These systems are generally unaware of perturbations and potential opportunities both within and outside the building envelope. Control and dispatch of loads and on-site generation is often rudimentary with heavy human interaction and extensive customization, which is neither cost effective nor scalable. In 2011, the National Energy Technology Laboratory (NETL) found that the potential nationwide value of demand dispatch (i.e. transactive control and energy within and to buildings) could be several billion dollars per year in reduced

energy costs to the U.S., with only 10 percent participation.[1] NETL also found that more than one-fourth of the 713 GW of U.S. electricity building demand in 2010 could be dispatchable—if only buildings could respond to that dispatch. Even though this resource could offset new generation and transmission and cost effectively facilitate more renewable penetration, existing buildings, building systems, and building components today cannot effectively respond. The primary building level issues that limits the scale and penetration of response is a deficiency in the ability to share performance information or transact load and energy services within the building and with other surrounding facilities or electric distribution systems. Building loads, similar to electric vehicle charging loads, can also serve as a resource to mitigate supply and demand imbalances in addition to other ancillary services. To provide additional cost effective, resiliency and robustness to the grid, and benefits to the building environment, while integrating renewables and other variable, distributed renewable generation assets, the following efforts are needed:

- Common definitions and data formats will facilitate scalable, lower cost solutions to facilitate building and building to grid optimization;
- Smart building solutions including automated controls to provide faster response will support greater penetration of end use solutions to U.S energy demand, and grid regulation needs (i.e. <50msec response to better enable ride through capabilities;
- Greater utilization of smart meter data to enable and appropriately value energy savings and building/component response; and
- Further U.S. innovation and leadership focused on new innovations and solutions to support greater cost effective energy efficiency and energy demand savings, renewable penetration, and grid support from the end use and building level.

As we move towards a truly integrated building to grid world, it is clear that systems and devices that can 'transact' their status, availability and identity are required. However, despite the progress that has been made over the past thirty years in building automation, we are not even close to the potential of fully deploying automation in buildings. Moreover, while it seems obvious that more and 'smarter' automation is required, most buildings do not even have the simplest of controls systems installed. If we do not develop a holistic approach to integrate these technologies building systems and connect with distribution systems, new technologies (including renewables) will not be adopted by utilities or the marketplace at relevant scale and the grid cannot utilize these assets to provide enhanced reliability and resiliency.

In addition, these funds may be used to support efforts such as peer reviews; data collection and dissemination; and technical, market, and economic studies and other analyses.

[1] Demand Dispatch—Intelligent Demand for a More Efficient Grid, NETL, and August, 2011. http://www.netl.doe.gov/File%20Library/Research/Energy%20Efficiency/smart%20grid/DemandDispatch_08112011.pdf.

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **Emerging Technologies $55,740,000** | **$112,500,000** | **$56,760,000** |
| *Lighting R&D ($25,800,000)*<br>• Continue support to improve performance and costs for LEDs and OLEDs. The roadmap-driven LED cost target is 144 lumens/$ for FY 2015. A competitive FOA will again be released to keep driving innovations in LED and OLED core technologies (i.e., down converters, stable white OLEDs), product development (i.e., LED package development, low-cost OLED electrodes), and manufacturing (i.e., LED test equipment, OLED materials manufacturing). | *Lighting R&D ($21,000,000)*<br>• Continue support to improve performance and cost for LEDs and OLEDs. The roadmap-driven LED cost target for FY 2016 is 160 lumens/$, an 11 percent increase over FY 2015 (144 lumens/$), leading to the 2020 goal of 217 lumens/$. A competitive FOA will again be released to pursue innovations in LED and OLED core technologies (i.e., LED emitter materials, OLED stable emitter systems), product development (i.e., novel LED luminaires, improved OLED light extraction), and manufacturing (i.e., LED luminaire manufacturing, OLED deposition equipment). | *Lighting R&D (-$4,800,000)*<br>• Although there is a reduction in the lighting R&D budget, overall support for lighting R&D, demonstration, and standards remains at approximately $25.8 million across the Building Technologies Program, as LED deployment activities for commercial buildings has moved to the CBI Program, and the development of minimum efficiency standards for LEDs has moved to the Standards Program. |
| *Space Conditioning and Refrigeration R&D ($8,038,000)*<br>• Continue development of heat-pump technologies, especially integrated heat pumps (IHPs) that combine space heating and cooling with water heating. A key project is development of a fully variable-speed version of an air-source IHP for the U.S. market with a 50-55 percent energy savings potential. A significant effort will be devoted to a competitive FOA to pursue non-vapor-compression air conditioning technologies that offer improved efficiency, reduced global warming potential, improved part-load performance, and building system integration capability. | *Space Conditioning and Refrigeration R&D ($41,000,000)*<br>• Lab-directed R&D on appliances, water heaters, and HVAC systems will continue, with particular emphasis on low-global-warming-potential commercial refrigeration systems using $CO_2$ as the refrigerant, efficient refrigeration using a rotating heat exchanger or the magnetocaloric cycle, gas-fired absorption heat pumps for water heating, and integrated heat pumps that provide space conditioning and water heating, both electric and gas-fired. One topic in the BENEFIT FOA will be on water heating, with the goal to improve the primary energy factor of electric water heaters from 0.65 in 2013 to 0.81 in 2020 (25 percent increase), while decreasing the cost from $16.26/gal in 2013 to $8.13/gal (50 percent decrease). A $30 million FOA R&D FOA in support of the Administration's Materials Genome Initiative and DOE's Clean Energy Manufacturing | *Space Conditioning and Refrigeration R&D (+32,962,000)*<br>• A new $30 million FOA will be released targeting advanced, high-throughput materials development in support of the Administration's Materials Genome Initiative and DOE's Clean Energy Manufacturing Initiative to yield a net increase. |

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
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| | Initiative will focus on the investigation and design of advanced materials through high-performance computing and experimental techniques capturing the effects of processing and end-use performance, with particular focus on improved non-vapor-compression refrigeration and building envelope materials, including those applicable to magnetocaloric, electrocaloric, and sorption (heat-activated) systems. | |
| *Transactive Controls ($8,854,000)*<br><br>• Invest in the development of an open-source open-architecture transactive software platform for building energy management. This will standardize the development and application of control strategies for existing and new buildings, especially small to medium sized buildings (<200k square feet). This work will build on the program's efforts to increase the operating efficiency of building energy systems, ensure persistence of operations through improved maintenance, and make buildings more grid-responsive. Additional tasks will address issues such as: standardized communication linkages between lighting and HVAC equipment, between buildings, and between utility demand response programs. These linkages will align with the protocols and standards under development by the Office of Electricity and others to ensure interoperability across the distribution system.<br>• Grid Integration Initiative ($3,226,000): The program will solicit technology and tool development and demonstration activities to ensure customer-owned electric vehicles, distributed renewable generation, and building | *Sensors & Controls (formerly Transactive Controls) ($28,000,000)*<br><br>• Lab-directed R&D will continue to enable building appliances and energy management systems to transact with the electric utility, based largely on the open-source VOLTTRON control platform developed at PNNL. Monitoring and verification capabilities will be improved in part by incorporating occupancy data, and the ability to dim lighting systems and control HVAC systems will be investigated for transactive purposes. One topic in the BENEFIT FOA will be on controls, with the goal to improve the fraction of building load controlled from 55 percent in 2014 to 80 percent in 2020 (45 percent increase), while reducing the cost from $5/ft$^2$ in 2014 to $1.25/ft$^2$ in 2020 (75 percent decrease).<br>• Building/Grid Integration (formerly Grid Integration Initiative) ($18,000,000): In coordination with the rest of EERE's grid integration related activities and the Office of Electricity Delivery and Energy Reliability, the program will support efforts in sensing and measuring, devices, and integrated systems testing. Improved sensors and techniques for easily sharing data will be developed. Building | *Sensors & Controls (formerly Transactive Controls) (+$19,146,000)*<br><br>• Increased funding to support sensors and controls topic in BENEFIT FOA.<br>• Building/Grid Integration (formerly Grid Integration Initiative) (+$14,774,000): This increase represents a ramp-up of building-related investments in building/grid integration R&D, grid-related work that is coordinated across all of EERE and DOE. |

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
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| equipment can be integrated to optimize their overall performance and designed to interact with the utility grid and better meet grid requirements as the concentration of these technologies on the grid increases. | energy loads will be characterized and approaches will be developed for integrating HVAC equipment, appliances, and distributed energy systems, into the grid most efficiently and effectively. | |
| *Building Envelope R&D ($2,611,000)*<br>• Core funding (building envelope and roofs at Oak Ridge National Laboratory and windows at Lawrence Berkeley National Laboratory) will continue to support the development of the software design tools and the accompanying experimental testing. A FOA topic will be released to support air sealing and infiltration control systems-level R&D focused on controlling heat, moisture and air flow in buildings. | *Building Envelope R&D ($13,700,000)*<br>• Lab-directed R&D will continue to improve the WINDOW and THERM software packages, and their integration with EnergyPlus. Support will continue for windows and building envelope testing facilities, to be used by manufacturers for testing and improving their products. The FOA topic on air sealing and infiltration control systems (5 air changes/hour at $\$0.9/ft^2$ in 2015, to 3 and $\$0.5/ft^2$ in 2020 for residential buildings) will not be released in FY 2015, but instead will be added to the FY 2016 BENEFIT FOA, along with topics on energy-efficient commercial roofs (R-30 at $\$10/ft^2$ in 2015, to R-45 at $\$3/ft^2$ in 2020), daylighting technologies (25 percent lighting energy reduction at $\$20/ft^2$ in 2015, to 35 percent and $\$13/ft^2$ in 2020), and dynamic windows ($\$20/ft^2$ in 2015 to $\$15/ft^2$ in 2020) & films ($\$15/ft^2$ in 2015 to $\$8/ft^2$). | *Building Envelope R&D (+$11,089,000)*<br>• Increased funding to support BENEFIT FOA topics in Building Envelope R&D. |
| *Analysis Tools ($2,437,000)*<br>• Core funding will continue to maintain and upgrade EnergyPlus with a focus on supporting generalized equipment control strategies. Significant effort will be devoted to modernizing Energy Plus. Core funding will be provided for Radiance for additional speedup work and refactoring to support simulation for the Modelica Buildings Library for component and controls models for the re-engineered EnergyPlus, and for the BESTEST (Building Energy | *Analysis Tools ($5,300,000)*<br>• Lab-directed funding will continue to support the development of the open-source EnergyPlus building energy modeling software, including two planned upgrade releases in FY 2016. Enabled by the recent migration from Fortran to C++, EnergyPlus will be refactored in an object-oriented design paradigm, which will allow parallel processing and easier code updates. BESTEST simulation validation tests and the Modelica Buildings Library will continue to be | *Analysis Tools (+$2,863,000)*<br>• Increased funding will support transition to open source user interfaces and be refactored in an object oriented design paradigm, which will allow parallel processing and easier code updates. |

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| Simulation Test) suite of simulation validation tests for airside equipment tests. | supported. Contractors selected through a competitive request for proposal will develop modules for some building components. | |
| *High-Impact Technology R&D ($8,000,000)*<br>• Similar to FY 2014, the program is issuing an "Incubator" FOA to support innovative technologies and solutions that could help meet existing goals but are not represented in a significant way in the program's existing MYPPs or current portfolios. The Incubator program allows EERE to assess new technologies for their potential to be "on ramped" to future MYPPs. Successful incubator projects will reduce the risk associated with potentially breakthrough approaches and technologies so that they could be viable candidates for inclusion in future program roadmaps. | *High-Impact Technology R&D ($3,500,000)*<br>• Funding supports a BUILD FOA that provides university-led funding in a variety of building energy-efficiency technologies. The remaining funds are directed towards a joint lab call with the Commercial Buildings Integration Program targeting near-term technologies facing the "valley of death." | *High-Impact Technology R&D (-$4,500,000)*<br>• Funding shifted to other technology areas/BENEFIT FOA. |

**Description**

The Commercial Buildings Integration (CBI) subprogram accelerates energy performance improvements in existing and new commercial buildings by developing, demonstrating, and broadly releasing a suite of cost-effective technologies, specifications, tools, and solutions, as well as analyzing their ability to deliver the intended energy savings. The CBI subprogram also works with industry to promote voluntary activities to prime and support improved energy efficiency in the commercial building sector, with an emphasis on underutilized high-potential products that meet performance and cost hurdles for commercial building investment. The goals for these activities are to demonstrate that it is cost effective to reduce the energy required to operate commercial buildings by 20 percent by 2020 and by 40 percent by 2030 in all climate zones and in building types representing 80 percent of building energy use.

The CBI subprogram implements its program strategy through three activity areas:

- Speeding the commercialization and market uptake of promising technologies through technology-to-market and demonstration activities;
- Developing tools and resources needed to build the market infrastructure for greater investment in efficiency; and
- Partnering with market leaders to accelerate adoption of these technologies and solutions by the commercial buildings market.

The CBI subprogram has developed and uses a rigorous "High Impact Technology (HIT)" investment prioritization process that uses rigorous technical and market analysis to (1) identify priority technologies that are most worthy and ready for CBI technology to market investments (based upon technical energy savings potential and potential market uptake) and (2) develop multi-year program plans for each priority CBI market transformation activity – which may include demonstrations, product specification development, case studies, and other efforts that are needed to accelerate adoption into the market. Successful examples of these market transformation efforts developed and executed to date include initiatives focused on efficient LED parking lighting adoption and adoption of high efficiency commercial rooftop units (RTUs) for air conditioning.

The CBI subprogram has worked through the Better Buildings Alliance (BBA) to support faster uptake of high-efficiency parking lighting and controls, a source of significant energy savings opportunity. In FY 2012, the BBA and industry partners launched the Lighting Energy Efficiency in Parking (LEEP) Campaign, building on several years of program technology research, development, and demonstration and the development of tools to drive high-efficiency lighting and controls into the market. More than 100 organizations have joined the campaign, committing to building and retrofitting over 300 million square feet of parking lots and structures with high-efficiency lighting and controls. Because of DOE R&D and subsequent market transformation activities, high-efficiency lighting is on its way to becoming market-accepted for parking lots and structures. Additionally, this work allowed the CBI subprogram and the Equipment and Building Standards subprogram to partner on a new International Energy Conservation Code (IECC) proposal for higher exterior lighting efficiency levels based on successful market adoption. If all parking lots and structures upgraded to systems meeting the CBI subprogram-developed specifications, the annual energy savings would be 866 TBtu and the annual utility cost savings would be $7.6 billion.

Similarly, the CBI subprogram has made significant strides in helping commercial building owners reduce the energy consumption and costs from their rooftop units (RTUs.) In the U.S., packaged air conditioners and heat pumps cool approximately 60 percent of the commercial floor space and consume approximately 2,582 trillion Btu of primary electricity energy annually. The successful "RTU Challenge", developed through the BBA, defined a new level of product performance that would significantly decrease energy used for RTU cooling and meet commercial requirements. DOE has recognized two commercially available units (Daiken Mcquay Rebel and Carrier WeatherExpert) that meet or exceed the 18 Integrated Energy Efficiency Ratio (IEER) level of efficiency of the Challenge, and two additional manufacturers have released RTUs that meet or exceed the Challenge level of efficiency—demonstrating the impact of Challenges in leading technology market transformation. These units can save up to 50 percent of the energy used in standard units in buildings today, depending on climate zone and facility type. The Building Technologies Program has also been supporting the development and market transformation of new advanced controls solutions that can save up to 40 percent of energy consumption with commercially-acceptable paybacks for RTUs that are not ready for replacement. New solutions have been demonstrated

and tested in DOE national labs and are currently undergoing building tests. In 2014, the CBI subprogram brought its resources - such as case studies, calculators and modeling tools - together to launch the Advanced RTU campaign with industry partners such as the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) and the Retail Industry Leaders Association (RILA). Organizations commit to replacing aging RTUs with high-efficiency units or retrofitting newer RTUs with energy-savings controls. As of mid-2014, organizations have committed to addressing over 13,000 RTUs across the U.S.

The CBI subprogram is also working with the ET subprogram on tech-to-market activities to speed the migration of technologies from R&D into market availability. This work addresses technical, commercialization, and manufacturing barriers by working with both researchers and manufacturers to identify and execute the full suite of activities necessary to move new technologies across the "valley of death" and into mass production. This includes technical and economic analyses, lab testing and systems integration demonstrations, and development of commercialization plans, training approaches, and early feedback from customers.

In 2014, the CBI subprogram and the ET subprogram jointly launched a pilot tech-to-market program to bridge the gap between R&D and market transformation of commercially available products. Through this pilot, the ET subprogram and the CBI subprogram identified new products at various stages of commercialization based on technical innovation, market potential, and the opportunity to wrap up efficiency gains by supporting the adoption of new appliance standards or building energy codes. For example, one technology currently funded to bridge this gap to from R&D to market is an easy-to-install air and water barrier membrane, expected to reduce installation errors and increase resulting energy performance. This activity will be continued in FY16.

The CBI subprogram is also helping increase the availability and interoperability of data on the energy performance and physical and operational characteristics of buildings. The CBI subprogram's Buildings Performance Database exceeded a milestone of 750,000 building records (including commercial, multifamily and residential buildings), making it the world's largest public database of real buildings' energy performance information. In 2014, the CBI subprogram released the Standard Energy Efficiency Data (SEED) platform, which the cities of Philadelphia, San Francisco and Washington D.C. have already committed to using to aggregate, clean, track, and publish data resulting from their building performance disclosure regulations. Furthermore, the Commercial Energy Asset Score, launched by the CBI subprogram in FY 2014, gives the building industry a rigorous, uniform way to assess the as-built efficiency of the equipment in their buildings.

In FY 2016, the CBI subprogram is supporting high impact technology market transformation activities ($7 million) to advance the adoption of commercially available, efficient, and cost-effective building technologies that are underutilized through demonstration and market transformation work. Priorities will be placed on high impact technologies that enable whole-building energy analysis and the control of building end uses as well as occupant plug load reductions, new advances in highly efficient interior lighting technologies, and energy savings strategies for multiple systems. The CBI subprogram will build on previous successes, and market transformation activities such as procurement and technical specifications, real building demonstrations and market adoption campaigns, will drive implementation by delivering resources for multiple audiences and building sectors.

The CBI subprogram will continue to build and deploy data and decision support tools ($7 million) that focus on common data structures, tools, and processes to support and drive greater investment in energy efficiency across all commercial market sectors. The CBI subprogram is focused on several areas that represent significant barriers to greater investment in energy efficiency. These include:

- Energy performance data access and utilization;
- Design and decision support tools that incorporate energy performance into organizational culture and real estate transaction points and that inform cost-effective organizational and business models; and
- Preparing the clean energy workforce to design, build and operate buildings more efficiently. Combined workforce development activities will continue in FY16, to improve the quality, consistency, and dependability of the commercial buildings advanced energy workforce through guidelines for high-quality training and certification programs.

The CBI subprogram activities will build on successful efforts to improve access to decision-grade information on building energy performance and make information interoperable, accurate, and readily available at all levels of granularity. This work is fundamental to ensure that owners, operators, tenants, and investors can use data effectively to create value in

buildings through improved energy efficiency and that state and local decision makers can better assess the results of efficiency projects and programs. In FY 2016, the CBI subprogram's proposed work in this area will focus on:

- Making data collection and use easier, cheaper, and more automated to reduce the cost of doing business and unlock new opportunities. Develop and demonstrate ways to automatically collect data on energy use and performance of equipment and buildings to improve the accuracy and usability of national data sets, using previously developed platforms that improve interoperability such as such as the Building Energy Data Exchange Specification (BEDES), the Buildings Performance Database (BPD) and the Standard Energy Efficiency Data Platform (SEED).
- Improve & standardize Evaluation, Measurement and Verification (EM&V) – demonstrate the potential of improved methods of evaluation, measurement, and verification of energy efficiency projects and programs to provide reliability in measurement, increase market trust in energy savings, and reduce the cost of doing business.
- Driving energy data into real estate transactions – Deploy tools such as the Commercial Energy Asset Score, the Buildings Performance Database and the SEED Platform as means to make information about individual building conditions and local market trends available to renters, buyers, brokers, appraisers and lenders during real estate transactions.

To meet our aggressive national energy savings targets, the CBI subprogram supports market-based public-private partnerships ($8 million) that work with leaders in the commercial buildings market. The BBA, launched in 2008 under the name the Commercial Building Energy Alliance, includes more than 200 organizations, representing over 10 billion square feet of commercial building space, accounting for over 10 percent of total US commercial building stock. These organizations work in collaboration with DOE focused on specific technology and market-related solutions that are then adopted by members. The BBA has issued two technology challenges, two technology adoption campaigns, and 10 procurement specifications to help companies select efficient heating, cooling, lighting, refrigeration, and water heating technologies. If all Americans switched today to technologies that meet these specifications, savings would equal $17 billion and more than 2.0 quads of source energy every year. Partners in the Better Buildings Challenge, launched in 2011, take on aggressive goals (minimum 20 percent over 10 years) and document progress toward their goals by sharing information on the energy intensity of their portfolios against a baseline year. On average through 2013, partners improved the energy performance of their portfolios by more than 2.5 percent per year.

The CBI subprogram will invest $8 million to continue to support market partnerships to accelerate the adoption of advanced technologies and energy-saving strategies for new and existing buildings. This includes the Better Buildings Alliance – a partnership with over 200 commercial building owners and operators who are working with DOE to develop and test new highly efficient and cost-effective technologies and techniques. In FY 2016, the CBI subprogram will expand its work with industry and non-governmental organizations to drive these solutions and tools further and faster through joint campaigns, new incentives, and other strategic activities.

Building on foundational work in 2013 and beyond, the CBI subprogram will invest $10 million in a competitive FOA for proposals that would test and replicate innovative, cost-effective technologies and programs to achieve deeper energy efficiency improvements, such as innovative incentive models with utility partners and non-traditional financing strategies, all targeted specifically to overcome the unique barriers that small and medium commercial building owners, tenants, and service-providers face for energy efficiency retrofits. Small and medium buildings make up over 95 percent of the floor space and about 50 percent of the energy consumed by commercial buildings in the U.S. This FOA will seek to leverage previous work funded by the program, including a broad scoping study and market assessment, as well as pilots of unique program and engagement models. The FOA will give preference to projects that can integrate DOE technical resources and build off previous successful pilots to scale them nationally, extending the impact of the best outcomes of the previous work developing these models, as well as lessons learned from the Pennsylvania State University Consortium for Building Energy Innovation Small Buildings Research such as demonstrating an HVAC control package for small building types that achieves 15 percent energy savings at low cost without requiring sophisticated in-building commissioning expertise.

In addition, these funds may be used to support efforts such as peer reviews; data collection and dissemination; and technical, market, and economic studies and other analyses.

**Commercial Buildings Integration**
**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **Commercial Buildings Integration $27,643,000** | **$32,000,000** | **+$4,357,000** |
| • CBI is charged with demonstrating and increasing adoption of promising new energy efficient technologies in commercial buildings.<br>• CBI will continue its focus on building a national approach to making building energy data available and usable. Through the Energy Data Accelerator started in 2014, CBI will support at least 19 city-utility pairs to meet their commitments to provide whole building energy data to building owners in their areas.<br>• CBI develops common data structures, tools, and processes that help decision makers evaluate the cost and benefits of energy efficiency improvements and identify cost-effective opportunities to improve building energy performance. In FY 2015, the program will partner with industry stakeholders to demonstrate and broaden the use of several tools, including the Commercial Building Asset Score to help people understand the efficiency of the equipment and systems in their buildings, the Standard Energy Efficiency Data platform to help cities and other entities standardize large amounts of building performance data. CBI will maintain market partnerships to accelerate adoption of energy efficiency technologies and practices that integrate these technologies to achieve maximum savings.<br>• In 2015, CBI will launch one new product "challenge specification" with the potential to reduce energy use by one quad and demonstrate | • Update the HIT Catalyst to guide technology to market activities. Execute technology demonstrations, procurement specifications and installation guides to accelerate market acceptance of FY15 focus technologies include interior lighting, building controls and technology systems. Assess HIT list to develop 3-4 focus technologies for FY16 and develop multi-year technology to market plan.<br>• Continue Tech to Market activities with the Emerging Technologies subprogram and collaboration with the Equipment and Building Standards subprogram through high-impact technology commercialization projects.<br>• Maintain its successful market partnership programs such as the BBA and Better Buildings Challenge to accelerate adoption of energy efficiency technologies and practices. In 2016, the CBI subprogram will focus on developing robust partnerships with industry organizations to extend the impact.<br>• Launch new product specifications with the potential to reduce energy use by 1 quad and demonstrate and evaluate impact of several promising new technologies in commercial buildings with the total potential to reduce energy use by 1 quad.<br>• Support a FOA to extend the impact of prior year work in the small and medium commercial buildings sector through regional and national partnerships. | • Increased funding will support a Commercial Buildings FOA for proposals that would test and replicate innovative, cost-effective technologies and programs to achieve deeper retrofits in small and medium commercial buildings. This FOA would focus on, extending successful pilots/ demonstrations of technical and market solutions to develop them into self-sustaining programs and to replicate them in different climate zones and jurisdictions around the country. Small and medium buildings make up over 95 percent of the floor space and about 50 percent of the energy consumed by commercial buildings |

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| and evaluate impact of several promising new technologies in commercial buildings with the total potential to reduce energy use by one quad. In 2015, CBI will continue to assist over 200 organizations representing 10 billion sq. ft. of commercial building space or more to demonstrate 2 percent per year portfolio-wide energy savings. | | |

**Description**

The mission of the PSU Consortium for Building Energy Innovation (formerly the Energy Efficiency Buildings HUB) is to help transform the energy efficiency market for existing small- and medium-sized buildings, and develop the tools and strategies to support vibrant ecosystems of workforce and service providers to identify and apply integrative technologies and innovative practices in existing buildings. This refocusing of PSU's efforts followed a rigorous technical review that identified high-value activities complementary to the work of other subprograms and examined the best approaches to adapting those activities to the unique and complex challenges of energy efficiency in commercial buildings. With a more integrated approach, and increased collaboration with the program's broader portfolio of performers across the U.S., the PSU Consortium will improve its ability to expand from a regional focus to a national audience and accelerate its national impact in the building retrofit market.

The PSU Consortium will "go deep" in areas where local expertise and the ability to customize the program's national approaches are required to achieve and validate lasting energy savings. In particular, the work at PSU complements the program by:

- Serving as a local test bed for DOE-produced solutions;
- Testing real-world integration of technologies and processes;
- Producing replicable solutions that require a local origin but can be applied nationally; and
- Collaborating with the program to advance research, development and integration of needed technologies.

The PSU Consortium is focused in three areas: (1) to develop market-tested pathways to 50 percent energy reduction in existing small and medium commercial buildings, (2) identify and overcome market barriers in implementing energy efficiency in existing small and medium commercial buildings, and (3) accelerate adoption of energy efficient retrofit solutions at local and national scales.

Key activities include:

- Developing and demonstrating packages of existing emerging technologies focused on integration of systems;
- Testing, verifying and demonstrating low-cost building operations solutions (e.g., sensors, controls, diagnostics);
- Developing and refining retrofit strategies and tools, tailored to Small/Medium Sized Commercial Buildings (SMSCB);
- Demonstrating strategies that can be applied at a regional level in collaboration with retrofit enablers (e.g., regulators, program administrators, service providers, the finance sector);
- Developing and demonstrating strategies to improve capacity for retrofits in the SMSCB market; and
- Packaging regional successes for application on a national scale.

As originally proposed, FY 2015 was the last year of funding requested for the PSU Consortium for Building Energy Innovation. There is no funding requested for this subprogram for FY 2016.

## Pennsylvania State University (PSU) Consortium for Building Energy Innovation
## Activities and Explanation of Changes

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **Pennsylvania State University (PSU) Consortium for Building Energy Innovation $10,000,000** | **$0** | **$10,000,000** |
| • In FY 2015, the PSU work will develop new technologies and solutions not currently available in the market that are needed to reduce energy use in small- and medium-size commercial buildings, and demonstrate new paths to market for real energy savings. PSU will continue to deploy their work and other energy saving solutions in small- and medium-sized commercial buildings in Greater Philadelphia, while working with other regions for national market transformation. | • No funding is requested. | • FY 2015 was the last year of funding requested for the PSU Consortium for Building Energy Innovation. No funding is requested for FY 2016. |

**Description**

The Residential Buildings Integration (RBI) subprogram has a goal of demonstrating at scale market-relevant strategies (technology to market) offering a reduction in U.S. building-related energy use in existing homes by 25 percent by 2020 and 40 percent by 2030. For new homes, the RBI subprogram's goal is demonstrating at scale market-relevant strategies offering 30 percent energy savings by 2020 and 50 percent energy savings above the 2009 International Energy Conservation Code (IECC) in homes by 2030. The RBI subprogram will conduct focused applied research (e.g. how builder/retrofitters can more cost effectively install technical solutions into homes) to resolve the major technology to market challenges to achieving these goals, develop infrastructure to support the construction or improvement of homes to meet higher performance levels, and demonstrate and then promote higher energy efficiency home retrofit and model homes for new construction that may be implemented at the state and local level.

The overarching strategy for RBI is to identify technology areas and technical solutions that offer the potential for large energy savings in new and existing homes. Through its Building America, Zero Energy Ready Homes, and Better Buildings programs, RBI demonstrates the viability of these technologies, and offers solutions to the challenges inherent in integrating these technologies into residential buildings. Once these technologies are first demonstrated, then accepted in the market by leading builders and retrofit contractors, they can be adopted into building codes based on their cost effectiveness and energy savings potential.

The RBI subprogram differentiates the residential building sector into two markets: new construction and existing homes (retrofit). Residential buildings last for decades. To optimize life cycle energy performance, sound initial construction offers a critical opportunity to ensure sustained energy performance. New construction, while currently only several hundred thousand units a year (less than 1 percent of the market), still represents the most cost effective and largest opportunity to impact a single building's future energy use and performance. There are also more than 100 million existing housing units that could benefit from cost-effective home improvement opportunities that will also significantly reduce their energy use and improve occupant comfort. For both the new construction market and the existing homes retrofit market, DOE will continue to develop a series of cost-effective technological and systems integration solutions that allow both the new construction and retrofit communities to deliver tremendous potential home energy efficiency and comfort benefits to increasing numbers of U.S. residential customers.

RBI will focus its integration of new technology into the marketplace, focusing on those key issues that currently impede the adoption of more energy efficient technologies, largely due to first cost, which in turn impacts the adoption of more stringent model energy codes and energy efficiency improvements. There is significant cross over between new home and existing homes research, with new technologies and processes that apply to both.

Technical Solutions—RBI will focus on the three most challenging topics that offer high potential for energy savings if solved: technical solutions for a high performance building envelope; cost effective solutions to maintain indoor air quality, including ventilation; and solutions for homes with much lower cooling requirements but uncomfortable humidity levels. Furthermore, specialized solutions for these research areas may be required for different climates, which must inform the scope of the Building America programs efforts in these high priority topic areas. The Building America teams will focus on not only whole house retrofits, but also staged retrofits that support a larger homeowner base for less expensive staged improvements, with significantly larger national energy and associated financial savings.

Market Transformation—in the new homes segment, the RBI subprogram's primary focus is to address the diverse and fragmented residential new homes market by providing actionable technical information on more cost-effective energy efficient solutions for new homes and use cases of successful implementation models from other builders for new builders constructing energy efficient homes. The Building America Solution Center provides a one-stop resource for builders to access the well-validated successful integrated building efficiency implementation approaches developed and demonstrated by the Building America program. This solution center also supports cost-effective retrofit solutions for the existing homes retrofit market.

One of the best ways to catalyze the development of higher performing new residential buildings is to educate future architecture and engineering professionals by assisting the development of building science curriculum for colleges and universities. The RBI subprogram's strategy in this critical workforce education area implemented through its annual Building Technology Program "Student Design Competition", which we will do again in FY 2016. This design competition, with over 40 teams, more than 400 students and 4 countries for the FY 2015 event, provides an opportunity for schools and their students to compete against each other on designing marketable energy efficient new homes. The expected outcome of the competition is to focus schools on the value of integrating building science into design courses in all major architecture, engineering, and construction management courses. The Solar Decathlon will move to EERE's Strategic Programs.

Formerly called the EERE's Challenge Home program, the revamped "Zero Energy Ready Homes" is a labeling program that highlights and promotes builders who have built new homes that are 40 percent to 50 percent more energy efficient than homes built to the IECC 2006 model energy code—a significant improvement beyond even the typical ENERGY STAR home. The Zero Energy Ready Homes program provides an avenue for builders to promote and increase the deployment of their high performing homes through EERE recognition and promotion, using many of the technologies emerging from the Building America Research Program, and demonstrating the value of zero energy ready homes to homeowners. New home purchasers are typically making the most significant purchase of their lives and therefore tend to be cautious about adopting high-impact new building efficiency technologies. This program is designed to provide Federal government certification and recognition of builders who are providing truly efficient homes, to assist consumers in being fully informed in home buying decisions.

Together these comprehensive RBI demonstration and market transformation programs are intended to enable the new homes market to achieve the highest level of home performance while minimizing lifecycle costs to homebuyers. Without these high-impact efforts, the thousands of U.S. homebuilders would not be able to develop the wide range of options that EERE research and support provides, nor be able to objectively demonstrate to customers their high degree of performance, which is provided by the DOE labeling program. Without such an approach, many new housing innovations may never appear in the market.

The most cost-effective home improvement opportunity is to retrofit the entire home, since this allows the owner to capture the benefits from the interactive effects of improving multiple systems. For instance, if the insulation of a residential building is significantly improved, the size of the HVAC system can be smaller and thus the homeowner may be able to afford a potentially a more efficient HVAC unit enabling a net lower cost solution to maintain comfort in the building. This represents the most cost effective opportunity; however, it is also the least likely opportunity since the upfront cost of a whole house retrofit averages approximately $9,000, a significant cost for most homeowners. To increase the uptake of energy efficiency improvements of existing homes without the significant cost of a whole-house upgrade, the RBI subprogram's existing homes/retrofit efforts are now focusing on addressing smaller, more staged market opportunities. This approach is intended to allow more homeowners to participate in such a program, leading to larger savings nationally.

Market Support—The Better Buildings Neighborhood Program (BBNP) is the evolution of the American Recovery and Reinvestment Act funded National Home Retrofit Program. The American Recovery and Reinvestment Act program funded over 41 grantees over the last three years to develop successful marketing, technology development and installation, and business solutions that improve the home retrofit opportunities. The original participants are now part of the broader BBNP program, the membership of this market facing program now includes all contractors and program administrators that want to access our free and easy to use resources, as well as participate in meetings and webinars to share best practices. The BBNP is now the framework for all of the program's residential retrofit activities.

Home Performance with ENERGY STAR program (HPwES), as part of the BBNP framework, is a premier whole house residential retrofit program that outlines the necessary processes, including quality assurance, for deep energy retrofits yielding on average 25 percent savings to homeowners. This program does not fund retrofitting homes but instead provides technical support which includes, development of work specifications, recommendation of best practices, communication and outreach support centered around the ENERGY STAR brand, and an extensive network of existing retrofit programs that share lessons learned among the programs. HPwES provides a model retrofit program, with name recognition from both the retrofit community and homeowners. RBI will continue supporting this program in FY 2016, and will continue our

progress in reducing the costs for participation by home retrofit companies and program sponsors in order to increase its availability to homeowners throughout the U.S.

In FY 2016, after engagement with the existing home performance industry, the weatherization network, and other relevant stakeholders to obtain input and recommendations, RBI will expand and adapt this program to support all residential buildings and income levels ($10 million). This would expand RBI's retrofit efforts beyond single-family homes to multi-family (low-rise) and manufactured homes. These additional housing types will require somewhat different energy efficiency solutions due to different construction types. In addition, this would also support RBI's continued shift to the larger opportunity of cost effective staged home improvements. While a staged approach does not achieve the deep energy savings of a whole house program, it has the potential to reach more households and thus provide significant energy savings. DOE will conduct analysis, regional forums, and other engagement activities, and will leverage the expertise of existing networks during program execution necessary to design and implement an effective and efficient program. In addition, DOE will conduct supporting analysis of new business models for multi-family housing focused on efficiency, distributed clean energy, and financing, like PACE.

Existing RBI programs will be leveraged to support this initiative. For example, the BBNP supports both whole home retrofits, and the larger opportunity of cost effective staged home improvements. A staged home improvement opportunity informs the retrofit company and the building owner what they can do to improve the performance of different home systems (roofs, windows, water heating, HVAC, etc.), in addition to informing them how staging their retrofits can improve the end result from an efficiency perspective. The order in which a building owner undertakes different projects has a direct impact on the cost and final energy savings, and while homeowners may make sequencing choices based upon other criteria (aesthetics, convenience, etc.), providing them with the staging benefits can help them make the best choices for their individual circumstances. These opportunities will be developed and presented to the BBNP network to increase all future home energy savings opportunities.

The RBI subprogram also supports the Home Energy Score (HEScore), providing information to homeowners and potential retrofit contractors, on the energy efficiency of their homes. HEScore is similar to a vehicle mile-per-gallon rating. It allows homeowners to compare the energy performance of their homes nationwide by using a 1-10 scale, with 10 being the most efficient. Low scores are intended to incent homeowners to make energy efficiency improvements, increasing home comfort and reducing energy costs. The RBI subprogram will begin a transition to a third party HEScore Program implementer while continuing to grow its influence and effectiveness.

The Building America Solution Center provides easy to use, web-based technical solutions for builders and contractors on energy efficiency improvements. Through the Building America Solution Center, builders and home improvement contractors can see and understand various aspects of installation of high efficiency technologies and state-of-the-art building practices and processes. The Better Buildings Solution Center is a counterpart to the Building America Solution Center (to be more integrated in the future). This Better Buildings Solution Center provides regional and local program sponsors and administrators implementing existing home retrofits with the best practices and lessons learned from the Better Buildings Neighborhood Program. These lessons include financing, work force development, demand-driver, quality assurance, and benchmarking characteristics of successful programs. In addition to the Better Buildings Solution Center, DOE will continue to convene program administrators and allies through conference calls and webinars to foster a community of program administrators sharing their successes as well as problems facing their programs through the Better Buildings Residential Network.

In FY 2016, the RBI subprogram will invest $26 million in the Building America Research Program. The centerpiece of this program will be its annual FOA ($15 million), which will fund a consortium of building science teams to develop and demonstrate technology and business solutions for the three highest priority challenges facing market adoption of more energy efficient solutions: (1) high performance building envelopes (wall, foundation, roof) that work in all climates, (2) comfort solutions for high latency load homes (e.g., home in humid climates), and (3) efficient ventilation and indoor air quality solutions. Through the expansion of the Building America Program, RBI can accelerate the research into these topic areas, providing multiple solutions for builders and contractors to these issues across multiple climate zones. This accelerated timeline is important to the housing trades. As production builders build more energy efficient homes, and home improvement contractors improve the energy efficiency of existing homes, RBI's research must resolve these issues to prevent unintended construction failures in the future. This becomes increasingly important as the country moves to

more stringent building codes and toward increasing adoption of voluntary programs such as the EPA's ENERGY STAR programs and DOE's Zero Energy Ready Homes. The goal of the RBI subprogram is to have cost effective deployable solutions to address these three market uptake challenges for most climate zones within three to five years. These technical solutions will be provided to the market through our existing web based Solution Centers.

In addition, the RBI subprogram will fund system integration R&D on two technologies developed by the ET subprogram that are close to being market-ready: Cold Climate Heat Pumps and Integrated Heat Pumps. Moreover, the RBI subprogram will continue to use its market integration tools (e.g. Zero Energy Ready Homes, Home Performance with ENERGY STAR, Staged Improvements) to move technologies and solutions resulting from Building America and National Laboratory R&D, and its Zero Energy Ready Homes, and Home Performance with ENERGY STAR partnerships into the market, with the goal of achieving cost effective scale adoption.

Energy efficiency has long been considered the least cost solution for reducing fossil fuel consumption across the industrial, manufacturing, commercial and residential building sectors. However, for the residential sector, homeowners do not always undertake energy efficiency improvements, despite the return on investments as well as the additional benefits of health, comfort and safety. There are many reasons for this. Some studies cite the homeowners' concerns that the savings will not be realized, while others state that the payback period is not sufficient given that homeowners are not likely to stay in their homes for more than seven years. RBI will allocate funds in FY 2016 to a R&D FOA to investigate the interplay between homeowner behaviors, decision-making, and effects on motivations for consuming or conserving energy. This effort will help identify opportunities to reduce soft costs and drive increased adoption of energy efficiency improvements.

For example, RBI has rolled out HEScore, an inexpensive yet accurate audit tool that allows homeowners to compare their homes' energy consumption to that of their neighbors. Does HEScore provide an adequate incentive to homeowners to improve their homes based on such a comparison? If not, what needs to be changed? State and local programs continue to promote financing as a tool to encourage energy efficiency by reducing the first costs of home improvements, yet only a small percentage of home improvements are financed. What inhibits homeowners from financing? The profit margins on energy efficient appliances and equipment, as well as efficiency upgrades, are larger than appliances and equipment built to appliance standard levels. Yet, contractors do not promote high efficiency equipment and their proper installation. These are several examples of the behavior issues that have long affected the home improvement market for energy efficiency. This FOA will provide insights to help answer these or similar questions, and help RBI improve its delivery of its energy efficiency programs.

The RBI subprogram FY 2016 planned activities include, but are not limited to:

- Building America: Issue FOA to address the three most important barriers to high efficiency homes, building off the FY 2015 FOA addressing the same barriers but in different climate zones;
- Building America Solution Center: Add 40 new guidance documents and at least 800 new registered users;
- Better Buildings Solution Center: Launch Solution Center nationally for use by program managers;
- Zero Energy Ready Homes: 6,000 highly efficient new homes constructed by building partners;
- Home Energy Score: 35,000 homes scored by local sponsors such as utilities, NGOs and state energy offices;
- Home Performance with ENERGY STAR: facilitating 130,000 retrofits in FY 2016;
- FOA released to evaluate the role of consumer behavior in improving the energy efficiency of homes;
- Evaluation, stakeholder engagement, and other activities to support the expansion of retrofit facilitation activities to all residential buildings and income levels.

In addition, these funds may be used to support efforts such as peer reviews; data collection and dissemination; and technical, market, economic, and other analyses.

**Residential Buildings Integration**
**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **Residential Buildings Integration $22,758,000** | **$48,000,000** | **+25,242,000** |
| • RBI will focus on building system R&D and partnering with market leaders to accelerate adoption of energy efficient solutions in the residential building sector, while developing databases and tools that reduce uncertainty associated with investment (i.e. Building America Solution Center and Home Energy Score).<br>• RBI will continue supporting development of innovations through applied research and industry partnership demonstrations, with strategic refinements to increase impact and accelerate adoption. RBI will expand capability to address secondary effects related to high performing homes such as indoor air quality, moisture/water management (for durability). RBI will examine and address technical code compliance issues and available retrofit technologies to reduce implementation costs. Investigate market transaction processes to identify and reduce impediments to technology adoption of technologies beneficial to the homeowner.<br>• RBI will continue to demonstrate market-based cases for net-zero energy ready homes to builders and homeowners.<br>• RBI will expand the network of private sector trainers for the Challenge Home Program under Building America to provide technical assistance to builders and to translate building science knowledge into educational materials for use by builders.<br>• Through Better Buildings Residential activities, RBI will continue to enhance a suite of resources | • Focus on applied research through its Building America Program as well as through its Better Buildings Residential Program. Technical research will address High Performance Enclosures, Optimal Comfort Solutions for Low-Load Homes and Healthy Efficient Ventilation & Indoor Air Quality Solutions in the remaining climate zones.<br>• Evaluation, stakeholder engagement, and other activities to support the expansion of retrofit facilitation activities to all residential buildings and income levels. This program would expand RBI's retrofit efforts beyond single-family homes to multi-family (low-rise) and manufactured homes. The program will support RBI's continued shift to the larger opportunity of cost effective staged home improvements.<br>• Continue to support infrastructure development through its Solution Centers, providing technical and programmatic solutions to the market. The RBI subprogram will support standards development and, Building Science curriculum development. The Home Energy Score will continue to provide information to homeowners on the energy efficiency of their homes. The RBI subprogram will demonstrate market-based cases through its Zero Energy Ready Homes Program to builders and homeowners. The RBI subprogram will also provide options for increasing lower-cost, high-volume single measure activities that increase efficiency in homes. The Home Performance with ENERGY STAR Program, the RBI subprogram will help efficiency programs and their partners to more | • Accelerate Building America R&D providing multiple solutions for builders and contractors to these issues across multiple climate zones. This accelerated timeline is important to the housing trades. As production builders build more energy efficient homes, and home improvement contractors improve the energy efficiency of existing homes, RBI's research must resolve these issues to prevent unintended construction failures in the future. This becomes increasingly important as the country moves to more stringent building codes and toward increasing adoption of voluntary programs such as the Environmental Protection Agency's (EPA) ENERGY STAR programs and DOE's Zero Energy Ready Homes.<br>• Expanded building retrofit facilitation program and multifamily housing analysis.<br>• Release R&D FOA to investigate the interplay between homeowner behaviors, decision-making, and effects on motivations for consuming or conserving energy. |

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| including expansion of access to best practices and lessons learned. RBI will provide options for increasing lower-cost, high-volume single measure activities that increase efficiency in homes. RBI will provide informational resources to help state and local decision makers in their support of residential efficiency programs.<br>• Through the Home Energy Score, RBI will provide clear information to homeowners and help enable state and local decision makers in their support of residential efficiency.<br>• Through the Home Performance with ENERGY STAR program, RBI will help efficiency programs and their partners to more comprehensively address barriers to adoption of retrofits. RBI will offer innovative implementation options for deploying building science best practices for retrofitting homes. | comprehensively address barriers to adoption of retrofits.<br>• Release R&D FOA to investigate the interplay between homeowner behaviors, decision-making, and effects on motivations for consuming or conserving energy based on actionable information. | |

## Buildings Technologies
## Equipment and Buildings Standards

**Description**

The Equipment and Buildings Standards subprogram supports performance based regulatory approaches to ensure that technically feasible and economically justified energy-efficient technologies overcome barriers to widespread adoption. The program generates cost-effective energy savings through the development of national appliance and equipment standards. The program sets minimum efficiency standards for covered products that are manufactured or imported into the U.S. and the program incrementally raises the standards to save energy by requiring the adoption of more efficient technologies currently offered in the marketplace. Test procedures and energy conservation standards developed by this program support national energy policy objectives, such as increasing energy savings and energy productivity, and reducing carbon emissions.

DOE remains committed to meeting all of its legislatively mandated deadlines for covered appliances and equipment and to actively enforcing its existing standards to the greatest extent practicable to provide a level playing field for all manufacturers. The program addresses market challenges or barriers to the adoption of energy efficient technologies primarily through support to ENERGY STAR, regulatory activities, and model building code activities. The Energy Policy and Conservation Act (as amended) legislatively mandate the vast majority of the subprogram's test procedure and standards rulemaking activities. The rulemaking schedule, and thus the level of program activity, is largely determined by existing legislation. Since 2009, 25 new or updated standards, covering more than 30 products, have been issued and will ensure annual energy savings over the coming years. Cumulative consumer utility bill savings associated with these recently enacted standards are projected to be hundreds of billions of dollars (undiscounted) through 2030. The Equipment and Building Standards subprogram will support the Climate Action Plan goal of reducing energy use and will support the establishment of efficiency standards from 2009 through the end of calendar year 2016 that cut greenhouse gas emissions by at least 3 billion metric tons through 2030.[1]

DOE will build upon prior year activities by initiating new energy conservation standards and test procedures for certain types of consumer products and commercial equipment and by issuing Notices of Proposed Rulemaking and Final Rules for standards and test procedures.

In FY 2016, the requested funding of $53.5 million for appliance and equipment standards activities will enable DOE to continue to take all necessary and feasible steps to finalize legally required efficiency standards consistent with all applicable judicial and statutory deadlines. DOE will build upon prior-year new product coverage activities by completing those rulemakings that deliver a high level of benefits beyond statutorily mandated rules. DOE will also maintain its activities in certification and enforcement to increase the effectiveness of existing energy conservation standards. The frequency and scope of product testing to verify compliance with DOE standards will reflect the compliance experience from previous years. The additional funding targeted for certification and enforcement will allow DOE to test increased volumes of commercial and industrial products, which tend to cost more to purchase and test than home appliances, but also use more energy per unit. With certification requirements for certain commercial products coming into play in mid- to late 2014, DOE will have many more products to test for compliance to minimum efficiency standards.

Specifically, in FY 2016, the Equipment and Building Standards subprogram will:

- Standards enacted since 2009 are projected to avoid a cumulative total of 2.2 billion metric tons of carbon emissions by 2030;
- Submit six draft test procedures for ENERGY STAR products;
- Test at least 100 products for compliance with Federal minimum efficiency standards or the ENERGY STAR program;
- Issue test procedure final rules for 8 products (8 rulemakings);
- Submit 6 draft test procedures for ENERGY STAR equipment; and
- Perform lab research on covered product technology barriers.

[1] At least three billion tons of carbon dioxide emissions will be avoided due to appliance and federal building standards finalized during the Obama Administration's first and second terms.

State and local building codes regulate 70 percent of building energy and represent the baseline for building energy efficiency. The associated cumulative energy savings through 2020, since program inception in 1992, is estimated to be 10.2 quads. Building energy codes are an existing solution that can provide between 20-30 percent whole building energy savings. The program assists states and localities in adopting, complying with, and enforcing energy codes for residential and commercial buildings, resulting in higher-performing buildings that maximize cost-effective energy savings. It also participates in the development of residential and commercial model building energy codes, as administered by the International Code Council (ICC) and ASHRAE. The Building Energy Code activity is a legislatively authorized program with a mandate to develop Federal determinations based upon model codes that address all new construction and major renovations in residential and commercial buildings. In FY 2016, the proposed funding for the Building Energy Codes subprogram is $15.5 million.

In FY 2016, the Building Energy subprogram will invest in a Commercial Energy Codes FOA ($10 million). DOE will develop and field test methodologies to establish a state baseline, and then measure the energy savings (which incorporates emission reductions and utility bill savings) associated with a state's adoption and compliance with commercial building energy codes. While commercial energy codes are adopted in almost all states there is currently no reliable data available regarding setting baselines and calculating the extent of compliance with the state's adopted codes, nor the potential benefits that could accrue from increasing those compliance rates.

Reliable, repeatable methodologies that can be applied by different states and their specific circumstances, would allow the state governments to objectively assess the costs and benefits of increasing code compliance, and it would allow private market investors, particularly utilities, to better monetize the value of actions they could take to increase compliance and justify large-scale programmatic investments.

The FOA results would serve as a data-based catalyst for both public and private investment in energy efficiency based upon codes.

In addition, these funds may be used to support efforts such as peer reviews; data collection and dissemination; and technical, market, and economic studies and other analyses.

**Equipment and Buildings Standards**
**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **Equipment and Buildings Standards $53,359,000** | **$69,000,000** | **+$15,641,000** |
| • Program will accelerate appliance efficiency standards rulemakings and actively enforce Federal minimum efficiency levels. The new product coverage determinations will be continued further into the rulemaking process.<br>• The Building Energy Codes Program will continue to meet statutory obligations to participate in national model code development activities, and seek to increase the number of states (by at least 5) that have adopted and are complying with updated codes. | • Program will complete work on final rules to increase or set new standards that are projected to provide over 250 million metric tons of carbon emissions savings. Program will continue to enforce minimum standards and verify the performance of ENERGY STAR products.<br>• The Building Energy Codes activity will continue to meet statutory obligations to participate in national model code development activities, and seek to increase the number of states (by at least 5) that have adopted and are complying with updated codes. | • Increased funding used to support Commercial Building Energy Codes FOA. |

**Description**

In FY 2016, EERE programs will continue to directly fund NREL site-wide facility costs that are not included in the Facilities and Infrastructure budget rather than fund those costs as laboratory overhead. This approach is consistent with Generally Accepted Accounting Practices and DOE management at other National Laboratories. EERE began this practice in FY 2014 to effectively control NREL's labor rate multiplier. One outcome has been reducing the cost of accessing unique NREL capabilities (such as facilities and staff expertise) by industry and academia. This practice also makes site operating costs more transparent in order to facilitate cost control and planning. In FY 2014, this practice resulted in a reduction in the Lab-wide direct labor multiplier of approximately 15 percent compared to FY 2013. The proposed FY 2016 Budget Request continues the approach applied in FY 2014 and FY 2015.

This subprogram funding supports research programs by providing basic site services, functions, and infrastructure for site operations, which includes: management, building operations, building and grounds maintenance, fire and emergency response, engineering and construction support, minor construction projects, electrical safety program, utilities, and facilities planning support; and activities within the Sustainability and Environmental Health and Safety (EHS) portfolios. These activities and their costs are relatively fixed and only vary significantly based upon variations in commodities, construction activity, emergencies, weather patterns, etc. They are considered to be the core functions for site operations, safety, environmental compliance, and sustainability at NREL. In FY 2016, this funding will continue to support more than 60 full time equivalents that manage and provide support for these core functions. It will also fund site-wide subcontracts such as janitorial services, refuse and recycling, and subcontracts for minor construction. Additionally, this funding will support site-wide costs associated with maintaining NREL's leadership position, such as: maintaining International Organization for Standardization (ISO), American Association for Laboratory Accreditation (A2LA), and other lab-wide accreditations, managing facilities to enable mission goals, improving sustainability, pollution prevention, waste minimization, improving energy efficiency, reducing water use, and maintaining an effective emergency management system.

The FY 2016 Budget Request remains consistent with the method EERE developed in FY 2015. This approach is a more precise, equitable, and economically neutral method that ensures a predictable net-zero impact on programs' funding. For each program, the contribution to direct funding for site-wide facility support is equivalent to the estimated contribution the program otherwise would have made through overhead charges. This method is based upon each program's level of funding to NREL, adjusted to account for anomalies from large capital expenditures and major subcontracts.

**NREL Site-Wide Facility Support**
**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **NREL Site-Wide Facility Support $2,500,000** | **$2,500,000** | **+$0** |
| • Directly fund NREL site-wide facility support costs that are not included in the Facilities and Infrastructure budget rather than continue to fund these costs in the laboratory overhead rate. | • Directly fund NREL site-wide facility support costs that are not included in the Facilities and Infrastructure budget rather than continue to fund these costs in the laboratory overhead rate. | • No change. |

**Building Technologies Performance**
**Performance Measures**

In accordance with the GPRA Modernization Act of 2010, the Department sets targets for, and tracks progress toward, achieving performance goals for each program.

| | CY 2014 | CY 2015 | CY 2016 |
|---|---|---|---|
| Performance Goal (Measure) | **Lighting - Decrease the manufacturing cost of a warm white LED package.** | | |
| Target | 128 lumens per dollar (lm/$) | 144 lm/$ | 160 lm/$ |
| Result | On track | On track | On track |
| Endpoint Target | 217 lm/$ by 2020 | | |

## Weatherization and Intergovernmental Programs

### Overview

The mission of the Weatherization and Intergovernmental Programs (WIP) is to partner with state and local organizations to significantly accelerate the deployment of clean energy (e.g., energy efficiency and renewable energy) technologies and practices by a wide range of government, community, and business stakeholders.

Aligning with the President's Climate Action Plan and the Administration's all-of-the-above approach to American energy, WIP addresses the demand and supply sides of energy by facilitating investments in both energy efficiency (demand), and clean energy generation (supply), as well as alternative transportation fuels and vehicles. WIP's subprograms include the Weatherization Assistance Program (WAP) and the State Energy Program (SEP). In addition, the Local Energy Program will be established in FY 2016. Similar to the State Energy Program, this program will provide support to local governments for energy planning, program development and implementation, analysis, and other related efforts through technical assistance and competitively awarded grants. This new program will allow WIP to expand partnerships with local governments to catalyze investments to advance the U.S. clean energy economy.

The program and its national network of state and local government agencies provide strategic leadership, resource leveraging, and market expertise to accelerate deployment of energy efficiency and renewable energy products and technologies that improve America's energy security and economic prosperity. For decades, states have demonstrated leadership through their unique authorities to develop and implement energy efficiency and renewable energy policies and programs. State governments wield considerable influence in the building sector through upgraded building codes and incentives; in the utility sector through energy efficiency and renewable energy targets and customer programs; and in the industrial sector with policies that encourage efficiency and/or fuels substitutions such as energy audits and combined heat and power. States are advancing these energy solutions through regional networks, strategic energy planning, executive orders, legislation and local ordinances, management of retrofit programs, and land use plans. WIP includes the ability to do the following:

- Use state energy and weatherization networks and competitive awards to local governments to spur widespread adoption of cost-effective energy efficiency and renewable energy technologies; and
- Help address market, planning, implementation, and financing barriers to enable accelerated deployment of effective clean energy policies and cost-effective clean energy technologies.

WIP uses an integrated approach consisting of the following strategies/pathways:

- Formula grants to support the core capabilities of state energy offices, and a weatherization provider network that assists low income families through provision of home energy retrofits;
- Competitive awards to support innovative state and local high-impact and self-sustaining clean energy projects;
- Technical assistance to facilitate energy efficiency and renewable energy technology delivery through "best practice" tools, "lead by example" methods, peer to peer forums, and strategic partnerships; and
- Active management of awardees through on-site reviews and integrated web-based systems for reporting, monitoring, and communication.

### Highlights of the FY 2016 Budget Request

WIP's FY 2016 Budget Request supports several key initiatives that contribute to achieving EERE and program objectives:

- WAP helps eligible low income households reduce the comparatively large percentage of available income that they spend on energy. The request supports:
  - The completion of approximately 33,000 low-income residential energy retrofits, with annual per unit average energy cost savings of $250-$480 per year between 2016-2036;
  - Continued improvements in workforce training, quality standards, and worker certification to improve the quality of the work performed; and
  - Competitively selected and managed high-impact projects on financing models for the retrofit of low-income multi-family buildings.
- SEP will continue support for core capacity and innovation in state energy offices and dissemination of best practices to:
  - Assist in reducing government facilities and operations energy use by 2 percent per year through 2020;

- Maintain the viability of the state energy office network and capacity to develop, improve, and implement state energy plans;
- Accelerate investment in public sector use of energy service performance contracts by an additional $2.0 billion by 2016; and
- Support high-impact projects focused on development and implementation of state policies addressing barriers limiting investment in energy efficiency and renewable energy, including self-sustaining financing models.

- The Local Energy Program will significantly enhance local government and community core capabilities in the planning and implementation of energy efficiency and renewable energy programs through:
  - Providing targeted technical assistance to partnerships on strategic energy and economic planning and development;
  - Expanding best practices tools, models, and strategies across a broad network of local government agencies and regional and national stakeholders; and
  - Supporting competitively selected projects that advance local energy efficiency solutions, transformative best practices, benchmarking, lead-by-example policies and strategies, and other energy planning or project activities that promote the expanded adoption of energy efficient and renewable energy technologies and practices.

## Weatherization and Intergovernmental Programs
## Funding ($K)

| | FY 2014 Enacted[1] | FY 2014 Current | FY 2015 Enacted | FY 2016 Request | FY 2016 vs FY 2015 |
|---|---|---|---|---|---|
| **Weatherization and Intergovernmental Programs** | | | | | |
| **Weatherization Assistance Program** | | | | | |
| Weatherization Assistance (formula and competitive grants) | 170,898 | 170,898 | 189,600 | 223,999[2] | +34,399 |
| Training and Technical Assistance | 2,998 | 2,998 | 3,000 | 4,000 | +1,000 |
| NREL Site-Wide Facility Support | 0 | 0 | 400 | 400 | 0 |
| **Total, Weatherization Assistance Program** | **173,896** | **173,896** | **193,000** | **228,399** | **+35,399** |
| **State Energy Program** | **49,970** | **49,970** | **50,000** | **70,100[3]** | **+20,100** |
| **Local Energy Program** | **0** | **0** | **0** | **20,000[4]** | **+20,000** |
| **Tribal Energy Program[5]** | **6,996** | **6,996** | **0** | **0** | **0** |
| **Total, Weatherization and Intergovernmental Programs** | **230,862** | **230,862** | **243,000** | **318,499** | **+75,499** |

[1] FY 2014 enacted funding reflects the contractor foreign travel rescission of $137,798.
[2] The FY 2016 Weatherization Assistance request is for $208,999 in formula grants and $15,000 in competitive financial assistance.
[3] The FY 2016 State Energy request is for $45,000 in formula grants, $15,000 in competitive financial assistance, and $10,100 in technical assistance.
[4] The FY 2016 Local Energy request is for $16,000 in competitive financial assistance and $4,000 in technical assistance.
[5] The FY 2015 President's Budget Request included the transfer of the EERE Tribal Energy Program activities and responsibilities to the Office of Indian Energy.

**Weatherization and Intergovernmental Programs**
**Explanation of Major Changes ($K)**

| | FY 2016 vs FY 2015 |
|---|---|
| **Weatherization Assistance Program** | |
| **Weatherization Assistance:** The formula grants request increase of $19 million will support critical infrastructure and a level of operations to provide weatherization retrofits for approximately 33,000 low-income families across the country. In addition, $15 million is also requested for weatherization competitive awards to develop and test out a number of financing models to support energy-efficiency retrofits in the underserved multi-family sector. | **+34,399** |
| **Training and Technical Assistance:** The $1 million increase from the FY 2015 request level will accelerate deployment of retrofit standards, improvement in the training and certification infrastructure for both workers and program managers, and support for expanded grantee monitoring and oversight of their local subgrantee networks. | **+1,000** |
| **State Energy Program:** The requested increase comprises: $6 million for formula grants to expand state-led comprehensive clean energy and emergency energy assurance planning capabilities and also address emerging environmental challenges; $10 million in support for a variety of multi-jurisdictional competitive energy projects that will have high impact/high-visibility and replicability to other state and local entities; and $4 million to facilitates clean energy technology delivery through additional "best practice" tools, “lead by example” methods, peer to peer forums, and strategic partnerships. | **+20,100** |
| **Local Energy Program:** The $20 million increase in competitive grants and related technical assistance supports critical policy and technical needs of local governments, expands partnership outreach, grows financial and policy “best practices” capabilities, and capitalizes on the significant leadership abilities of local governments to harness the full potential of renewable energy and energy efficiency. | **+20,000** |
| **Total, Weatherization and Intergovernmental Programs** | **+75,499** |

**Weatherization and Intergovernmental Programs**
**Weatherization Assistance Program**

**Description**

The Weatherization Assistance Program (WAP) mission is to increase the energy efficiency of dwellings owned or occupied by low-income persons, reduce their total residential energy expenditures, and improve their health and safety. Through retrofitting residential buildings, WAP activities reduce the cost of low-income household energy bills, which are significantly disproportionately higher relative to higher income households. Up to 40 million low-income households in the U.S. are eligible for low-income housing energy assistance. Since 1976, WAP has performed 6 million upgrades to low-income households, including 1 million retrofits supported through American Recovery and Reinvestment Act of 2009[1] funding.

Weatherization Assistance ($224 million)

The FY 2016 Budget Request includes an amount of $209 million for Weatherization formula grants, which provides sufficient resources to accomplish approximately 33,000 home retrofits in FY 2016. This work is estimated to save $277 million for these low-income households over the 20-year life of the measures installed. This allows eligible low income families to use retrofit enabled energy cost savings to purchase other essential basic needs (like food, medicine, etc.). These formula grants help support the largest and one of the most technically advanced networks of residential energy retrofit providers in the country, providing a foundation for related services funded by other Federal and Non-Federal sources as well. Funds are allocated on a statutory formula basis and awarded to a single agency within each State, Washington, DC, and U.S. territories, to increase the energy efficiency of homes occupied by families with household incomes of 200 percent or less of the Office of Management and Budget's Annual Poverty Guidelines. These agencies, in turn, contract with approximately 800 Community Action Agencies and local governmental and nonprofit agencies, providing jobs and delivering weatherization services to low-income families in every geographic area of the country. Weatherization service providers choose the best package of efficiency measures for each home based on a comprehensive energy audit. Typical energy conservation measures include installing insulation, sealing ducts, repairing or replacing heating and cooling systems, reducing air infiltration, improving hot water production and use, and reducing electric base load consumption. The consistent delivery of quality services is addressed through active Federal, regional and state training and technical assistance programs. The program leverages both Federal and non-Federal funding sources to expand the array of services available for each home or to increase the number of homes weatherized.

In addition, $15 million is requested for competitively selected projects to demonstrate the viability of a variety of financing programs for replicability across the country. The financing models that prove successful will support expansion of weatherization activities in the underserved residential multi-family sector. Currently, more than 50 percent of low-income residents reside in multi-family housing stock. The expansion of multi-family financing programs is the most practical means to dramatically increase the impact of Federal funds utilized in the weatherization of low-income households. In FY 2016, the program will competitively select and manage high-impact projects that would enable recipients to establish financing and loan models for the retrofit of low-income multi-family buildings. Competitive assistance activities will incorporate data collection and share the project results including best practices.

Training and Technical Assistance ($4 million)

WAP's Training and Technical Assistance (T&TA) activities improve program effectiveness, service delivery, resource accountability, and operational efficiency. Specifically, T&TA funds support the development and implementation of a variety of tools needed to implement work quality, training accreditation, and worker certification. Some examples of the WAP T&TA activities to be undertaken in FY 2016 include the following:

- Maintenance and upgrades to the standard work specifications (SWS) online tool (https://sws.nrel.gov/). This tool houses the SWS for home energy upgrades, which serves as the backbone of the WAPs work quality initiatives. The enhanced functionality of the tool allows grantees to develop work quality standards as well as illustrated field guides, work orders and checklists. The SWS requires regular review and updating to ensure it is current with codes,

[1] (http://www.gpo.gov/fdsys/pkg/PLAW-111publ5/pdf/PLAW-111publ5.pdf)

technology and best practice for residential upgrades. The SWS online tool requires ongoing maintenance to respond to user's needs and ensure consistent functionality.

- Maintenance of the home energy professional (HEP) certifications and their underlying resources, such as the job task analyses and certification schemes. The HEP quality control inspector certification is required of all grantees and must be maintained in order to retain their ANSI accreditation.
- Development of training resources to respond to continually evolving needs in the field, including an enhanced curriculum, updating of the ASHRAE 62.2 curriculum, and updating several modules related to weatherizing multi-family buildings.
- Upgrade of and enhancements to the suite of energy auditing tools for single family buildings, mobile homes, and multi-family buildings -- including moving these tools online. One related project includes integrating the WAP audit tools with DOE's home energy scoring tool.
- Implementation of strategic planning and analysis; define program performance measurement; and facilitate advanced techniques and collaborative strategies through pilot programs, publications, training programs, workshops, and peer exchange.

The national evaluation of WAP will be completed in FY 2015. An impact analysis will estimate national energy savings and program cost effectiveness, as well as, non-energy benefits and a comprehensive process evaluation will address program characterization, operation, training, and quality assurance. The evaluation will cover the program year 2007 and 2008 and American Recovery and Reinvestment Act of 2009 (http://www.gpo.gov/fdsys/pkg/PLAW-111publ5/pdf/PLAW-111publ5.pdf) periods.

NREL Site-Wide Facility Support ($0.4 million)

In FY 2016, EERE programs will continue to directly fund NREL site-wide facility costs that are not included in the Facilities and Infrastructure budget rather than fund those costs as laboratory overhead. This approach is consistent with Generally Accepted Accounting Practices and DOE management at other National Laboratories. EERE began this practice in FY 2014 to effectively control NREL's labor rate multiplier. One outcome has been reducing the cost of accessing unique NREL capabilities (such as facilities and staff expertise) by industry and academia. This practice also makes site operating costs more transparent in order to facilitate cost control and planning. In FY 2014, this practice resulted in a reduction in the Lab-wide direct labor multiplier of approximately 15 percent compared to FY 2013. The proposed FY 2016 Budget Request continues the approach applied in FY 2014 and FY 2015.

This subprogram funding supports research programs by providing basic site services, functions, and infrastructure for site operations, which includes: management, building operations, building and grounds maintenance, fire and emergency response, engineering and construction support, minor construction projects, electrical safety program, utilities, and facilities planning support; and activities within the Sustainability and Environmental Health and Safety (EHS) portfolios. These activities and their costs are relatively fixed and only vary significantly based upon variations in commodities, construction activity, emergencies, weather patterns, etc. They are considered the core functions for site operations, safety, environmental compliance, and sustainability at NREL. In FY 2016, this funding will continue to support more than 60 full time equivalents that manage and provide support for these core functions. It will also fund site-wide subcontracts such as janitorial services, refuse and recycling, and subcontracts for minor construction. Additionally, this funding will support site-wide costs associated with maintaining NREL's leadership position, such as: maintaining International Organization for Standardization, American Association for Laboratory Accreditation, and other lab-wide accreditations, managing facilities to enable mission goals, improving sustainability, pollution prevention, waste minimization, improving energy efficiency, reducing water use, and maintaining an effective emergency management system.

The FY 2016 Budget remains consistent with the method EERE developed in FY 2015. This approach is a more precise, equitable, and economically neutral method that ensures a predictable net-zero impact on programs' funding. For each program, the contribution to direct funding for site-wide facility support is equivalent to the estimated contribution the program otherwise would have made through overhead charges. This method is based upon each program's level of funding to NREL, adjusted to account for anomalies from large capital expenditures and major subcontracts.

**Weatherization Assistance Program**
**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **Weatherization Assistance Program $193,000,000** | **$228,399,000** | **+$35,399,000** |
| *Weatherization Assistance ($189,600,000 for formula grants)*<br>• Supports energy upgrades in the homes of low income families.<br>• Award and actively manage 59 weatherization formula grantees, which will support over 30,000 comprehensive energy audits and residential energy retrofits. | *Weatherization Assistance ($223,999,000; $209 million for formula grants, $15 million for competitive grants)*<br>• Supports energy upgrades in the homes of low-income families through formula grants.<br>• Award and actively manage 59 weatherization formula grantees, which will support approximately 33,000 comprehensive energy audits and residential energy retrofits.<br>• Competitively select and manage more than 20 high-impact projects on financing models for the retrofit of low-income multi-family buildings. | *Weatherization Assistance (+$34,399,000)*<br>• The $208.999M funding level for Weatherization formula grants will support critical infrastructure and a level of operations and serve an additional 3,000 low-income families across America.<br>• Test effectiveness of various financing models from selected proposals to inform the development of policies that increase production in the multi-family housing market without significant federal investment. |
| *Training and Technical Assistance ($3,000,000)*<br>• Improves technical capabilities and overall program effectiveness.<br>• Continue upgrade of weatherization provider network technical capabilities and management.<br>• Review and implement changes based on the findings of the National Weatherization Evaluation.<br>• In coordination with the Healthy Homes Initiative, expand national network of trained and certified weatherization service providers who have the skills to assess health issues along with conservation needs.<br>• Continue to cooperate with other Federal agencies involved in the Federal Healthy Homes initiative (HUD, EPA, Centers for Disease Control and Prevention, Department of Labor), and local non-profit organizations to ensure strong effective partnerships between programs and complete implementation of certifications of | *Training and Technical Assistance ($4,000,000)*<br>• Continue development of national certifications and work specifications for residential retrofit worker training, energy audits, inspections, and weatherization methods. Activities include: updating 14 training curricula for crew workers, crew leaders, auditors, and QC inspectors skills development; reviewing certification requirements for energy auditors and preparing any needed training modules; and conducting one or more workshops with training centers and community colleges to identify available resources and improvements to training platforms.<br>• Improve grantee and subgrantee performance through state plan process with adoption of WAP Quality Work Plans features including certified quality control inspectors.<br>• Continue grantee and subgrantee operations improvement through the WAP Quality | *Training and Technical Assistance (+$1,000,000)*<br>• The $1.0 million increase will accelerate deployment of retrofit standards infrastructure and support expanded grantee monitoring and oversight.<br>• Continues success in improving work training standards and training accreditation. |

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| select workforce through job task analysis. | Management Plan for training and skills development through identifying the knowledge, skills and abilities state and local staff need, reviewing existing training resources, conducting gap analysis of training needs and resources available; and developing two or more curricula designed to address specific management needs.<br>• Continue to cooperate with other Federal agencies involved in the Federal Healthy Homes Initiative (HUD, EPA, Centers for Disease Control and Prevention, Department of Labor), and local non-profit organizations to provide training to 400-500 weatherization service providers to help qualify them to assess health issues along with conservation needs.<br>• Facilitate the on-line use of a suite of residential energy auditing tools related to the WAP.<br>• Implement strategic planning and analysis; define program performance measurement; and facilitate advanced techniques and collaborative strategies through pilot programs, publications, training programs, workshops and peer exchanges. | |
| *NREL Site-Wide Facility Support ($400,000)*<br>• Directly fund NREL site-wide facility support costs that are not included in the Facilities and Infrastructure budget rather than continue to fund these costs in the laboratory overhead rate. | *NREL Site-Wide Facility Support ($400,000)*<br>• Directly fund NREL site-wide facility support costs that are not included in the Facilities and Infrastructure budget rather than continue to fund these costs in the laboratory overhead rate. | *NREL Site-Wide Facility Support*<br>• No change. |

## Weatherization and Intergovernmental Programs
## State Energy Program

**Description**

The State Energy Program (SEP) assists states in establishing and implementing clean energy (e.g., energy efficiency and renewable energy) plans, policies, and programs to reduce energy costs, increase competitiveness, enhance economic competitiveness, improve emergency planning, and improve the environment. States have purview over many of the policy and program levers that can catalyze greater investment in clean energy and help the country realize the suite of economic and environmental benefits associated with clean energy. SEP provides states with capacity building resources, technical assistance, and best practice sharing networks to facilitate the adoption of plans, policies, and programs that are appropriate based on state and regional circumstances.

In FY 2016, $70.1 million is requested for SEP. Of that total, $45 million will provide a basic level of formula-based funding that allows states, Washington, D.C., and U.S. territories to advance their energy priorities through the design and implementation of energy efficiency and renewable energy programs. These grants support the work of the state energy office network and its development and maintenance of energy plans. Examples of the types of projects supported by the program, and administered by state energy offices include: energy planning, building energy code adoption, implementation and compliance; financing mechanisms for institutional retrofit programs; loan programs; energy savings performance contracting to retrofit government buildings and facilities; comprehensive residential energy programs for homeowners; transportation programs that accelerate the use of alternative fuels; and programs that remove barriers and support supply side and distributed renewable energy.

SEP funds will also provide for an increased scope of competitive projects and technical assistance targeted to high-impact projects within state energy offices that will create more public-private partnerships initiated by states within and outside of their borders to address critical clean energy challenges. In FY 2016, $15 million in competitive awards will be made to individual state projects as well as multi-jurisdictional approaches where state energy offices partner with other states and/or local government energy or economic development agencies to develop and implement initiatives aimed at creating and/or transforming markets to enable scaled-up adoption of energy efficiency and clean energy technologies. The awards may also include funding to assist states with comprehensive energy planning that promotes energy efficiency and renewable energy as part of an all-of-the above approach that considers economic development, energy assurance, and environmental regulations. Approaches will leverage analyses and stakeholder engagements to develop plans and design the necessary regulations, policies or other actionable strategies that will drive demonstrable progress toward the state and regional clean energy goals. These awards will be focused on facilitating the efforts of participating jurisdictions to take proven models and adapt them to enable their replication across the state and/or region. Awardees will receive support to help them adopt effective new policies and use regional best practices that have been applied successfully in areas that have similar energy needs, priorities and market situations to develop and carry out clean energy measures.

Through competitive financial assistance awards, states are able to join together on sector, regional, and/or nationally focused initiatives aimed at finding solutions to barriers states face in meeting their clean energy economy goals. These competitive projects also provide opportunities for the states to submit innovative proposals addressing issues specific to their situations and to leverage other funding to create sustainable, high-impact solutions in energy efficiency and renewable energy development. The primary objective is for awardees to develop public-private partnerships to develop and deploy policies and technologies that have the best opportunity for local geographic and economic impact. DOE will use the experience and capabilities of at least 20-30 FY 2016 awardees to advance transformative best practices, benchmarking, and lead-by-example policy strategies.

SEP funds will also provide technical assistance to state energy offices and related stakeholders, in support of WIP Program activities. The technical assistance may be provided through use of other appropriate mechanisms for providing effective and efficient support to states. Technical assistance is an interdependent component to the financial assistance activities—making technology deployment more efficient and effective and enhancing the likelihood of program success. Technical assistance resources are integral to (1.) tools development, decisional information, and other technical assistance to grantees and sub-recipients; (2.) national energy initiatives and strategic partnerships focused on deployment and best practices; (3.) improvement of web-based reporting and monitoring systems; and (4.) metrics and evaluation of state

planning, analysis, and evaluation activities. Of special note is the planned completion a major SEP national evaluation in FY 2015, which will identify high-impact clean energy policies and programs for potential adoption across the SEP portfolio key metrics include energy savings, renewable energy production, carbon emissions reductions, and employment impacts. The evaluation will cover the FY 2008 and American Recovery and Reinvestment Act of 2009 (http://www.gpo.gov/fdsys/pkg/PLAW-111publ5/pdf/PLAW-111publ5.pdf) periods and will be completed in mid FY 2015 and results will be used to inform future program planning and goal-setting.

In addition to the work outlined above, SEP has made significant progress through the following initiatives and activities, which will continue in FY 2016:

- SEP leads the public sector section in EERE's Better Buildings Challenge and other cooperative initiatives. Between FY 2010 and mid-FY 2014, the program established partnerships with:
  - 90+ public-sector partners to reduce their energy intensity by 20 percent or more by 2020; and
  - 29 states to develop replicable approaches for improving public buildings, to include the use of energy savings performance contracts.
- The program utilizes partnerships with national and regional organizations that represent key decision-makers in order to improve the pace of energy efficiency and renewable energy project implementation. Partners include: the National Association of State Energy Officials, the National Governors' Association Center for Best Practices, and the National Conference of State Legislatures. Funds may be used to support efforts such as peer reviews, data collection and dissemination, technology assistance, and technology-to-market activities.

**State Energy Program**
**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **State Energy Program $50,000,000** | **$70,100,000** | **+$20,100,000** |
| • Advance deployment of energy efficiency and renewable energy policies and technologies by state governments.<br>• Award and actively manage 56 formula grants.<br>• Competitively select and manage at least 8-15 innovative state/regional projects in a variety of areas including comprehensive energy planning, public-private efforts to expand use of and development of new financing and PACE models, expand use of performance contracting in underserved sectors and with local governments, state/local partnerships to lead by example on clean energy technology upgrades, benchmarking and disclosure, streamlining permitting and interconnection for renewable and other distributed energy resources, etc.<br>• Complete the major national evaluation of the program and review findings to inform planning.<br>• Develop and deliver a portfolio of strategic technical assistance offerings to state energy offices, including "on request" assistance through regional and other real-time channels. | • Advance deployment of effective energy efficiency and renewable energy policies and technologies by state governments.<br>• Award and actively manage 56 formula grants.<br>• Competitively select and manage at least 20-30 innovative state/regional projects in a variety of areas including comprehensive energy planning, public-private efforts to expand use of and development of new financing and PACE models, expand use of performance contracting in underserved sectors and with local governments, state/local partnerships to lead by example on clean energy technology upgrades, benchmarking and disclosure, streamlining permitting and interconnection for renewable and other distributed energy resources, etc.<br>• Begin implementing changes based on the findings of the major national evaluation of the program.<br>• Develop and deliver a portfolio of strategic technical assistance offerings to state energy offices. | • Formula grants: expands state-led comprehensive clean energy planning capabilities and emerging environmental challenges.<br>• Competitive Financial Assistance: includes significant expansion of targeted efforts in energy planning, analysis, and innovative practices.<br>• Technical Assistance: expands SEP's highly effective mechanisms for accelerating energy efficiency adoption through activities and strategic partnerships with state energy offices, including the public sector Better Buildings Challenge and technical assistance through its own activities and those of national state associations and regional organizations. |

**Weatherization and Intergovernmental Programs**
**Local Energy Program**

**Description**

Through technical assistance and competitive grants this program supports local government energy program and project planning, development, and implementation. Municipal and county governments are in a unique position to reduce greenhouse gas emissions and implement clean energy solutions.

DOE will fund competitively selected projects to advance local renewable energy and energy efficiency solutions, transformative best practices, benchmarking, and lead-by-example policy strategies. Local energy efficiency policies, implemented at the scale, in a municipality, county or metropolitan area will lower energy costs, reduce greenhouse gas emissions, and support economic development goals. The objective is to serve as a catalyst for developing creative and effective solutions through projects that improve local energy code implementation; expansion of energy upgrades in commercial buildings and residential buildings, upgrades to the energy efficiency of their own public facilities and operations; development of sustainable funding and financing resources. DOE anticipates supporting 35-40 replicable, high impact, competitively selected, energy efficiency projects across the country. Funds may be used to support efforts such as peer reviews, data collection and dissemination, technology assistance, and technology-to-market activities.

Funding is also requested to provide technical assistance through partnerships with local governments to help them scale up investments in energy efficiency and renewable energy technologies at the community level. The Local Energy Program builds on the progress made by 2,200 local governments that conducted, primarily, energy efficiency projects (including revolving loan programs) during the American Recovery and Reinvestment Act of 2009. (http://www.gpo.gov/fdsys/pkg/PLAW-111publ5/pdf/PLAW-111publ5.pdf). The Program will significantly enhance the capability of local governments to overcome market barriers and create major opportunities for energy savings, low carbon energy, and jobs. This program provides a unique and highly leveraged funding program within WIP to enable it to work with and assist with local governments on their energy efficiency and clean energy challenges and opportunities.

Through this effort, DOE will provide technical support to assist many local governments with strategic energy and economic planning, policy and program design and implementation, energy data management and evaluation, and financing solutions. More specifically, DOE will work with local entities to demonstrate successful models for cost-effectively reducing energy use and will provide local entities with best practice models utilized in jurisdictions of similar size and situation and assist them in developing and implementing strategies to achieve their clean energy technology goals. Areas offering significant cost savings to governments include high performance outdoor lighting technologies (such is currently being done in cities like Detroit, Little Rock, and Kansas City), expanding government building energy efficiency retrofit activity through the use of energy savings performance contracts and other finance mechanisms (such as is currently being done in Houston, Newark, and Cincinnati), and local entities engaging in challenges with their business communities to reduce building energy use more broadly (such as is currently being done in Atlanta).

A major focus area is working closely with local entities on their public buildings. Public buildings consume about 15 percent of total commercial building energy use, and local governments have significant additional energy requirements for street/outdoor lighting and water/wastewater services. Energy costs are the second leading source of expenditures, trailing only personnel costs. Energy savings can be used to provide improved public services including education (e.g., purchase of additional textbooks or computer resources), health care, and public safety, and can stimulate local economic development.

**Local Energy Program**
**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **Local Technical Assistance Program $0** | **$20,000,000** | **+$20,000,000** |
| • No funding provided. | • Targeted policy and technical assistance to municipal and county governments and K-12 school systems.<br>• Support for high impact efforts for local governments including the ESPC Accelerator, High Efficiency Street and Outdoor Lighting Initiative, and Better Building Challenge partnerships.<br>• Support 35-40 replicable, highly effective, competitively selected, energy efficiency projects across the country. | • Competitively selected projects and related technical assistance supports critical policy and technical needs of local governments, expands partnership outreach, grows financial and policy "best practices" capabilities, and capitalizes on the significant leadership abilities of local governments to harness the full potential of energy efficiency. |

**Weatherization and Intergovernmental Programs**
**Performance Measures**

In accordance with the GPRA Modernization Act of 2010, the Department sets targets for, and tracks progress toward, achieving performance goals for each program.

| | FY 2014 | FY 2015 | FY 2016 |
|---|---|---|---|
| Performance Goal (Measure) | **Retrofits - Number of low income family homes weatherized.** | | |
| Target | 24,600 | 30,000[1] | 33,000 |
| Result | Exceeded - 38,000 | Not Applicable | Not Applicable |
| Endpoint Target | Support 300,000 home energy retrofits between FY 2013 and FY 2022. | | |

[1] Revised Target: Original target of 33,100 retrofits was based on FY 2015 request level of $209 million. The revised target of 30,000 retrofits is based on the FY 2015 appropriation level of $189.6 million.

## Program Direction

### Overview

Program Direction enables EERE to maintain and support a world-class Federal workforce to accomplish its mission to create and sustain American leadership in the sustainable transportation, renewable power, and energy efficiency sectors. The FY 2016 Program Direction Budget Request provides necessary resources for program and project management, administrative support, contract administration, human capital management, headquarters and field site non-laboratory facilities and infrastructure, and contractor support.

The FY 2016 Program Direction Budget Request supports EERE's ongoing efforts to improve operations. Examples of recent accomplishments include the following:

- EERE completed its implementation of a uniform approach to Active Project Management across its full portfolio of projects, including the creation and enforcement of rigorous "Go/No-Go" milestones, performance of regular in-depth project site visits/reviews, and termination of under-performing projects.
- EERE worked with the National Laboratories to refine and enhance the EERE-wide uniform process for planning laboratory projects and monitoring their progress over time.
- EERE partnered within the Department to consolidate support services to EERE personnel. The DOE Chief Information Officer assumed responsibility for providing EERE with commodity Information Technology (IT) services, and the DOE Chief Human Capital Officer took over Human Resources functions.

### Highlights of the FY 2016 Budget Request

The FY 2016 Program Direction Budget Request has four primary goals:

- Hire staff up to a maximum Full-Time Equivalent (FTE) level of approximately 719;
- Strengthen EERE's workforce through training and talent management programs, including effective recruitment strategies, career and leadership development, and succession planning;
- Support lean Active Project Management across EERE's full portfolio of projects, including travel to project sites and IT systems support for project and portfolio management; and
- Maximize the efficient and effective use of available resources to accomplish EERE's core mission. EERE will continue to re-engineer its operations to reduce overall operational expenses and improve the delivery of EERE services to the public.

## Program Direction
### Funding ($K)

| | FY 2014 Enacted | FY 2014 Current | FY 2015 Enacted | FY 2016 Request | FY 2016 vs FY 2015 |
|---|---|---|---|---|---|
| **Washington Headquarters** | | | | | |
| Salaries and Benefits | 71,589 | 71,589 | 73,629 | 75,894 | +2,265 |
| Travel | 2,905 | 2,905 | 3,196 | 4,890 | +1,694 |
| Support Services | 24,112 | 24,112 | 18,345 | 17,177 | -1,168 |
| Other Related Expenses | 22,191 | 22,191 | 22,716 | 23,221 | +505 |
| **Total, Washington Headquarters** | **120,797** | **120,797** | **117,886** | **121,182** | **+3,296** |
| **Golden Field Office** | | | | | |
| Salaries and Benefits | 22,876 | 22,876 | 23,634 | 24,594 | +960 |
| Travel | 154 | 154 | 170 | 187 | +17 |
| Support Services | 2,149 | 2,149 | 2,364 | 2,600 | +236 |
| Other Related Expenses | 1,591 | 1,591 | 1,751 | 1,926 | +175 |
| **Total, Golden Field Office** | **26,770** | **26,770** | **27,919** | **29,307** | **+1,388** |
| **National Energy Technology Laboratory** | | | | | |
| Salaries and Benefits | 8,332 | 8,332 | 8,484 | 8,559 | +75 |
| Travel | 161 | 161 | 177 | 195 | +18 |
| Support Services | 565 | 565 | 621 | 683 | +62 |
| Other Related Expenses | 5,375 | 5,375 | 4,913 | 5,404 | +491 |
| **Total, National Energy Technology Laboratory** | **14,433** | **14,433** | **14,195** | **14,841** | **+646** |
| **Total Program Direction** | | | | | |
| Salaries and Benefits | 102,797 | 102,797 | 105,747 | 109,047 | +3,300 |
| Travel | 3,220 | 3,220 | 3,543 | 5,272 | +1,729 |
| Support Services | 26,826 | 26,826 | 21,330 | 20,460 | -870 |
| Other Related Expenses | 29,157 | 29,157 | 29,380 | 30,551 | +1,171 |
| **Total, Program Direction** | **162,000** | **162,000** | **160,000** | **165,330** | **5,330** |
| **Total FTEs** | **679** | **679** | **697** | **719** | **22** |

## Support Services and Other Related Expenses

| | FY 2014 Enacted | FY 2014 Current | FY 2015 Enacted | FY 2016 Request | FY 2016 vs FY 2015 |
|---|---|---|---|---|---|
| **Support Services** | | | | | |
| Technical Support | 17,258 | 17,258 | 13,744 | 13,311 | -433 |
| Management Support | 9,568 | 9,568 | 7,586 | 7,149 | -437 |
| **Total, Support Services** | **26,826** | **26,826** | **21,330** | **20,460** | **-870** |
| | | | | | |
| **Other Related Expenses** | | | | | |
| Other Services | 13,311 | 13,311 | 12,996 | 13,604 | +607 |
| Working Capital Fund | 15,846 | 15,846 | 16,384 | 16,947 | +564 |
| **Total, Other Related Expenses** | **29,157** | **29,157** | **29,380** | **30,551** | **1,171** |

**Program Direction**
**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **Program Direction $160,000,000** | **$165,330,000** | **+$5,330,000** |
| **Salaries and Benefits** | | |
| • Funding enables EERE to maintain and support a world-class Federal workforce to accomplish its mission to win the clean energy race in the transportation, renewable power, and energy efficiency sectors. Provides necessary resources for program and project management, administrative support, contract administration, and human capital management. | • Funding enables EERE to maintain and support a world-class Federal workforce to accomplish its mission to win the clean energy future in the transportation, renewable power, and energy efficiency sectors. Provides necessary resources for program and project management, administrative support, contract administration, and human capital management. FTE numbers will increase as EERE recruits to reach its operational hiring goals. | • Funding increases slightly to meet additional workload demands as result of the increased total EERE funding of $1.9 billion in FY 2015 to $2.7 billion in FY 2016 as well as support the cost of pay raises, step increases, and promotions at Headquarters, Golden Field Office, and the National Energy Technology Laboratory (NETL). |
| **Travel** | | |
| • Travel funding supports intensified project management. | • EERE's FY 2016 travel budget supports management of projects across the country, providing government oversight of EERE-funded projects. | • Increase in funding to support travel need for annual project site-visits to ensure proper risk management and oversight of projects. |
| **Support Services** | | |
| • Support services will continue to provide EERE with a range of services needed to meet its mission, including IT services, specialized contractual support services and training, education, safety, health support, and safeguards and security. | • Support services funding provides technical and administrative contract support and information technology services. This funding also contributes to training, education, safety, health support, safeguards and security, computer configuration, and maintenance. | • Slight decrease in funding to support increases in travel and other related expenses. . |
| **Other Related Expenses** | | |
| • Other Related Expenses provides funds for office space and overhead at DOE Headquarters and field sites through EERE's contribution to the Department's Working Capital Fund (WCF) for common administrative services and through direct payments in the field. Expenses covered include building operations, telecommunications, network connectivity, supplies/equipment, printing/graphics, | • Other Related Expenses provides funds for office space and overhead at DOE Headquarters and field sites through EERE's contribution to the WCF for common administrative services and through direct payments in the field. Expenses covered include building operations, telecommunications, network connectivity, supplies/equipment, printing/graphics, copying, mail, contract closeout, purchase card surveillance, computer equipment (hardware, software, licenses and support), utilities, postage, administrative | • Slight growth accounts for cost increases in the WCF and other shared services. |

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| copying, mail, contract closeout, purchase card surveillance, computer equipment (hardware, software, licenses and support), utilities, postage, administrative expenses, security, and publications. | expenses, security, and publications. | |

## Strategic Programs

### Overview

Strategic Programs supports high-impact, cross-cutting, integrative activities that cannot occur within a single EERE Technology Program. This includes platform "technology-to-market" activities to catalyze more successful clean energy commercialization, entrepreneurship, technology transfer, and manufacturing competitiveness outcomes from EERE's research, development, demonstration & deployment (RDD&D) programs and sound cross-cutting strategic analysis and impact assessments to inform programmatic and management decision making. Strategic Programs also includes communications efforts to efficiently and effectively engage with EERE's stakeholders to widely disseminate clean energy information, tools, and resources made available through EERE efforts. Strategic Programs focuses on a cohesive and limited set of priority, high-impact activities that support the acceleration of successful EERE technology commercialization, including from DOE's National Laboratories and support development of international export markets for U.S. clean energy companies.

Strategic Programs is organized across four principal subprograms:

- Technology-to-Market – develops high-impact partnerships and programs with industry, academic institutions, DOE's National Laboratories, and others to develop the talent pipeline, facilitate investment, and foster the innovation infrastructure to advance the clean energy economy through accelerated technology commercialization, technology transfer, and manufacturing competitiveness broadly across the EERE portfolio.
- International – catalyzes the development of international export markets for U.S. clean energy solutions with strategically important countries through technical and policy assistance, analysis, and the promotion of U.S.-based standards, test procedures, and certifications.
- Strategic Priorities and Impact Analysis – provides a portfolio-based analytical foundation to perform impact assessments of EERE's portfolio and informs research, development, demonstration & deployment (RDD&D) strategic planning and decision making for continuous improvement of EERE's approach. The organization also leads EERE implementation of the President's Open Data Policy (EO M-13-13).
- Communications and Outreach – provides key stakeholders and the general public with the latest and most accurate information regarding advances, impacts, and issues on clean energy technology development and deployment, in addition to resources available through EERE, communicated objectively and transparently across a range of traditional and online media.

### Highlights of the FY 2016 Budget Request

- The Technology-to-Market subprogram will launch a new initiative to catalyze and accelerate investments from a range of philanthropic organizations in clean energy technology research, development, and commercialization. Under this initiative, EERE will provide technical assistance and other resources that will help philanthropic organizations understand opportunities and needs in clean energy technology development, and share best practices and other information that can guide investment. Furthermore, a new Secretarial-level Clean Energy Jobs Initiative will be launched and partially funded through EERE Strategic Programs (the balance coming from Program Direction funding) to provide analysis, technical support, and targeted activities that will help improve U.S. renewable energy and energy efficiency jobs data tracking, significantly enhance EERE's efforts on energy workforce development, and increase clean energy manufacturing related economic development and competitiveness These activities will be coordinated through a DOE Jobs Strategy Council that will be chaired by the Secretary and consist of members from 20 offices within the Department of Energy. The Council will also work directly on interagency partnerships with the Department's National Laboratories, U.S. Departments of Labor, Education, Defense, Commerce, Agriculture, and Veterans Affairs.
- The Strategic Priorities and Impact Analysis (SPIA) subprogram will launch a new initiative to partner with select cities to explore the long-range potential that deployment of clean energy technologies can provide. These assessments will include consideration of evaluation of the opportunities related to various sustainable transportation, efficiency, and renewable power technologies; the identification and assessment of city-level policies and practices that can promote their cost-effective; adoption and evaluation of the potential carbon mitigation and economic benefits that can be realized by deploying these technologies and practices in various ways. Funding from the 2016 Budget will also be used to conduct an assessment of EERE program office methodologies and assumptions for prospective impact analyses. Funding will also support program impact evaluations using EERE's peer-reviewed methodology.
- The International subprogram will continue its support of bilateral clean energy research and development with Israel. It will also increase the number and scope of key partnerships. For example, the subprogram will develop a boiler

system training and certification program with China, since 80% of Chinese boilers are coal-fired, and on average, these systems are 20-30% less efficient than advanced equivalents in the U.S. The project aims to train facility engineers to identify inefficient equipment and processes, and to offer U.S. technology and service solutions to meet China's goals for efficiency and emissions reduction.

- In 2016, the Solar Decathlon will be transferred from the Building Technologies Program to Strategic Programs (under the Technology-to-Market subprogram) to be better coordinated with Strategic Programs' workforce development and communications resources, and to reflect that the Solar Decathlon has grown beyond buildings initiative. It is a high profile award winning DOE initiative that creates partnerships with competitively selected university-based student teams to design, build, and operate residential homes houses that incorporate solar and other advanced clean energy technologies, including vehicles, in an affordable and attractive manner.

**Strategic Programs**
**Funding ($K)**

| | FY 2014 Enacted | FY 2014 Current | FY 2015 Enacted | FY 2016 Request | FY 2016 vs FY 2015 |
|---|---|---|---|---|---|
| **Strategic Programs** | | | | | |
| Technology-to-Market | 6,590 | 6,590 | 6,263 | 11,070 | +4,807 |
| Strategic Priorities and Impact Analysis | 6,400 | 6,400 | 6,506 | 6,000 | -506 |
| International | 4,550 | 4,550 | 3,682 | 6,000 | +2,318 |
| Communications and Outreach | 6,000 | 6,000 | 4,549 | 4,800 | +251 |
| **Total, Strategic Programs** | **23,540** | **23,540** | **21,000** | **27,870** | **+6,870** |

| | FY 2016 vs FY 2015 |
|---|---|
| **Technology-to-Market**: The increased funding request largely reflects the transfer of support for the Solar Decathlon student competition from the Building Technologies Program (BTP) to Strategic Programs to be better coordinated across EERE programs. Strategic Programs' management of the Solar Decathlon will include the exploration of alternative business models to ensure that this initiative continues to deliver and even improve upon its historical can be workforce development and technology deployment impacts while minimizing EERE's investment. The increase also supports the launch of a new initiative to support and accelerate investment from a range of philanthropic organizations to into clean energy technology research, development, and commercialization. Under this initiative, EERE will provide technical assistance and other informational resources that will help philanthropies understand opportunities and needs in clean energy technology development, share best practices and other information that can guide their investments, and allow the philanthropic sector to significantly increase both the amount and impact of their investments into clean energy innovation. Under a new Clean Energy Jobs Initiative, EERE will develop classifications, career pathways and analytical tools for jobs related to clean energy technologies and conduct outreach and education events that can help accelerate education, workforce development, and hiring actions. These activities will be conducted with a broad array of stakeholders but strongly targeted for specific city, state, and regional impact to get maximum return in high potential or high need areas. A DOE Jobs Strategy Council chaired by the Secretary and consisting of members from 20 offices within the Department of Energy will provide intra-department coordination and oversight. The Council will also work directly on interagency partnerships with the Department's National Laboratories, U.S. Departments of Labor, Education, Defense, Commerce, Agriculture, and Veterans Affairs. | **+4,807** |
| **Strategic Priorities and Impact Analysis (SPIA):** The FY 2016 request reflects a partial shift in responsibility for analytical work from Strategic Programs to the EERE Technology Programs and the Office of Energy Policy and Systems Analysis (EPSA). At this funding level, SPIA will focus on core cross-cutting services including a new initiative to partner with select cities to explore the long-range potential that deployment of clean energy technologies can provide. These assessments will include consideration of the various sustainable transportation, efficiency, and renewable power technologies, potential of city-level policies that can promote their cost-effective adoption and the potential carbon mitigation and economic benefits that might be realized. In FY 2016 SPIA will conduct an assessment of EERE program office methodologies and assumptions for prospective impact analyses and project data collection, identify best practices, and establish a standard approach across EERE to ensure consistent and comparable information is available to inform policy decisions. Funding will also be used to significantly increase program impact evaluations using EERE's peer-reviewed methodology. Responsibility for crosscutting analysis activities related to grid integration analysis and clean energy manufacturing analysis will be reduced and partially transition to the EERE Technology Programs. | **-506** |

| | FY 2016 vs FY 2015 |
|---|---|
| **International:** The FY 2016Budget will continue support of bilateral clean energy research and development with Israel. The subprogram will support activities with up to 12 core partner countries, an increase from approximately 7 countries in FY 2015, to accelerate development of markets for U.S. clean energy product manufacturers with the additional benefits of increasing U.S. energy security and reducing global greenhouse gas emissions. Representative activities include: developing a boiler system training, certification, and retrofit program with China to upgrade with U.S. equipment some of China's 600,000 industrial boilers, facilitating policy development in Mexico that would promote expansion of combined heat & power (CHP) systems, which could have significant U.S.-manufactured content; assessing the performance small island grids in Indonesia that have added capacity using renewables based on EERE tech assistance, with the aim of replicating across hundreds of Indonesian microgrids. | **+2,318** |
| **Communications and Outreach:** Under the FY 2016 Request, Communications and Outreach support for EERE's clean energy manufacturing and lab impact initiatives will be increased to ensure that EERE is effectively engaging with industry and other key stakeholders on successes and opportunities to increase U.S. technical and manufacturing competitiveness. Communications and Outreach will also provide support for public inquiries function, with DOE's Executive Secretariat handling all generic inquiries, and most other inquiries being handled directly by programs. | **+251** |
| **Total, Strategic Programs** | **+6,870** |

**Description**

The Technology-to-Market subprogram's mission is to accelerate the commercialization and market adoption of EERE technologies to overcome key barriers to the development and success of commercial enterprises built around EERE technologies and initiatives. In support of this mission, the subprogram works to facilitate investment in clean energy by providing industry innovators and entrepreneurs with insight and access to resources such as national laboratories to increase financing for and implementation of clean energy technologies; foster the innovation infrastructure by delivering reliable tools, resources, knowledge, and expertise to help state and local government, utilities, national laboratories, start-ups, and small- and medium-sized enterprises success in the clean energy economy; and support the talent pipeline by offering credible energy curriculum for schools, student competitions, and career planning tools to cultivate the next generation of clean energy professionals. The subprogram's efforts are targeted , high-impact, cross-cutting enabling programs to overcome key barriers to the successful commercialization of EERE technologies that are not fully and sufficiently addressed by the focused RDD&D activities within EERE's individual Technology Programs. Through strategic and targeted activities, the Technology-to-Market subprogram bridges EERE-funded research & development (R&D) to the private sector, catalyzes increased U.S. clean energy entrepreneurship and investment, partners with strategic regional U.S. partners to facilitate coordinated regional first-market-adoption of cutting-edge EERE technologies through integrated deployment activities, provides platform resources to support the development of a well-trained American workforce for rapidly growing clean energy industries, and supports cross-cutting activities to assess and increase U.S. clean energy manufacturing competitiveness.

The Technology-to-Market subprogram supports technology commercialization activities focusing on innovative approaches and partnerships to attract top technologists, entrepreneurs, and investors to EERE technologies and to bridge gaps in the U.S. clean energy ecosystem, especially in the areas of entrepreneurship, technology transfer, and early-stage finance. Ongoing fully front funded Technology-to-Market activities include the National Incubator Initiative for Clean Energy (NIICE) (a program designed to create a national network of high-impact clean energy technology business incubators), the Cleantech University Prize (a university focused clean energy entrepreneurship competition), Lab-Corps (a program focused on creating a culture of early-stage clean energy commercialization within DOE's National Labs, modeled after the National Science Foundation's I-Corps effort), oversight of EERE Technology Program investments into technology-to-market activities in the national laboratories, beyond the Lab-Corps program. In addition, the Technology-to-Market subprogram coordinates EERE's Small Business Innovation Research (SBIR) investments across all of EERE's Technology Programs and oversees the implementation of the Climate Action Champions Initiative.

The Technology-to-Market subprogram will launch a new initiative to catalyze and accelerate investments from a range of philanthropic organizations in clean energy technology research, development, and commercialization. Under this initiative, EERE will provide technical assistance and other resources that will help philanthropic organizations understand opportunities and needs in clean energy technology development, and share best practices and other information that can guide investment. The initiative will be executed through an alliance between the Department of Energy, philanthropic leaders, and mission-driven investors and will scale-up catalytic investment in the clean energy innovation pipeline, from laboratory R&D to startup funding and project finance. An independent entity, the alliance is envisioned as an expert intermediary/translator between philanthropic investors and the clean energy technology sector. Through the provision of legal, financial, and technical expertise—supported by EERE—the alliance will reduce transaction costs, spread promising investment models, and allow both grant-makers and fund managers to magnify their environmental and social impact.

The Technology-to Market subprogram will also support "energy transition" activities to take a comprehensive approach to catalyzing first–market adoption of cutting edge clean energy technologies and solutions in high-cost and/or locally motivated markets to accelerate cost reduction through market scaling. This effort will focus on working directly with a limited number of communities with high energy costs to adopt numerous EERE technologies in an integrated fashion, depending on each community's unique needs and circumstances. Previous activities funded by this effort were primarily focused on technical assistance to specific communities who were looking to EERE technologies to achieve specific local goals, such as cost reductions and fuel diversity. In FY 2016 and going forward, energy transition efforts will be designed specifically for higher scalability of impact by focusing on creating replicable models that can be adopted by a wide array and large number of communities and regions. An example of this has been the development of an Island Energy Transition Playbook, which was developed in FY 2015 for island economies based on EERE's experience in Hawaii and the U.S. Virgin

Islands, as well as other specific engagements. The playbook provides an action-oriented guide to successfully initiating, planning, and completing a transition to an energy system that primarily relies on local resources to eliminate dependence on or two imported fuels. Under a new Secretary-level Clean Energy Jobs initiative, EERE will develop a clear definition of energy jobs, identify gaps in renewable energy and energy efficiency jobs data collection, and provide annual reporting to the Department and general public in energy jobs growth. Two competitive pilot projects will be modeled with successful states to demonstrate the benefit of anchoring local economic development programs in energy deployment strategies. EERE will also conduct outreach activities to ensure that the full array of DOE's technical and financial assistance resources are made available to specific areas or regions, working in concert with economic development officials. Efforts will be focused on developing pipelines to employment for select audiences—veterans, minorities, and women—to energy sectors by providing DOE technical expertise to our interagency partners at the Departments of Labor, Education, Veterans Affairs, and Defense in a select group of place-based initiatives.

Finally, beginning in 2016, the Technology-to-Market subprogram budget will include the Solar Decathlon, a design and build competition that challenges collegiate teams to build and operate cost effective, energy efficient, attractive solar-powered homes. Support for Solar Decathlon is transferred from the Building Technologies Program (BTP) to better coordinate with EERE's other workforce education and technology deployment activities. Strategic Programs will continue to operate the Solar Decathlon as a standalone program as it was within BTP. Strategic Programs will begin exploring alternative competition models to ensure that this initiative is sustainable as a workforce development and technology deployment activity while also seeking to minimize EERE's investment. Potential business models may include licensing and/or partnering with external organizations to expand the Solar Decathlon toward commercially specific building designs and technologies.

## Technology-to-Market
## Activities and Explanation of Changes

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **Technology-to-Market $6,263,000** | **$11,070,000** | **+$4,807,000** |
| ***Technology-to-Market ($6,263,000)***<br>• Launch Phase II of the National Clean Energy Business Plan Competition as the Cleantech University Prize (3 years, fully front funded).<br>• Provide ongoing support for focused effort on National Laboratory technology transfer and commercialization activities.<br>• Provide initial support to seed a clean energy philanthropy investment alliance.<br>• Scale the Island Energy Transition Initiative from one anchor location in the Caribbean to others within the broader region.<br>• Finalize transfer of National Training and Education Resource (NTER) system stewardship to an external entity.<br>• Outreach on Energy Literacy and Energy 101 clean energy education frameworks. | ***Technology-to-Market ($8,570,000)***<br>• Launch a new program to accelerate investment from a range of philanthropic organizations to clean technology development and commercialization.<br>• Launch a new Clean Energy Jobs Initiative to develop classifications, career pathways and analytical tools for jobs related to clean energy technologies and conduct outreach and education events that help accelerate education, workforce development, and hiring in the clean energy sector.<br>• Scale the Lab-Corps program from the FY 2014-FY 2015 pilot effort to a full program across all National Laboratories. Expand other lab impact and commercialization activities for continued acceleration of moving EERE technologies into the market.<br>• Continue implementation and management of existing programs including NIICE and the National Student Entrepreneurship Prize (NSEP).<br>• Provide ongoing support to the Energy Transition Initiative for islands and expand to other sectors, specifically local governments.<br>• Develop a customizable, online, multi-disciplinary energy mini-course for the public.<br>• Continue minimal support of NTER as is necessary to complete transition to external entity. | ***Technology-to-Market (+$2,307,000)***<br>• Reflects launch of new clean energy philanthropy alliance and jobs initiative as well as expansion of Lab-Corps and other lab impact and commercialization activities. |

| | | |
|---|---|---|
| ***Solar Decathlon ($0)***<br>Supported by the Buildings Technology Program. | ***Solar Decathlon ($2,500,000)***<br>• Supports the EERE Solar Decathlon, an award-winning program that challenges college teams to design, build, and operate cost-effective, energy-efficient, and attractive solar-powered houses.<br>• Strategic Programs' management of the Solar Decathlon will include the exploration of alternative business models to ensure that this initiative is sustainable as a workforce development and technology deployment activity. | ***Solar Decathlon (+$2,500,000)***<br>• Reflects the transfer of the Solar Decathlon from the Buildings Technology Program to Strategic Programs to be better coordinated with Strategic Programs' workforce development and communications resources. |

## Strategic Programs
## Strategic Priorities and Impact Analysis

**Description**

The Strategic Priorities and Impact Analysis (SPIA) subprogram's mission is to provide a portfolio-based analytical foundation to perform impact assessment of EERE's portfolio and inform strategic planning and decision making for continuous improvement of EERE's approach.

The activities of the SPIA subprogram provide a number of core services that allow EERE leadership to ensure high quality and consistency in analysis products. SPIA leads EERE in implementing structures, methodologies, and approaches for retrospective and prospective impact evaluation studies and return-on-investment calculations; provides support to meeting government Open Data standards and initiatives; and provides coordination and analytical resources for responding to quick turnaround requests from internal and external clients. The SPIA subprogram's analyses therefore assist decision makers in EERE and throughout the Department to select portfolios and pathways that will most effectively and productively advance DOE's economic, environmental, energy security, and management excellence goals.

The SPIA subprogram investments reflect goals that include:

- Providing internal and, when appropriate, external corporate and strategic expertise, resources, and integrated information to EERE Technology Programs, in support of EERE's analysis, strategic planning, and road-mapping efforts, particularly those with a cross-cutting nature.
- Quantification of EERE impacts, both retrospective and prospective, to support EERE management in evaluating different technology research and programmatic portfolios.

In 2016, SPIA subprogram funding will go toward expansion of activities begun within the National Laboratories in 2015 to explore long-term clean energy pathways for cities. Cities represent a prime opportunity to realize the full benefit of new technologies and policies as evidenced by ongoing efforts in Austin, Denver, Chicago, New York, Boston, Knoxville, and Los Angeles, among others. Under this program, EERE will partner and fund competitively selected cities and provide analysis tools and studies that can explore scenarios that employ a range of clean transportation, generation, and efficiency technologies and adoption and incentive policies with their associated benefits in greenhouse gas reduction and economic development. This information can then be used to develop specific achievable and target goals for cities to implement over a time horizon spanning 10 years or more. EERE efforts will focus initially on data collection to ensure that models and analysis are fully informed. This initiative will be supported by funds from the Technology-to-Market subprogram.
Funding under the SPIA subprogram will also go toward direct support of impact evaluation studies for EERE technical programs. These studies will follow EERE's peer reviewed methodology, which follow similar methodologies employed by NASA and the Department of Commerce. Impact assessments can be used to determine overall return on investment (ROI) in terms of economic activity or acceleration of development timelines that results from government funded activities and therefore help long-term management of EERE's technical activities.

Also in FY 2016, the subprogram will conduct an assessment of EERE program office methodologies and assumptions for prospective impact analyses and project data collection, identify best practices, and establish a standard approach across EERE to ensure consistent and comparable information is available to inform policy decisions.

**Strategic Priorities and Impact Analysis**
**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **Strategic Priorities and Impact Analysis $6,506,000** | **$6,000,000** | **-$506,000** |
| • Fund $2 million for a joint industrial scale integrated energy systems research and development effort with the Office of Nuclear Energy.<br>• Provide oversight and advisement on program sponsored retrospective impact and ROI evaluation studies that quantify EERE impact and guide future EERE program implementation. Develop and support implementation of a common set of metrics that be used to track program effectiveness.<br>• Initiate planning and tool development for city focused clean energy technology deployment program. Develop data base structures and related requirements.<br>• Provide analytical support to assess impact of potential climate related policies for internal DOE stakeholders.<br>• Provide support for grid integration efforts, focusing on scenarios that can achieve maximum grid flexibility with high penetration of renewable technologies. Examine technical and economic valuation of EERE technologies in the electric grid of the future to determine the full costs and benefits of EERE technologies as they increasingly penetrate the distribution system and the grid.<br>• Support clean energy databases that contain real-world market data, modeled cost and performance data, and reviews of published studies as well as an inventory of state policies and incentives that impact the deployment of EERE technologies.<br>• Provide support to EERE's implementation of the | • Complete at least four new retrospective impact and ROI evaluation studies that quantify EERE impact and guide future EERE program implementation.<br>• Launch new funding opportunity announcement (FOA) to partner with competitively selected cities to acquire data and perform analysis toward long-term clean energy roadmaps.<br>• Continue to support and maintain the DOE Data Catalog on OpenEI.org developed in FY 2015 by EERE to ensure DOE datasets housed across various platforms are properly federated with Data.gov and OSTI in accordance with Project Open Data and open data priorities.<br>• Provide analytical support to assess impact of potential climate related policies to internal DOE stakeholders.<br>• Provide support for grid integration efforts, focusing on scenarios that can achieve maximum grid flexibility with high penetration of renewable technologies.<br>• Support clean energy databases that contain real-world market data, modeled cost and performance data, and reviews of published studies as well as an inventory of state policies and incentives that impact the deployment of EERE technologies.<br>• Complete an assessment of EERE program office methodologies and assumptions for prospective impact analyses methods and assumptions for impact analyses and project data collection, identify best practices, and establish a standard approach across EERE to ensure consistent and | • Increased funding for direct support of program impact studies as well as FOA for clean energy cities initiative.<br>• Decrease reflects shifts in responsibilities to programs for market forecasting and analysis of EERE market deployment barriers and cross-cutting initiatives including grid integration and clean energy manufacturing analysis enables these savings.<br>• Decrease reflects shifting of Data Catalog development toward maintenance as well as associated reduction in Open Data Initiative support efforts. |

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| President's Open Data Initiative. | comparable information is available to inform policy decisions. | |

**Description**

The International subprogram's mission is to increase the speed and scale of clean energy deployment and facilitate market access for American companies through international collaboration with strategic partners. The subprogram funds only U.S.-based technical experts to lead engagement in targeted opportunity spaces. Project activities lead to increased exports of U.S. clean energy technology and services, improved energy security, and reduced global greenhouse gas emissions, supporting both the President's Climate Action Plan and National Export Initiative. The International subprogram also facilitates R&D partnerships with strategic partners in developed economies, as identified by EERE Technology Programs, to leverage the funding and expertise of foreign governments and researchers to achieve EERE's domestic program goals.

The International subprogram prioritizes partner countries and topic areas informed by Administration priority as well as internal analysis on potential for impact. The subprogram also considers policy and market insights from U.S. and international public- and private-sector partners, including the Department of Commerce's Renewable Energy Top Markets Report. The International subprogram measure project impacts in terms of U.S. export promotion, clean energy deployed, and favorable renewable energy or energy efficiency policy changes facilitated (such as adoption of U.S. industry-preferred standards or rating systems for technologies from solar Photovoltaics (PV) to windows; successful development and implementation of more stringent building codes, etc.).

The International subprogram's market priming activities focus on rapidly growing countries such as China, India, and Brazil that are constructing power plants, commercial buildings, industrial facilities, and housing at an unprecedented rate. Priming markets and building capacity in these countries through technical assistance on policy options—developing codes and standards, as well as evaluating and addressing technology product reliability from different sources—will help this development occur with the cleanest energy profile possible. These activities also generate market pull for energy efficiency and renewable energy technologies, which can be met with U.S. clean energy exports. The activities include technical collaborations that focus on establishing business cases for adopting codes, standards, and advanced EERE technologies in a manner that is within DOE's mission space and expertise. Other markets, including South Africa and the Middle East may also represent first-adopters for emerging energy technologies. EERE International also supports targeted demonstration opportunities in specific markets that can prove the performance of emerging U.S. products and services to support early commercial success. These activities also help U.S. companies inform their product offerings to compete in global markets. The subprogram's market-priming activities have led to U.S. companies subsequently tapping the trade promotion tools (e.g., low-cost financing, feasibility study support, etc.) of other Federal agencies to promote exports.

This International subprogram will support the development of partnerships with key countries can advance the deployment of clean energy technologies, increase regional and global energy security, and achieve substantial, measurable reduction of greenhouse gas emissions. Global deployment activities that are planned to continue in FY 2016 include informing policy and technology solutions that can help improve energy efficiency and increase deployment of renewable energy in the Middle East to reduce growing demand for oil and natural gas in those domestic markets, and maintain supplies to global markets, and conducting electricity system modeling with China that can inform China's setting of increased targets for domestic deployment of renewables.

Finally, the International subprogram will support the U.S.-Israel Energy Cooperative Program is an annual competitive solicitation that makes awards to applicants consisting of U.S. and Israeli partners with complementary clean energy technologies or expertise. Since 2009, the program has issued awards for R&D in bioenergy, solar, wind, energy management and controls, fuel cells, and energy storage systems.

## International
## Activities and Explanation of Changes

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **International $3,682,000** | **$6,000,000** | **+$2,318,000** |
| • Provides U.S. contribution to support the U.S.-Israel Energy Cooperative Agreement.<br>• Focus on core partner countries (China, India, Brazil, Indonesia, and Mexico) and 1 multilateral organization (International Partnership for Energy Efficiency and Conservation (IPEEC)) that have the highest potential to grow the U.S. market for clean energy technology and services exports and to promote the deployment of clean energy technologies globally. | • Provides U.S. contribution to support the U.S.-Israel Energy Cooperative Agreement.<br>• Support market-priming and clean energy deployment activities with up to 12 core partner countries. Specific activities will depend on Administration priorities, partner country interest and cost share, results of existing efforts, new opportunity analysis, and other factors. Sample activities include: expand testing of PV reliability (U.S.-made panels) in Indian climates; develop an industrial energy efficiency audit program and database of retrofit opportunities with Brazil; train experts in South Africa on simulation and testing of energy efficient building envelope components; facilitate project finance for up to 3 demonstration sites for renewables deployment in remote Indonesian grids, and develop a replication strategy; conduct technical review of proposed energy efficiency legislation in Chile and develop new programs to promote energy efficiency by large energy consumers. | • Fully support base program activities that have previously been funded through prior year appropriations balances.<br>• Increase market-priming and clean energy deployment activities with up to 12 partner countries, up from 5-7 core partner countries in FY 2015. |

## Strategic Programs
## Communications and Outreach

**Description**

The Communications and Outreach subprogram's mission is to provide strategic communications leadership, coordination, and operational support for EERE and for the Department through organizing, editing, and disseminating information to media and the public on EERE programs, activities, and technologies, as well as their associated impacts. This information helps raise awareness and overcome informational barriers to understanding these technologies, makes stakeholders aware of resources and opportunities that may be available to them through EERE, and helps encourage the accelerated adoption of EERE technologies and practices.

The Communication and Outreach subprogram's activities ensure that EERE information is available to the general public, news media, and stakeholders in close coordination and consultation with EERE's programs. The Communication and Outreach subprogram's externally-facing tools and communications include Web content and services; traditional, social, and multi-media; informational materials and publications; and letters in response to public inquiries. Through these channels, the Communication and Outreach subprogram communicates with a range of EERE stakeholders, the media, and the public.

The Communications and Outreach subprogram handles all processing of requests for information from the media, stakeholders, and the public. In support of EERE programs, departmental offices, and other entities, Communications and Outreach activities result in the development, processing, editing, approval, and distribution of more than 400 different communications items each month.

The Communication and Outreach subprogram activities in 2016 will include:

- Providing objective, up-to-date, and relevant informational materials to EERE's many audiences to improve understanding of what EERE does and why it is important, helping increase awareness, and decrease non-technical barriers to accelerating the Nation's transition to a cleaner energy economy.
- Supporting EERE's programs in communicating information online, to the media, and to stakeholders, with a continued focus on educating stakeholders about EERE's activities, resources, and accomplishments; metrics include increasing traffic to key website and social media assets by at least 20 percent in comparison to FY 2014.
- Supporting EERE's senior leaders through developing and presenting information for frequent engagements with internal and external stakeholders as well as the public.
- Meeting White House and Departmental requirements for online and open data policies. This includes implementing a digital strategy that reduces EERE's print footprint, while making its publications more widely available online.

**Communications and Outreach**
**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **Communications and Outreach $4,549,000** | **$4,800,000** | **+$251,000** |
| • Maintain core digital/online presence.<br>• Better enable technology programs and initiatives to conduct high-value communications activities.<br>• Maintain high-priority media presence/activities.<br>• Maintain executive communications function with emphasis on digital-only dissemination of materials.<br>• Maintain internal communications, stakeholder engagement, and legislative affairs support functions. | • Maintains content for EERE web and social media presence.<br>• Provides modest support for analysis of communications data.<br>• Complete transition of subsites and content to the Energy.gov platform and maintain support for ongoing content management.<br>• Maintain public inquiries and distribution function as digital publications strategy is executed.<br>• Maintain support for legislative affairs and stakeholder engagement.<br>• Expands support for high-priority crosscutting activities, including the Clean Energy Manufacturing and National Lab impact initiatives.<br>• Continues support to EERE senior leaders in developing presentation materials and messages for frequent speaking engagements. | • Increase reflects expanded support for EERE's clean energy manufacturing and lab impact initiatives. |

## Facilities and Infrastructure

**Overview**

The National Renewable Energy Laboratory (NREL) is the Nation's only National Laboratory with a primary mission dedicated to the research, development, and demonstration (RD&D) of energy efficiency, renewable energy, and related technologies. The Office of Energy Efficiency and Renewable Energy (EERE) is NREL's steward, primary client, and sponsor of NREL's designation as a federally funded research and development center. The Facilities and Infrastructure (F&I) budget maintains NREL's research and support infrastructure, ensures availability for EERE's use, and provides a safe and secure workplace for employees and the public.

The Energy Systems Integration Facility (ESIF), entering into the third year of operation as a grid integration research and user facility, receives core support from the Facility Management subprogram activities. ESIF research and development (R&D) capabilities are nearing full capacity, and the FY 2016 Budget includes an additional $6 million relative to FY 2015 to fund the expansion of ESIF equipment, NREL staff, and training to continue safe and effective operations.

EERE is committed to maintaining and fully utilizing NREL's capabilities as the Nation's premier energy efficiency and renewable energy research laboratory. EERE invests in NREL's energy technology research, property, people, and support infrastructure to create and maintain the physical and operational assets required to achieve NREL's assigned mission in a safe, secure, and efficient manner.

The F&I Program Strategy is to:

- Provide the laboratory with a safe and secure work environment and protect EERE partners and the public;
- Maintain EERE's science and support infrastructure investments through regular annual reinvestments reflecting age, condition, risk, and DOE and industry standards;
- Renovate research and support infrastructure on a regular schedule to ensure the availability of a world-class RD&D environment and support ongoing EERE mission activities;
- Acquire new mission-critical capabilities, when warranted, to ensure EERE's ability to execute its mission;
- Providing direct operating funding for all appropriate activities, consistent with Generally Accepted Accounting Principles, for both F&I and site-wide investments; and
- Develop energy systems integration as a new aspect of energy R&D for the Nation through experiments and development of capabilities at ESIF and at remote locations through high-performance computer models and hardware-in-the-loop modeling and testing.

**Highlights and Major Changes in the FY 2016 Budget Request**

Completing the three-year start-up of ESIF, the FY 2016 Budget includes an additional $6 million, relative to the FY 2015 Enacted funding level of $30 million to support the expansion of equipment and NREL staff to further the research capability of ESIF. The increase will support investments in high performance computing (HPC), allowing for a near doubling of NREL's current HPC capacity to about 2.2 petaflops. Currently, the computational science center at ESIF is oversubscribed and demand for computer time is increasing as new users are requesting to work at ESIF. The Budget also includes additional funding to provide 1 megawatt of additional PV simulation and expand the Research Electrical Distribution Bus (REDB) to enable conducting more than one experiment at a time on the electrical grid simulation system.

In FY 2016, the Facility and Infrastructure budget supports two Departmental Crosscuts: Grid Modernization and Cybersecurity.

Continued funding of ESIF supports the Grid Modernization crosscut. ESIF's primary role is to explore and enhance the integration of energy supplies from fossil, renewable, and electric systems with consumer's demands. Opened in September 2013, ESIF is a state-of-the-art facility designed for testing, simulation, data analysis, engineering, and evaluation techniques for addressing grid integration challenges using real hardware and software in a controlled environment. ESIF provides a set of shared grid integration R&D capabilities and facilities for utilities, advanced clean energy technology manufacturers, and system integrators. The capabilities available at ESIF allow scientists and engineers from both the private and public sectors, to conduct critical research, development, testing, and validation activities that directly benefit and inform equipment providers, utilities, policymakers, and others with an interest in integrating renewable energy and advanced efficiency technologies into the Nation's electricity grid.

FY 2016 investments in the DOE Cybersecurity crosscut include funding for the existing and expanding capabilities of the Peregrine High Performance Computer (HPC). This equipment enables work with the DOE labs and Joint Cybersecurity Coordination Center to test systems and explore challenges to HPC operations in various settings. This work will help to predict future risks and examine technologies targeted to solve fundamental problems in coordination with the Cyber Sciences Laboratory. In addition, funding is included for NREL staff to support network services to ensure protection from external or internal breaches or other potential malicious activity.

**FY 2016 Crosscuts ($K)**

| | Grid Modernization | Cybersecurity | Total |
|---|---|---|---|
| **Facilities and Infrastructure** | **36,000** | **2,200** | **38,200** |

**Facilities and Infrastructure**
**Funding ($K)**

| | FY 2014 Enacted | FY 2014 Current | FY 2015 Enacted | FY 2016 Request | FY 2016 vs FY 2015 |
|---|---|---|---|---|---|
| **Facilities and Infrastructure** | | | | | |
| Operations and Maintenance | 25,973 | 25,973 | 26,000 | 26,000 | 0 |
| Facility Management | 20,000 | 20,000 | 30,000 | 36,000 | +6,000 |
| **Total, Facilities and Infrastructure** | **45,973** | **45,973** | **56,000** | **62,000** | **+6,000** |

**Facilities and Infrastructure**
**Explanation of Major Changes ($K)**

| | FY 2016 vs FY 2015 |
|---|---|
| **Facilities and Infrastructure** | |
| **Facility Management:** The additional $6 million relative to the FY 2015 enacted funding level will increase ESIF's high performance computing capability, photovoltaic simulation hardware capabilities, facility staffing, and expand the Research Electrical Distribution Bus. | **+6,000** |
| **Total, Facilities and Infrastructure** | **+6,000** |

## Facilities and Infrastructure
## Operations and Maintenance

**Description**

The Operations and Maintenance subprogram provides the program planning and implementation required by DOE Order 430.1B, Real Property and Asset Management to maintain the real property assets at NREL. The subprogram includes General Plant Projects (GPP), General Plant Equipment (GPE), Maintenance & Repair (M&R), and Safeguards & Security (S&S).

GPP investments maintain and enhance the real property portfolio, renovate general science capabilities and buildings, and upgrade laboratories for technical advancements. Examples of GPP are laboratory refurbishments, laboratory reconfigurations, utility enhancements, facility additions, and projects to accommodate new research capabilities.

GPE investments acquire shared science and support equipment to keep pace with new technological advances and research requirements. Examples of GPE are equipment to meet new technology for current research mission needs, replacement of outdated technology, and to provide for emergent research opportunities.

In addition, M&R funding provides recurring maintenance and repair of real property and equipment to include prevention, prediction, and repair of failed items. S&S funding provides a secure work environment and protects cyber networks and property.

**Operations and Maintenance**
**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **Operations and Maintenance $26,000** | **$26,000** | **$0** |
| • Provides funding for GPP, GPE, M&R, Construction Line Item projects, and S&S at NREL. EERE's investments ensure that the science and support infrastructure at NREL is maintained in good condition and readily available for use by EERE and other users. Maintains an Asset Utilization Index of 0.97 (Excellent) for all NREL facilities. | • Provides funding for GPP and GPE at NREL. EERE's investments ensure that the science and support infrastructure at NREL is maintained in good condition and readily available for use by EERE and other users. Maintains an Asset Utilization Index of 0.97 (Excellent) for all NREL facilities.<br>• Provides funding for M&R and S&S at NREL for operational readiness and a secure environment. | • Continuation of ongoing efforts; such as maintaining facility readiness to meet the EERE research mission. Capital investments provide and maintain a world-class research environment for renewable energy and energy efficiency activities. There are no significant changes from the planned activities in FY 2015. |

**Facilities and Infrastructure**
**Facility Management**

**Description**

The Facility Management subprogram provides funding for core operations at ESIF ensuring the availability of this important user-facility to EERE and EERE's other DOE, Federal agency, university, and private sector partners. ESIF is a unique national asset with a demonstrated record of providing the public and private sectors with the ability to conduct critical R&D on multiple technologies and energy sources in integrated energy systems.

ESIF provides utilities and other stakeholders a grid-isolated RD&D facility to explore and reduce the risk of these integration barriers without jeopardizing current grid operations or reliability. ESIF also combines HPC and system component experimentation and testing capabilities to identify and resolve the technical and operational risks of large-scale integration of renewable energy and energy efficiency technologies in today's energy environment. ESIF provides the technical capabilities needed to help advance the Nation's energy system into a cleaner, more intelligent and modernized infrastructure.

The technological challenges addressed by ESIF span the entire energy system—from generation to transmission, distribution, and end-use applications. ESIF has a broad range of capabilities to help address technical and integration challenges facing a variety of systems, including: advanced electrical systems (storage, power electronics, etc.), buildings systems and controls, industrial systems and controls, community power generation and microgrids, utility generation, thermal and hydrogen systems, energy efficient and advanced grid technologies, distributed control architectures, device and system interoperability, demand response, data and control integration, and grids that incorporate distributed, and/or variable renewable energy (solar, wind, water, fuel cells, etc.) and advanced vehicles.

Commissioned in September 2013, the 182,500 square feet facility contains 15 state-of-the-art laboratories and several outdoor test areas. These facilities will be used by approximately 200 NREL researchers and support staff and will provide office space for 45 external users in FY 2016 as well as access to its unique experimental and testing capabilities. FY 2016 will be the third and final year of the startup of the facility. Starting in 2013, after major equipment installation and validation, ESIF was commissioned and open for business for manufacturers, utilities, large energy customers, and other energy stakeholders in industry, government research laboratories, and academia on both a non-proprietary and proprietary basis. RD&D conducted at ESIF will accelerate commercialization and adoption of renewable energy and energy efficiency technologies into contemporary energy systems where they can operate synergistically with other energy resources and technologies.

Modeling and simulation provides critical support to the breadth of EERE's mission. Simulations conducted on NREL's HPC have led to significant advances in energy efficiency and renewable energy technologies. Examples include the improved understanding of how cellulase enzymes work, identified rate-limiting steps at the molecular level to enable protein engineering, and identified new protein engineering targets, which will help reduce the cost of renewable fuels. Solar energy researchers are using simulations to identify novel alloys and materials with prescribed physical properties. In wind energy, researchers create models to better understand how upwind turbines impact downwind turbines, to reduce the cost of electricity. Researchers studying the electrical grid have developed and used unique approaches to study the entire U.S. Eastern Interconnect under incremental renewable penetration scenarios. EERE's HPC system at NREL has also been used to develop the first 1-minute resolution National Solar Irradiance Dataset: 120,000 locations around US over 8 years (2005-2012). This publicly accessible solar power data set is being used for grid integration studies, variability analysis, power system operation, and evaluating the impact of emerging technologies such as utility-scale storage and demand response.

Overall, the demand for computational capability to support the EERE mission is nearly twice the available computational capability. Demand for computing from well-established R&D efforts supported by the Wind, Solar and Bioenergy Offices alone, is sufficient to saturate the current HPC. Thus, there is a critical need to increase EERE's current HPC capabilities from 1 to 2 Petaflops at NREL, to meet growing demand from traditional users and meet anticipated rapid growth in demand in completely new areas including energy system integration, grid modernization, and other new program initiatives as they develop.

During calendar year 2014, the first full year of operations at ESIF, fourteen partner projects utilized ESIF's Research Electrical Distribution Bus (REDB) and the REDB associated fixed equipment (grid, PV, and load emulators). These projects focused on the ability of devices to provide grid services, such as reactive power and voltage support for the grid; microgrid devices, and architectures to enhance the energy security of forward operating and domestic military bases; and technology solutions to enable high penetrations of clean energy technologies, such as plug-in electric vehicles, smart appliances and intermittent renewables (e.g. solar). As a result of these successful partnering efforts, ESIF's REDB infrastructure was at or near capacity for much of the year. This trend is continuing into 2015, with wait times now approximately 4-6 months. This timeline has already proven prohibitive to some potential partners. Because of ESIF's unique capabilities for MW-scale testing, the demand for REDB testing is expected to continue to grow. Future upgrades of the REDB will greatly enhance ESIF capabilities to accommodate more concurrent experiments with industry partners and experiments at higher power levels.

**Facility Management**
**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **Facility Management $30,000** | **$36,000** | **+$6,000** |
| • The staff of ESIF will be expanded and trained to support the research, development, and demonstration of external and DOE supported users. DOE work supported by ten programs will be conducted by NREL and other DOE laboratory staff onsite or through high-speed data connections. Multiple hardware-in-the-loop and simulation projects will be completed on the HPC, some with comprehensive simulation demonstrations. User proposals will be collected, externally reviewed, awardees selected and standard agreements negotiated to conduct user-facility projects. We anticipate ESIF staff will complete approximately $30 million of DOE-supported projects and leverage $30 million of external user projects funds. | • In the third and final year of facility startup, the FY 2016 Budget completes the planned expansion of ESIF equipment and staff and supports continued training for safe and effective operations. NREL will develop ESIF's unique external user support capabilities and report on the facility's demonstrated value through reports and articles in technical literature. The first full year of external user proposals will be peer reviewed, selected, and developed into active projects in various electrical, thermal and fossil fuel laboratories. Project outputs will include the demonstrated delivery of multiple energy sources to a single customer's demand for heating, cooling, lighting, and electrical service. | • The $6 million increase funds computational science capability, PV simulation, staffing, and expanding the REDB. Of the total increase, $4 million will provide an increase in computational science computing, nearly doubling the current capacity to about 2.2 petaflops. Currently, the computational science center is oversubscribed and demand for computer time is increasing as new users are requesting to work in ESIF. The remaining $2 million will provide 1 megawatt of additional PV simulation, expanded REDB flexibility, and additional staff thereby furthering the research capability of ESIF. |

**Facilities and Infrastructure**
**Capital Summary ($K)**

| | Total | Prior Years | FY 2014 Enacted | FY 2014 Current | FY 2015 Enacted | FY 2016 Request | FY 2016 vs FY 2015 |
|---|---|---|---|---|---|---|---|
| **Capital Operating Expenses Summary (including Major Items of Equipment (MIE))[1]** | | | | | | | |
| Capital Equipment > $500K (including MIE) | n/a | n/a | 3,573 | 3,573 | 3,600 | 3,600 | 0 |
| Plant Projects (GPP) (<$10M) | n/a | n/a | 7,800 | 7,800 | 7,800 | 7,800 | 0 |
| **Total, Operations and Maintenance Expenses** | **n/a** | **n/a** | **11,373** | **11,373** | **11,400** | **11,400** | **0** |
| **Capital Equipment > $500K (including MIE)** | | | | | | | |
| Total Non-MIE Capital Equipment (>$500K) | n/a | n/a | 3,573 | 3,573 | 3,600 | 3,600 | 0 |
| **Total, Capital Equipment (including MIE)** | **n/a** | **n/a** | **3,573** | **3,573** | **3,600** | **3,600** | **0** |
| **Plant Projects (GPP and IGPP) (Total Estimated Cost (TEC) <$10M)** | | | | | | | |
| Total Plant Projects (GPP/IGPP) (Total Estimated Cost (TEC) <$5M) | n/a | n/a | 7,800 | 7,800 | 7,800 | 7,800 | 0 |
| **Total, Plant Projects (GPP/IGPP) (Total Estimated Cost (TEC) <$10M)** | **n/a** | **n/a** | **7,800** | **7,800** | **7,800** | **7,800** | **0** |
| **Total, Capital Summary** | **n/a** | **n/a** | **11,373** | **11,373** | **11,400** | **11,400** | **0** |

[1]Each MIE Total Estimated Cost (TEC) > $2,000,000 Each Plant Project (GPP/IGPP) Total Estimated Cost (TEC) > $5,000,000

**NREL Site-Wide Crosscut Contributions**

In FY 2016, EERE programs will continue to fund directly a portion of NREL site-wide costs, a practice begun in FY 2014that is consistent with Generally Accepted Accounting Principles and with other DOE management of National Laboratories. This practice has lowered NREL's labor rate multiplier, which makes the lab more affordable to industry for collaborating and thus increases the probability of our technologies achieving market impact. It has also strengthened and supported EERE's commitment to making site-operating costs more transparent and to facilitating cost control and planning. Individual EERE program sections of this Congressional Justification clearly identify "NREL Site-Wide Facility Support" funding levels. This combined funding supports basic site services, functions, and infrastructure for site operations. Additionally, the site-wide facility funding supports site-wide activities, such as maintaining International Organization for Standardization (ISO) certification, management, project management, and engineering support, and facility planning.

The NREL Site-Wide Crosscut Contributions have contributed to a net 23 percent increase in partnership activity from FY 2013 to FY 2014. In FY 2014, new partner agreements increased to 38 percent, representing nearly a three-fold increase in NREL's ability to attract new first-time partners.

The FY 2016 contribution calculated for each program is consistent with the methodology used in FY 2015 for assessing program contributions, using a proportional allocation based on work performed at NREL for each program in the previous fiscal year. The FY 2016 Request is estimated based on the FY 2015 Enacted distribution. The allocation for the FY 2016 request will be updated in the execution year once we have final costs incurred for FY 2015. The distribution of site-wide contributions across the EERE programs is included below.

**NREL Site-Wide Crosscut**
**(Provided through Program Budgets)**
**Funding ($K)**

| | FY 2015 Enacted | FY 2016 Request |
|---|---|---|
| Advanced Manufacturing | 0 | 0 |
| Building Technologies | 2,500 | 2,500 |
| Federal Energy Management Program | 800 | 800 |
| Weatherization and Intergovernmental Programs | 400 | 400 |
| Geothermal Technologies | 500 | 500 |
| Solar Energy Technologies | 9,100 | 9,100 |
| Water Power | 700 | 700 |
| Wind Energy | 4,700 | 4,700 |
| Vehicle Technologies | 3,000 | 3,000 |
| Bioenergy Technologies | 6,500 | 6,500 |
| Fuel Cell Technologies | 1,800 | 1,800 |
| **Total, Site-Wide Funding** | **30,000** | **30,000** |

## Energy Efficiency and Renewable Energy
## Facilities Maintenance and Repair

The Department's Facilities Maintenance and Repair activities are tied to its programmatic missions, goals, and objectives. The Facilities Maintenance and Repair activities funded by this budget and displayed below are intended to halt asset condition degradation.

**Costs for Direct-Funded Maintenance and Repair (including Deferred Maintenance Reduction) ($K)**

| | FY 2014 Actual Cost | FY 2014 Planned Cost | FY 2015 Planned Cost | FY 2016 Planned Cost |
|---|---|---|---|---|
| National Renewable Energy Laboratory | 11,990 | 13,051 | 10,180 | 10,251 |
| **Total, Direct-Funded Maintenance and Repair** | **11,990** | **13,051** | **10,180** | **10,251** |

**Costs for Indirect-Funded Maintenance and Repair (including Deferred Maintenance Reduction) ($K)**

| | FY 2014 Actual Cost | FY 2014 Planned Cost | FY 2015 Planned Cost | FY 2016 Planned Cost |
|---|---|---|---|---|
| National Renewable Energy Laboratory | 0* | 0* | 0* | 0* |
| **Total, Indirect-Funded Maintenance and Repair** | **0*** | **0*** | **0*** | **0*** |

* NREL transitioned from Indirect to Direct funding for Maintenance in FY2014; therefore, no indirect costs are planned in current or future years.

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## Report on FY 2014 Expenditures for Maintenance and Repair

This report responds to legislative language set forth in Conference Report (H.R. 108-10) accompanying the Consolidated Appropriations Resolution, 2003 (Public Law 108-7) (pages 886-887), which requests the Department of Energy provide an annual year-end report on maintenance expenditures to the Committees on Appropriations. This report compares the actual maintenance expenditures in FY 2014 to the amount planned for FY 2014, including changes directed by Congress.

**Energy Efficiency and Renewable Energy**
**Total Costs for Maintenance and Repair ($K)**

| | FY 2014 Actual Cost | FY 2014 Planned Cost |
|---|---|---|
| National Renewable Energy Laboratory | 13,051 | 13,051 |
| **Total, Maintenance and Repair** | **13,051** | **13,051** |

The Planned Cost is an estimate developed at the beginning of the year and is a minimum target amount. Final FY 2014 actual costs show that NREL was able to invest approximately the planned on the repair and maintenance of real property assets on the South Table Mountain site and remain within funding limits.

**Energy Efficiency and Renewable Energy**
**Research and Development ($K)**

| | FY 2014 Current[1] | FY 2015 Enacted | FY 2016 Request | FY 2016 vs FY 2015 |
|---|---|---|---|---|
| Basic | 0 | 0 | 0 | 0 |
| Applied | 540,146 | 512,138 | 823,334 | +311,196 |
| Development | 326,271 | 304,025 | 466,366 | +162,341 |
| Subtotal, R&D | 866,417 | 816,163 | 1,289,700 | +473,537 |
| Equipment | 3,573 | 3,600 | 3,600 | 0 |
| Construction | 0 | 0 | 0 | 0 |
| **Total, R&D** | **869,990** | **819,763** | **1,293,300** | **+473,537** |

[1] Funding reflects the SBIR/STTR amounts transferred to the Office of Science

**Energy Efficiency and Renewable Energy Research and Development**
**Small Business Innovative Research/Small Business Technology Transfer (SBIR/STTR) ($K)**

| | FY 2014 Transferred | FY 2015 Projected | FY 2016 Request | FY 2016 vs FY 2015 |
|---|---|---|---|---|
| Vehicle Technologies | 7,536 | 7,474 | 11,973 | +4,499 |
| SBIR | 6,594 | 6,568 | 10,411 | +3,843 |
| STTR | 942 | 906 | 1,562 | +656 |
| Bioenergy Technologies | 4,963 | 4,085 | 4,582 | +497 |
| SBIR | 4,343 | 3,590 | 3,984 | +394 |
| STTR | 620 | 495 | 598 | +103 |
| Hydrogen and Fuel Cell Technologies | 3,410 | 2,170 | 2,575 | +405 |
| SBIR | 3,129 | 1,907 | 2,239 | +332 |
| STTR | 281 | 263 | 336 | +73 |
| Solar Energy | 2,753 | 2,200 | 2,032 | -168 |
| SBIR | 2,498 | 1,933 | 1,767 | -166 |
| STTR | 255 | 267 | 265 | -2 |
| Wind Energy | 1,091 | 1,064 | 1,901 | +837 |
| SBIR | 955 | 935 | 1,653 | +718 |
| STTR | 136 | 129 | 248 | +119 |
| Water Power | 731 | 1,001 | 1,232 | +231 |
| SBIR | 640 | 880 | 1,071 | +191 |
| STTR | 91 | 121 | 161 | +40 |
| Geothermal Technologies | 973 | 712 | 2,846 | +2,134 |
| SBIR | 851 | 626 | 2,475 | +1,849 |
| STTR | 122 | 86 | 371 | +285 |
| Advanced Manufacturing | 5,071 | 5,825 | 12,903 | +7,078 |
| SBIR | 4,437 | 5,119 | 11,220 | +6,101 |
| STTR | 634 | 706 | 1,683 | +977 |
| Building Technologies | 4,237 | 2,970 | 4,451 | +1,481 |
| SBIR | 3,957 | 2,610 | 3,870 | +1,260 |
| STTR | 280 | 360 | 581 | +221 |
| **Total, SBIR** | 27,404 | 24,168 | 38,690 | +14,522 |
| **Total, STTR** | 3,361 | 3,333 | 5,805 | +2,472 |

**Energy Efficiency and Renewable Energy**
**Safeguards and Security ($K)**

| | FY 2014 Current | FY 2015 Enacted | FY 2016 Request | FY 2016 vs FY 2015 |
|---|---|---|---|---|
| Protective Forces | 5,200 | 5,200 | 5,200 | 0 |
| Physical Security Systems | 0 | 0 | 0 | 0 |
| Information Security | 200 | 200 | 200 | 0 |
| Cybersecurity | 2,190 | 2,190 | 2,190 | 0 |
| Personnel Security | 720 | 720 | 720 | 0 |
| Material Control and Accountability | 0 | 0 | 0 | 0 |
| Program Management | 490 | 490 | 490 | 0 |
| Security Investigations | 400 | 400 | 400 | 0 |
| Transportation Security | 0 | 0 | 0 | 0 |
| Construction | 0 | 0 | 0 | 0 |
| **Total, Safeguards and Security** | **9,200** | **9,200** | **9,200** | **0** |

Department Of Energy
FY 2016 Congressional Budget
Funding By Appropriation By Site
($K)

| Energy Efficiency and Renewable Energy | FY 2014 Current | FY 2015 Enacted | FY 2016 Request |
|---|---|---|---|
| **Ames Laboratory** | | | |
| **Energy Efficiency and Renewable Energy** | | | |
| Vehicle Technologies | 1,770 | 1,900 | 1,900 |
| Advanced Manufacturing | 25,024 | 25,000 | 25,000 |
| **Total, Energy Efficiency and Renewable Energy** | **26,794** | **26,900** | **26,900** |
| **Total, Ames Laboratory** | **26,794** | **26,900** | **26,900** |
| **Argonne National Laboratory** | | | |
| **Energy Efficiency and Renewable Energy** | | | |
| Wind Energy | 541 | 1,208 | 1,208 |
| Geothermal Technologies | 367 | 173 | 300 |
| Hydrogen & Fuel Cell Technologies | 8,304 | 8,420 | 9,000 |
| Water Power | 1,018 | 106 | 0 |
| Solar Energy | 610 | 580 | 589 |
| Vehicle Technologies | 40,718 | 39,188 | 39,188 |
| Building Technologies | 1,981 | 150 | 0 |
| Federal Energy Management Program | 1,759 | 1,410 | 0 |
| Advanced Manufacturing | 2,411 | 1,625 | 2,500 |
| Strategic Programs | 70 | 325 | 0 |
| Bioenergy Technologies | 5,300 | 4,000 | 4,000 |
| **Total, Energy Efficiency and Renewable Energy** | **63,079** | **57,185** | **56,785** |
| **Total, Argonne National Laboratory** | **63,079** | **57,185** | **56,785** |
| **Brookhaven National Laboratory** | | | |
| **Energy Efficiency and Renewable Energy** | | | |
| Geothermal Technologies | 530 | 345 | 500 |
| Hydrogen & Fuel Cell Technologies | 1,155 | 1,170 | 1,300 |
| Solar Energy | 600 | 0 | 0 |
| Vehicle Technologies | 2,232 | 3,008 | 3,008 |
| Strategic Programs | 0 | 0 | 0 |
| Bioenergy Technologies | 75 | 0 | 0 |
| **Total, Energy Efficiency and Renewable Energy** | **4,592** | **4,523** | **4,808** |
| **Total, Brookhaven National Laboratory** | **4,592** | **4,523** | **4,808** |
| **Chicago Operations Office** | | | |
| **Energy Efficiency and Renewable Energy** | | | |
| Wind Energy | 75 | 75 | 75 |
| Hydrogen & Fuel Cell Technologies | 0 | 2,180 | 2,500 |
| Solar Energy | 102 | 0 | 0 |
| Vehicle Technologies | 100 | 0 | 0 |
| **Total, Energy Efficiency and Renewable Energy** | **277** | **2,255** | **2,575** |
| **Total, Chicago Operations Office** | **277** | **2,255** | **2,575** |

**Department Of Energy**
**FY 2016 Congressional Budget**
**Funding By Appropriation By Site**
**($K)**

| Energy Efficiency and Renewable Energy | FY 2014 Current | FY 2015 Enacted | FY 2016 Request |
|---|---|---|---|
| **Golden Field Office** | | | |
| **Energy Efficiency and Renewable Energy** | | | |
| Wind Energy | 33,421 | 50,621 | 88,167 |
| Program Direction | 19,555 | 19,424 | 19,424 |
| Geothermal Technologies | 16,838 | 4,200 | 32,000 |
| Hydrogen & Fuel Cell Technologies | 34,450 | 36,830 | 40,500 |
| Water Power | 34,533 | 36,819 | 42,924 |
| Solar Energy | 123,738 | 152,400 | 237,500 |
| Vehicle Technologies | 110 | 0 | 0 |
| Building Technologies | 29,127 | 30,521 | 112,500 |
| Federal Energy Management Program | 1,427 | 4,004 | 6,945 |
| Weatherization Assistance | 1,000 | 1,200 | 16,600 |
| State Energy Program | 6,970 | 6,930 | 18,200 |
| Tribal Energy Activities | 5,971 | 0 | 0 |
| Advanced Manufacturing | 122,794 | 139,969 | 347,570 |
| Strategic Programs | 4,308 | 3,775 | 6,925 |
| Bioenergy Technologies | 68,473 | 115,800 | 140,000 |
| **Total, Energy Efficiency and Renewable Energy** | **502,715** | **602,493** | **1,109,255** |
| **Total, Golden Field Office** | **502,715** | **602,493** | **1,109,255** |
| **Idaho National Laboratory** | | | |
| **Energy Efficiency and Renewable Energy** | | | |
| Wind Energy | 530 | 845 | 845 |
| Geothermal Technologies | 1,616 | 2,146 | 2,900 |
| Hydrogen & Fuel Cell Technologies | 58 | 1,200 | 100 |
| Water Power | 530 | 0 | 0 |
| Vehicle Technologies | 7,870 | 10,740 | 10,740 |
| Federal Energy Management Program | 143 | 304 | 527 |
| Advanced Manufacturing | 420 | 250 | 440 |
| Strategic Programs | 0 | 60 | 0 |
| Bioenergy Technologies | 13,800 | 10,000 | 10,000 |
| **Total, Energy Efficiency and Renewable Energy** | **24,967** | **25,545** | **25,552** |
| **Total, Idaho National Laboratory** | **24,967** | **25,545** | **25,552** |

Department Of Energy
FY 2016 Congressional Budget
Funding By Appropriation By Site
($K)

| Energy Efficiency and Renewable Energy | FY 2014 Current | FY 2015 Enacted | FY 2016 Request |
|---|---|---|---|
| **Lawrence Berkeley National Laboratory** | | | |
| **Energy Efficiency and Renewable Energy** | | | |
| Wind Energy | 636 | 1,113 | 1,113 |
| Geothermal Technologies | 4,034 | 2,978 | 4,000 |
| Hydrogen & Fuel Cell Technologies | 2,220 | 2,250 | 2,400 |
| Solar Energy | 1,706 | 1,422 | 1,443 |
| Vehicle Technologies | 10,932 | 16,444 | 16,444 |
| Building Technologies | 28,416 | 17,158 | 24,218 |
| Federal Energy Management Program | 3,289 | 2,047 | 3,551 |
| Weatherization Assistance | 470 | 450 | 650 |
| State Energy Program | 700 | 800 | 1,400 |
| Advanced Manufacturing | 3,460 | 4,833 | 5,400 |
| Strategic Programs | 1,430 | 1,700 | 1,695 |
| Bioenergy Technologies | 4,000 | 4,000 | 4,000 |
| **Total, Energy Efficiency and Renewable Energy** | **61,293** | **55,195** | **66,314** |
| **Total, Lawrence Berkeley National Laboratory** | **61,293** | **55,195** | **66,314** |
| **Lawrence Livermore National Laboratory** | | | |
| **Energy Efficiency and Renewable Energy** | | | |
| Wind Energy | 285 | 949 | 949 |
| Geothermal Technologies | 1,268 | 1,070 | 1,500 |
| Hydrogen & Fuel Cell Technologies | 1,869 | 1,900 | 2,000 |
| Vehicle Technologies | 2,896 | 2,437 | 2,437 |
| Advanced Manufacturing | 0 | 700 | 900 |
| Strategic Programs | 0 | 275 | 0 |
| **Total, Energy Efficiency and Renewable Energy** | **6,318** | **7,331** | **7,786** |
| **Total, Lawrence Livermore National Laboratory** | **6,318** | **7,331** | **7,786** |
| **Los Alamos National Laboratory** | | | |
| **Energy Efficiency and Renewable Energy** | | | |
| Geothermal Technologies | 808 | 150 | 200 |
| Hydrogen & Fuel Cell Technologies | 6,046 | 6,130 | 6,600 |
| Solar Energy | 675 | 667 | 677 |
| Vehicle Technologies | 1,084 | 1,100 | 1,100 |
| Strategic Programs | 0 | 275 | 0 |
| Bioenergy Technologies | 1,770 | 1,500 | 1,500 |
| Local Technical Assistance Program | 0 | 0 | 20,000 |
| **Total, Energy Efficiency and Renewable Energy** | **10,383** | **9,822** | **30,077** |
| **Total, Los Alamos National Laboratory** | **10,383** | **9,822** | **30,077** |

**Department Of Energy**
**FY 2016 Congressional Budget**
**Funding By Appropriation By Site**
**($K)**

| Energy Efficiency and Renewable Energy | FY 2014 Current | FY 2015 Enacted | FY 2016 Request |
|---|---|---|---|
| **National Energy Technology Lab** | | | |
| **Energy Efficiency and Renewable Energy** | | | |
| Program Direction | 12,248 | 12,299 | 12,299 |
| Geothermal Technologies | 5,317 | 29,000 | 35,000 |
| Vehicle Technologies | 119,284 | 122,270 | 122,270 |
| Building Technologies | 22,580 | 24,343 | 22,580 |
| State Energy Program | 0 | 200 | 300 |
| Advanced Manufacturing | 0 | 250 | 0 |
| Strategic Programs | 0 | 0 | 0 |
| **Total, Energy Efficiency and Renewable Energy** | **159,429** | **188,362** | **192,449** |
| **Total, National Energy Technology Lab** | **159,429** | **188,362** | **192,449** |
| **National Renewable Energy Laboratory** | | | |
| **Energy Efficiency and Renewable Energy** | | | |
| Wind Energy | 33,508 | 29,761 | 29,761 |
| Facilities and Infrastructure | 45,973 | 56,000 | 62,000 |
| Geothermal Technologies | 3,917 | 3,615 | 5,000 |
| Hydrogen & Fuel Cell Technologies | 16,358 | 17,590 | 17,800 |
| Water Power | 4,226 | 4,156 | 4,156 |
| Solar Energy | 59,571 | 55,704 | 55,052 |
| Vehicle Technologies | 28,013 | 23,456 | 23,456 |
| Building Technologies | 21,057 | 12,647 | 17,752 |
| Federal Energy Management Program | 5,130 | 4,173 | 7,239 |
| Weatherization Assistance | 100 | 700 | 800 |
| State Energy Program | 750 | 650 | 1,000 |
| Tribal Energy Activities | 400 | 0 | 0 |
| Advanced Manufacturing | 770 | 1,200 | 1,400 |
| Strategic Programs | 6,303 | 7,000 | 6,280 |
| Bioenergy Technologies | 49,000 | 40,000 | 40,000 |
| **Total, Energy Efficiency and Renewable Energy** | **275,076** | **256,652** | **271,696** |
| **Total, National Renewable Energy Laboratory** | **275,076** | **256,652** | **271,696** |
| **Oak Ridge Institute for Science & Education** | | | |
| **Energy Efficiency and Renewable Energy** | | | |
| Geothermal Technologies | 130 | 0 | 0 |
| Solar Energy | 400 | 0 | 0 |
| Vehicle Technologies | 0 | 200 | 200 |
| Building Technologies | 753 | 935 | 0 |
| Advanced Manufacturing | 896 | 830 | 800 |
| Strategic Programs | 523 | 0 | 0 |
| **Total, Energy Efficiency and Renewable Energy** | **2,702** | **1,965** | **1,000** |
| **Total, Oak Ridge Institute for Science & Education** | **2,702** | **1,965** | **1,000** |

**Department Of Energy**
**FY 2016 Congressional Budget**
**Funding By Appropriation By Site**
**($K)**

| Energy Efficiency and Renewable Energy | FY 2014 Current | FY 2015 Enacted | FY 2016 Request |
|---|---|---|---|
| **Oak Ridge National Laboratory** | | | |
| **Energy Efficiency and Renewable Energy** | | | |
| Geothermal Technologies | 535 | 920 | 1,300 |
| Hydrogen & Fuel Cell Technologies | 5,048 | 5,120 | 5,500 |
| Water Power | 4,219 | 2,798 | 2,800 |
| Vehicle Technologies | 41,903 | 32,402 | 32,402 |
| Building Technologies | 17,816 | 11,437 | 11,134 |
| Federal Energy Management Program | 2,673 | 2,332 | 4,045 |
| Weatherization Assistance | 322 | 200 | 500 |
| State Energy Program | 550 | 550 | 700 |
| Advanced Manufacturing | 12,345 | 17,918 | 12,700 |
| Strategic Programs | 938 | 300 | 400 |
| Bioenergy Technologies | 9,778 | 9,650 | 9,650 |
| **Total, Energy Efficiency and Renewable Energy** | **96,127** | **83,627** | **81,131** |
| **Total, Oak Ridge National Laboratory** | **96,127** | **83,627** | **81,131** |
| **Oak Ridge Office** | | | |
| **Energy Efficiency and Renewable Energy** | | | |
| Wind Energy | 220 | 0 | 0 |
| Hydrogen & Fuel Cell Technologies | 327 | 330 | 400 |
| Strategic Programs | 108 | 275 | 600 |
| **Total, Energy Efficiency and Renewable Energy** | **655** | **605** | **1,000** |
| **Total, Oak Ridge Office** | **655** | **605** | **1,000** |
| **Office of Scientific & Technical Information** | | | |
| **Energy Efficiency and Renewable Energy** | | | |
| Solar Energy | 28 | 0 | 0 |
| **Total, Office of Scientific & Technical Information** | **28** | **0** | **0** |

**Department Of Energy**
**FY 2016 Congressional Budget**
**Funding By Appropriation By Site**
**($K)**

| Energy Efficiency and Renewable Energy | FY 2014 Current | FY 2015 Enacted | FY 2016 Request |
|---|---|---|---|
| **Pacific Northwest National Laboratory** | | | |
| **Energy Efficiency and Renewable Energy** | | | |
| Wind Energy | 2,279 | 3,105 | 3,105 |
| Geothermal Technologies | 2,095 | 1,842 | 2,500 |
| Hydrogen & Fuel Cell Technologies | 3,480 | 3,530 | 3,800 |
| Water Power | 4,161 | 3,306 | 3,300 |
| Solar Energy | 2,271 | 0 | 0 |
| Vehicle Technologies | 9,335 | 11,693 | 11,693 |
| Building Technologies | 12,291 | 22,064 | 22,730 |
| Federal Energy Management Program | 2,034 | 858 | 1,488 |
| Advanced Manufacturing | 280 | 200 | 290 |
| Strategic Programs | 740 | 740 | 705 |
| Bioenergy Technologies | 15,215 | 15,000 | 15,000 |
| **Total, Energy Efficiency and Renewable Energy** | **54,181** | **62,338** | **64,611** |
| **Total, Pacific Northwest National Laboratory** | **54,181** | **62,338** | **64,611** |
| **Sandia National Laboratories** | | | |
| **Energy Efficiency and Renewable Energy** | | | |
| Wind Energy | 9,075 | 6,473 | 6,473 |
| Geothermal Technologies | 5,807 | 6,061 | 8,300 |
| Hydrogen & Fuel Cell Technologies | 4,750 | 4,820 | 5,200 |
| Water Power | 4,661 | 4,616 | 4,620 |
| Solar Energy | 17,160 | 16,102 | 13,300 |
| Vehicle Technologies | 8,659 | 8,300 | 8,300 |
| Building Technologies | 1,000 | 0 | 0 |
| Federal Energy Management Program | 110 | 83 | 144 |
| Tribal Energy Activities | 425 | 0 | 0 |
| Advanced Manufacturing | 0 | 225 | 0 |
| Strategic Programs | 0 | 275 | 0 |
| Bioenergy Technologies | 475 | 475 | 475 |
| **Total, Energy Efficiency and Renewable Energy** | **52,122** | **47,430** | **46,812** |
| **Total, Sandia National Laboratories** | **52,122** | **47,430** | **46,812** |
| **Savannah River National Laboratory** | | | |
| **Energy Efficiency and Renewable Energy** | | | |
| Wind Energy | 610 | 106 | 106 |
| Hydrogen & Fuel Cell Technologies | 2,862 | 2,900 | 3,100 |
| Solar Energy | 2,205 | 2,097 | 2,129 |
| Bioenergy Technologies | 405 | 405 | 405 |
| **Total, Energy Efficiency and Renewable Energy** | **6,082** | **5,508** | **5,740** |
| **Total, Savannah River National Laboratory** | **6,082** | **5,508** | **5,740** |

**Department Of Energy**

**FY 2016 Congressional Budget**

**Funding By Appropriation By Site**

**($K)**

| Energy Efficiency and Renewable Energy | FY 2014 Current | FY 2015 Enacted | FY 2016 Request |
|---|---|---|---|
| **SLAC National Accelerator Laboratory** | | | |
| **Energy Efficiency and Renewable Energy** | | | |
| Solar Energy | 200 | 0 | 0 |
| **Total, SLAC National Accelerator Laboratory** | **200** | **0** | **0** |
| **Stanford Site Office** | | | |
| **Energy Efficiency and Renewable Energy** | | | |
| Vehicle Technologies | 600 | 0 | 0 |
| **Total, Stanford Site Office** | **600** | **0** | **0** |
| **Washington Headquarters** | | | |
| **Energy Efficiency and Renewable Energy** | | | |
| Wind Energy | 5,855 | 12,744 | 13,698 |
| Program Direction | 130,197 | 128,277 | 133,607 |
| Geothermal Technologies | 1,540 | 2,500 | 2,500 |
| Hydrogen & Fuel Cell Technologies | 2,591 | 2,630 | 2,800 |
| Water Power | 4,486 | 9,199 | 9,200 |
| Solar Energy | 45,039 | 4,028 | 26,010 |
| Vehicle Technologies | 6,695 | 6,862 | 170,862 |
| Building Technologies | 38,610 | 52,745 | 53,086 |
| Federal Energy Management Program | 11,683 | 11,789 | 19,149 |
| Weatherization Assistance | 172,004 | 190,450 | 209,849 |
| State Energy Program | 41,000 | 40,870 | 48,500 |
| Tribal Energy Activities | 200 | 0 | 0 |
| Advanced Manufacturing | 7,000 | 7,000 | 7,000 |
| Strategic Programs | 9,120 | 6,000 | 11,265 |
| Bioenergy Technologies | 14,036 | 24,170 | 20,970 |
| **Total, Energy Efficiency and Renewable Energy** | **490,056** | **499,264** | **728,496** |
| **Total, Washington Headquarters** | **490,056** | **499,264** | **728,496** |
| **Total, Energy Efficiency and Renewable Energy** | **1,837,676** | **1,937,000** | **2,722,987** |

# Electricity Delivery and Energy Reliability

# Electricity Delivery and Energy Reliability

**Electricity Delivery and Energy Reliability**

**Table of Contents**

**Electricity Delivery and Energy Reliability**
**Proposed Appropriation Language**

For Department of Energy expenses including the purchase, construction, and acquisition of plant and capital equipment, and other expenses necessary for electricity delivery and energy reliability activities in carrying out the purposes of the Department of Energy Organization Act (42 U.S.C. 7101 et seq.), including the acquisition or condemnation of any real property or any facility or for plant or facility acquisition, construction, or expansion, [$147,306,000] *$270,100,000*, to remain available until expended: Provided, That [$27,606,000] *$32,600,000* shall be available until September 30, [2016] *2017*, for program direction.

**Public Law Authorizations**

Public Law 95–91, "Department of Energy Organization Act", 1977

Public Law 109-58, "Energy Policy Act of 2005"

Public Law 110-140, "Energy Independence and Security Act, 2007"

## Electricity Delivery and Energy Reliability
## ($K)

| FY 2014 Enacted | FY 2014 Current | FY 2015 Enacted | FY 2016 Request |
|---|---|---|---|
| 147,242 | 144,205 | 146,975 | 270,100 |

**Overview**

The Office of Electricity Delivery and Energy Reliability (OE) leads the Department's efforts to strengthen, transform, and improve our energy infrastructure so that consumers have access to reliable, secure, and clean sources of energy. To accomplish this critical mission, OE works with private industry and Federal, state, local, and tribal governments on a variety of initiatives to modernize the electric grid.

Grid modernization is critical to achieving public policy objectives, sustaining economic growth, supporting environmental stewardship, and mitigating risks to secure the Nation. The goal for the future grid is to provide a platform for U.S. economic prosperity and energy innovation in a global clean energy economy. It will deliver reliable, affordable, and clean electricity to consumers where, when, and how they want it.

Within the next decade, proactive, coordinated, and innovative steps are needed that address four critical challenges:

- Changes in demand driven by population growth, adoption of more energy efficient technologies, dynamic economic conditions, and broader electrification, including possible mass-markets for electric vehicles;
- Changes in the supply mix (such as renewables, nuclear energy, natural gas, and coal) and location (centralized, distributed, and off-shore) of the Nation's generation portfolio driven by technology, market, and policy developments;
- Increasing variability and uncertainty from both supply and demand, including integration of variable renewables, more active consumer participation, and accommodating new technologies and techniques; and
- Increasing challenges to the reliability and security of the electric infrastructure (such as more frequent and intense extreme weather events, cyber and physical attacks, and interdependencies with natural gas and water).

Due to the critical role the electric grid plays in successfully implementing an all-of-the-above energy strategy across Federal, state, and local jurisdictions, OE programs are working in an integrated manner, in partnership with industry and other stakeholders as well as other DOE offices, to enhance key characteristics of the U.S. electric transmission and distribution systems:

- Reliability—consistent and dependable delivery of high quality power;
- Flexibility—the ability to accommodate changing supply and demand patterns and new technologies;
- Efficiency—low losses in electricity delivery and more optimal use of system assets;
- Resiliency—the ability to withstand and quickly recover from disruptions and maintain critical function;
- Affordability—more optimal deployment of assets to meet system needs and minimize costs;
- Security—the ability to protect system assets and critical functions from unauthorized and undesirable actors; and
- Minimal environmental footprint—grid system designs that reduce total environmental impact of grid components and connected systems

OE programs are aligned with the Administration's report, *A Policy Framework for the 21st Century Grid: Enabling Our Secure Energy Future* (June 2011), the *President's Climate Action Plan* (June 2013), and other Departmental efforts to address energy infrastructure needs and challenges. Timely action is needed to ensure a reliable electric power grid that enables the clean energy economy and the vitality of other critical sectors that depend on electricity, such as telecommunications, banking and finance, water, and public health and safety. A reliable and resilient power grid is critical to U.S. economic competiveness and leadership in the global clean energy economy.

Within the appropriation, OE funds:

- Research and Development—pursues technologies to improve grid reliability, efficiency, flexibility, functionality, and security; investments and demonstrations are aimed at bringing new and innovative technologies to maturity and helping them transition to market;
- Modeling and Analytics—develops core analytic, assessment, and engineering capabilities that can evolve as the technology and policy needs mature to support decision making within the Department and for stakeholders; analyses explore complex interdependencies such as energy-water and electric-gas;

- Institutional Support and Technical Assistance—builds capacity in the industry and convenes stakeholders to coordinate modernization efforts; provides technical assistance to states and regions to improve policies, utility incentives, state laws, and programs that facilitate the modernization of the electric infrastructure;
- Coordination of Federal Transmission Permits—streamlines permits, special use authorizations, and other approvals required under Federal law to site electric transmission facilities; and
- Emergency Preparedness and Response—enhances the reliability, survivability, and resiliency of energy infrastructure, and expedites recovery from disruptions to energy supply.

**Highlights and Major Changes in the FY 2016 Budget Request**

The FY 2016 request reflects the Administration's priority on modernizing the electric grid and boosting the resilience of infrastructure. The request accelerates ongoing efforts to support the Administration's all-of-the-above energy strategy and emphasizes programs that increase electric grid resilience, including managing risks, increasing system flexibility and robustness, increasing visualization and situational awareness, and deploying advanced control capabilities.

**Clean Energy Transmission and Reliability** ($40,000,000; +$5,738,000) increases primarily due to an expansion of university research in mathematics for power systems.

**Smart Grid Research and Development** ($30,000,000; +$14,561,000) increases to promote higher performing grids by integrating new assets and information streams with advanced distribution management systems and exploring new market-based control paradigms that can more efficiently integrate distributed generation resources.

**Cybersecurity for Energy Delivery Systems** ($52,000,000, +$6,001,000) supports research on cutting edge cybersecurity solutions, information sharing to enhance situational awareness, implementing tools to aid industry to improve their cybersecurity posture, and building an effective, timely, and coordinated cyber incident management capability in the energy sector. The increase establishes a virtual energy sector advanced digital forensics analysis platform, which can be used to analyze untested and untrusted code, programs, and websites without allowing the software to harm the host device.

**Energy Storage** ($21,000,000; +$9,000,000) addresses challenges in cost competitive energy storage technology, validated reliability and safety, an equitable regulatory environment, and industry acceptance. New and advanced energy storage technologies will enable the stability, resiliency and surety of the modernized grid as well as support increased levels of renewables.

**Transformer Resilience and Advanced Components** ($10,000,000) is a new budget line in FY 2016 to address unique challenges facing transformers and other critical grid components in a more dynamic and vulnerable operating environment. The request expands the study of geomagnetic disturbances impacts on large power transformers to include electromagnetic pulses and supports power electronics R&D.

**National Electricity Delivery** ($7,500,000; +$1,500,000) expands institutional support activities, including expanding the modeling and analytical tools for decision makers at the state, regional, and Federal levels. It is critical to grid modernization to help ensure state, local, regional, and tribal entities have the capabilities and support to deal with rapidly evolving technologies, policies, and regulatory structures.

**Infrastructure Security and Energy Restoration** ($14,000,000; +$8,000,000) supports operations of DOE Emergency Operations Center as an operational environment with the technology and tools to enable analysts to, in real time, monitor, simulate, and track energy disruptions. Funding for Federal staff supporting Operational Energy and Resilience operations is requested within Program Direction.

**State Energy Reliability and Assurance Grants** ($63,000,000) is a new program including $27,500,000 of grants to states localities, regions, and tribal entities for long-term electricity transmission, storage, and distribution reliability planning to promote and integrate reliability, efficiency, environmental protection (including climate adaptation), and climate resilience planning and action, as well as $35,500,000 for energy assurance formula grants to states, localities, and tribes to enhance and/or develop plans to enhance resilience through energy assurance planning and exercises.

**Crosscutting Initiatives**

The FY 2016 Budget Request continues crosscutting programs that coordinate across the Department and seek to tap DOE's full capability to effectively and efficiently address the United States' energy, environmental, and national security challenges. OE is part of the Grid Modernization and Cybersecurity crosscuts.

**Grid Modernization**: U.S. prosperity and energy innovation in a global clean energy economy depends on the modernization of the National Electric Grid. To support this transformation, the Department of Energy's Grid Modernization Initiative will create tools and technologies that measure, analyze, predict, and control the grid of the future; focus on key policy questions related to regulatory practices, market designs, and business models; ensure the development of a secure and resilient grid; and collaborate with stakeholders to test and demonstrate combinations of promising new technologies. The Grid Modernization crosscut encompasses the entire OE program, save for Grants for Energy Assurance within the State Energy Reliability and Assurance Grants program and Program Direction.

**Cybersecurity**: DOE engages in three categories of cyber-related activities: protecting the DOE enterprise from a range of cyber threats that can adversely impact mission capabilities; bolstering the U.S. Government's capabilities to address cyber threats; and improving cybersecurity in the electric power subsector and the oil and natural gas subsector. The cybersecurity crosscut supports central coordination of the strategic and operational aspects of cybersecurity and facilitates cooperative efforts such as the Joint Cybersecurity Coordination Center (JC3) for incident response and the implementation of Department-wide Identity Control and Access Management (ICAM).

**FY 2016 Crosscuts ($K)**

| | Grid Modernization | Cybersecurity | Total |
|---|---|---|---|
| Clean Energy Transmission and Reliability | 40,000 | 0 | 40,000 |
| Smart Grid Research and Development | 30,000 | 0 | 30,000 |
| Cybersecurity for Energy Delivery Systems | 52,000 | 52,000 | 52,000[a] |
| Energy Storage | 21,000 | 0 | 21,000 |
| Transformer Resilience and Advanced Components | 10,000 | 0 | 10,000 |
| National Electricity Delivery | 7,500 | 0 | 7,500 |
| Infrastructure Security and Energy Restoration | 14,000 | 0 | 14,000 |
| State Energy Reliability and Assurance Grants | 27,500 | 0 | 27,500 |
| **Total, Crosscuts** | **202,000** | **52,000** | **202,000** |

**FY 2014 Key Accomplishments**

Clean Energy Transmission and Reliability

An enhanced wide-area, oscillation detection system was demonstrated for the first time in the Eastern Interconnection. This system accommodates four times the phasor measurement unit signals of previous systems and provides grid operators with greater visibility into system conditions. Furthermore, the program demonstrated significantly increased speed and fidelity of models and simulations for the electric system. These advanced grid models along with the improved measurement network support grid reliability, helping to contain or avoid outages.

To support the transition of synchrophasor research into commercial-grade tools, OE competitively awarded six projects to facilitate quick and effective response to grid conditions; utility partners have committed to deploying these tools after the two-year projects are complete.

OE completed a pilot study that explores the feasibility of assessing the impacts of sea level rise on energy infrastructure, which included facilities in the oil, natural gas, and electric sectors for four major metropolitan statistical areas: Houston, Miami, Los Angeles, and New York City. The pilot program resulted in a repeatable framework which could be used broadly to better inform long-term planning decisions by potentially impacted stakeholders.

Smart Grid Research and Development

In support of the collaborative framework established in the MOU between DOE and New Jersey, OE completed a Resiliency Assessment and Feasibility Study for constructing and operating a microgrid to provide resilient power to multimodal transportation systems in New Jersey (*NJ TRANSIT Grid*), as well as a conceptual design with a portfolio of buildings identified to be serviced by the microgrid in Hoboken, NJ, in support of rebuilding from Hurricane Sandy.

[a] The entire $52,000,000 for the Cybersecurity for Energy Delivery Systems program is included within both the Cybersecurity and Grid Modernization crosscuts but is only counted once in the total.

In a second phase of a two-phase effort to develop and deploy smart grid data access tools, OE selected a project, from among seven Phase I projects, to empower 400,000 residential customers to better manage their electricity use through improved access to their electricity consumption data.

Cybersecurity for Energy Delivery Systems

Cutting edge cybersecurity solutions transitioned to the energy sector in 2014 included substation control system components and field devices designed to allow only expected cyber-activity, strengthening protections against unauthorized access, communications or executable processes.

Two documents that provide guidance to enhance cybersecurity to industry were issued. An expanded *Integrating Electricity Subsector Failure Scenarios into a Risk Assessment Methodology* provides guidance to utilities on developing and implementing a risk assessment process using various failure scenarios. The *Cybersecurity Procurement Language for Energy Delivery Systems* provides a common understanding of appropriate cybersecurity controls in the energy sector that can be considered by utilities and suppliers during the procurement process. It helps utilities know what to ask for, and suppliers know what cybersecurity controls are appropriate for their products.

The Electric Sector Cybersecurity Capability Maturity Model (C2M2), which encourages adoption of best practices and informs cybersecurity investment decisions in industry, was expanded through increased industry participation and tool development. In addition, a C2M2 version for the oil and natural gas sector was developed and released in collaboration with stakeholders. OE also worked with industry to develop guidance on the use of C2M2 to meet the objectives of the National Institutes of Standards and Technology Cybersecurity Framework for reducing cyber risks to critical infrastructure.

Energy Storage

OE expanded work in redox flow battery electrode and cell optimization, and component life testing, along with improved testing techniques. This resulted to the development of a bench top redox flow battery with 4 times the power and operating at a 50 percent greater current density compared to FY 2013, resulting in a cost equivalent of $400 per kWh for a projected 4-hour system.

A first-of-a-kind system was installed for testing grid-connected, second-use electric vehicle batteries in stationary applications. If successful, this system could provide a subsequent use for electric vehicle batteries, after they are no longer capable of meeting vehicle needs, rather than having them go directly into disposal. A testing platform was constructed, and the first year of testing was completed based on collected residential load data to validate the control and economic potential of distributed energy storage systems.

National Electricity Delivery

Consistent with its responsibilities for Federal authorization of transmission projects that cross the Canadian and Mexican borders, OE completed the Final Environmental Impact Statement for Champlain Hudson Power Express Transmission Line. The 336-mile transmission line will bring up to 1,000 megawatts of clean, renewable power from Canada to the New York metro area. The successfully completed EIS was a basis for the Department's issuance of its Record of Decision approving the project for final permitting.

OE expanded opportunities for stakeholder input in the development of the *National Electric Transmission Congestion Studies*, preparing a consultation draft of the current study, which was distributed to states and regional reliability entities for comment, followed by a revised draft released in August 2014 for public comment. The principal finding of the draft study is that transmission congestion has declined in most areas of the Nation due to long-term trends such as slower growth in electricity demand, lower prices for natural gas as generation fuel, and continued utility investment in transmission expansion projects.

At the request of western states, OE developed a framing analysis of the possible challenges to electric utility business models from high levels of customer-owned generation (solar and natural gas) and related business developments. State electricity decision makers affirmed that this analysis was very useful in their regulation of electric utilities because it enabled them to understand better the problems they and their utilities are likely to face over the next several years.

Infrastructure Security and Emergency Restoration

OE supported 24 energy emergency events, physical security events, wild fires, winter storms, fuel shortages, national security events, storms, and typhoons, seven of which were Presidentially-designated disasters pursuant to the Stafford Act.

OE began the expansion of monitoring and visualization capabilities, including development of tools such as Lantern-Live (a mobile application being designed to inform the public during energy emergencies), the hardware and software stabilization of OE's EAGLE-I, and the identification of newer capability requirements to be added into EAGLE-I or as standalone architecture. In FY 2014, the user base for EAGLE-I increased to over 600 accounts for users from DOE and 20 other Federal agencies.

**Electricity Delivery and Energy Reliability**
**Funding by Congressional Control ($K)**

| | FY 2014 Enacted | FY 2014 Current[a] | FY 2015 Enacted | FY 2016 Request | FY 2016 vs FY 2015 |
|---|---|---|---|---|---|
| Clean Energy Transmission and Reliability | 32,383 | 31,474 | 34,262 | 40,000 | +5,738 |
| Smart Grid Research and Development | 14,592 | 14,125 | 15,439 | 30,000 | +14,561 |
| Cybersecurity for Energy Delivery Systems | 43,476 | 42,301 | 45,999 | 52,000 | +6,001 |
| Energy Storage | 15,192 | 14,706 | 12,000 | 21,000 | +9,000 |
| Transformer Resilience and Advanced Components | 0 | 0 | 0 | 10,000 | +10,000 |
| National Electricity Delivery | 5,997 | 5,997 | 6,000 | 7,500 | +1,500 |
| Infrastructure Security and Energy Restoration | 7,996 | 7,996 | 6,000 | 14,000 | +8,000 |
| State Energy Reliability and Assurance Grants | | | | | |
| Grants for Electricity Transmission, Storage, and Distribution Reliability | 0 | 0 | 0 | 27,500 | +27,500 |
| Grants for Energy Assurance | 0 | 0 | 0 | 35,500 | +35,500 |
| Total, State Energy Reliability and Assurance Grants | 0 | 0 | 0 | 63,000 | +63,000 |
| Program Direction | 27,606 | 27,606 | 27,606 | 32,600 | +4,994 |
| **Subtotal, Electricity Delivery and Energy Reliability** | **147,242** | **144,205** | **147,306** | **270,100** | **+122,794** |
| Rescission of prior year balances | 0 | 0 | -331 | 0 | +331 |
| **Total, Electricity Delivery and Energy Reliability** | **147,242[b]** | **144,205** | **146,975** | **270,100** | **+123,125** |
| | | | | | |
| **Federal FTEs** | **80** | **80** | **83** | **99** | **+16** |
| Additional FE FTEs at NETL supporting OE[c] | 31 | 31 | 29 | 29 | 0 |
| Total OE-funded FTEs | 111 | 111 | 112 | 128 | +16 |

SBIR/STTR:

- FY 2014 Transferred: SBIR: $2,657; STTR: $380
- FY 2015 Projected: SBIR: $2,702; STTR: $373
- FY 2016 Request: SBIR: $3,720; STTR: $559

[a] Funding reflects the transfer of SBIR/STTR to the Office of Science.
[b] The $147,306,000 appropriation was reduced by $64,000 for a rescission for Contractor foreign travel.
[c] OE funds 29 FTEs at FE's National Energy Technology Laboratory who support OE activities. The 29 FTEs are in FE's FTE totals and are not included in the OE FTE totals shown on the "Federal FTEs" line.

## Clean Energy Transmission and Reliability

### Overview

The Clean Energy Transmission and Reliability (CETR) program improves energy system decision-making through system measurement, modeling, and risk analysis. CETR develops and demonstrates the transmission-level measurement systems, as well as software models and tools, that enable electricity system stakeholders to better manage their systems. The results of CETR's investments include operational improvements that allow operators to better monitor system conditions and maintain system stability, incorporate new generating resources, manage demand response resources, and accommodate active consumer loads. CETR also improves system planning under deep uncertainty in policy, technology, system evolution, and demand for electricity, among other factors. Further, CETR assesses integrated energy system performance and risk, working closely with Federal-, state-, and local-level partners and stakeholders to encourage risk-informed investments and operations.

The electricity system depends upon the inherent stability of a network of traditional power plants to balance electricity supply and demand. When disruptions occur, operators typically are able to direct actions to maintain system stability. But the basis of the system is changing:

- Changing sources of electricity generation reduce the inertia, and thus the inherent stability, of the system.
- Wind and solar generating resources are highly variable and their increasing use introduces uncertainty in whether the resource is available and how it interacts with the system.
- A wide range of loads are becoming active participants in the electricity system, adding an additional level of complexity to system modeling and operations.

The electricity system must provide key services even during disruptions. Recent weather-related events have reinforced the urgent need for reliable and robust monitoring, modeling, and analytical capabilities to support not only the industry, but also emergency response efforts at the state and Federal levels.

CETR organizes its activities into three subprograms, Transmission Reliability, Advanced Modeling Grid Research, and Energy Systems Risk and Predictive Capability (formerly Energy Systems Predictive Capability), which support research, development, and demonstration in three areas:

- **Measurements** builds on the deployment of time-synchronized, phasor measurement units (PMUs), commonly referred to as synchrophasors, and the establishment of the communication networks that link these devices together. CETR managed nine Recovery Act projects that deployed measurement and communication systems; as a result of these investments, the number of synchrophasors on the network has increased from 200 at the start of the program to almost 2,000 today, and wide-area visibility into the grid is a reality. CETR is now focused on demonstrating value-added applications of the technology that include: performing forensic analysis after an event (e.g., after the 2011 Southwest Blackout); identifying when a power system component is failing, thus enhancing equipment maintenance; improving the estimate of the state of the system, thus improving market behavior and reliability; and enhancing overall system efficiency and asset utilization.
- **Advanced modeling** transforms real-time measurements of what is happening into information about what could happen, improving operational decision making. When a reliability or security event occurs, model-based decision support tools are essential to identify opportunities for operational flexibility that help guide operators quickly along a path to recovery.
- **Predictive analytics** for energy systems combines Big Data and energy systems analysis to assess energy infrastructure system risks. CETR uses the analysis results to inform emergency response to events affecting energy systems and to develop tools to assist stakeholders in near- and long-term risk-informed decision making, helping to minimize potential disruptions.

CETR directly engages energy stakeholders and decision makers to disseminate research results and to promote application development, innovation, and risk-informed energy system decisions. CETR activities also focus on advancing university-based power systems research, thus ensuring an enduring strategic national capability for advancement in this essential area.

**Highlights of the FY 2016 Budget Request**

CETR's investments will lay the foundation for a modern grid and ensure that investments made to improve energy infrastructure appropriately factor risk and uncertainty as a key element. For FY 2016, CETR focuses its efforts in the following ways:

- Research investments target fundamental measurements and tools needed by the grid to ensure continued reliability, economic competitiveness, and resilience.
- Applications and solutions are developed in close partnership with the electricity industry to guarantee wide deployment of new grid management tools.
- A thorough accounting of risks to energy systems and services facilitates decision-making by states and communities, the private sector, and the Federal government to make appropriate tradeoffs regarding investments in energy systems.
- Robust engagement and joint problem-solving with the private sector, states, and communities accelerates innovation, the translation of research and development to commercial application, and risk-informed decision making regarding energy infrastructure.

Within the FY 2016 Budget Request, CETR supports the Departmental Grid Modernization crosscut. The goal of the Grid crosscut is to create tools and technologies that measure, analyze, predict, and control the grid of the future; focus on key policy questions related to regulatory practices, market designs, and business models; and collaborate with stakeholders to test and demonstrate combinations of promising new technologies. The entire CETR program supports this crosscut.

**FY 2016 Crosscuts ($K)**

| | Grid Modernization |
|---|---|
| Clean Energy Transmission and Reliability | 40,000 |

**Clean Energy Transmission and Reliability**
**Funding ($K)**

| | FY 2014 Enacted | FY 2014 Current[a] | FY 2015 Enacted | FY 2016 Request | FY 2016 vs FY 2015 |
|---|---|---|---|---|---|
| **Clean Energy Transmission and Reliability** | | | | | |
| Transmission Reliability | 18,190 | 17,608 | 17,424 | 18,000 | +576 |
| Advanced Modeling Grid Research | 10,195 | 9,868 | 10,648 | 15,000 | +4,352 |
| Energy Systems Risk and Predictive Capability | 3,998 | 3,998 | 6,190 | 7,000 | +810 |
| **Total, Clean Energy Transmission and Reliability** | **32,383** | **31,474** | **34,262** | **40,000** | **+5,738** |

SBIR/STTR:

- FY 2014 Transferred: SBIR: $795; STTR: $114
- FY 2015 Projected: SBIR: $814; STTR: $112
- FY 2016 Request: SBIR: $990; STTR: $149

[a] Funding reflects the transfer of SBIR/STTR to the Office of Science.

**Clean Energy Transmission and Reliability**
**Explanation of Major Changes ($K)**

| | FY 2016 vs FY 2015 |
|---|---|
| **Transmission Reliability**: Increased support for value-added applications of synchrophasors for transmission asset owners. | **+576** |
| **Advanced Modeling Grid Research**: Increase reflects expansion of university research in mathematics for power systems, and a competitive solicitation focused on maturing basic research into industrial applications to improve operational reliability and security. | **+4,352** |
| **Energy Systems Risk and Predictive Capability**: The increase will help connect and further integrate the research outputs of the Transmission Reliability and Advanced Modeling Grid Research subprograms into the products developed by ESRPC. In FY 2016, Energy Systems Predictive Capability has been renamed to Energy Systems Risk and Predictive Capability. | **+810** |
| **Total, Clean Energy Transmission and Reliability** | **+5,738** |

**Description**

The Transmission Reliability subprogram supports partnerships among DOE national laboratories, universities, and the electricity industry to develop and deploy advanced technologies that enhance the reliability of U.S. electricity transmission infrastructure. Competition and market forces are increasing the volume of power transactions exponentially. In addition, coal plant retirements, abundant low-cost natural gas, and integration of large wind plants are transforming the nature and character of electricity generation and causing the grid to be used in ways for which it was not designed. Time synchronized measurements from advanced sensors (the sensors are phasor measurement units [PMUs] and their measurements become synchrophasors when aggregated) installed on the transmission system can monitor the flow of electricity with much greater precision and provide unprecedented insight into system health. Transmission Reliability funds the development of cyber-secure applications employing synchrophasor data to enhance the flexibility, reliability, and resilience of the Nation's power system.

Following the 2003 Northeast blackout report and findings, DOE and the North American Electric Reliability Corporation (NERC) joined with North American electric utilities, vendors and researchers to form the North American Synchrophasor Initiative (NASPI) with the goal of improving the reliability of the power system through wide-area measurement, analysis tools, and control. The collaborative has worked to deploy networked phasor measurement units and visualization tools nationwide, advance information sharing, and promote joint problem solving among utilities, vendors, universities, and governments. Funding from the Recovery Act accelerated this process and catalyzed investment: from 2009 through 2013 the number of networked phasor measurement units deployed on the U.S. electricity transmission system grew from approximately 200 to over 1,600.

In FY 2016, OE will complete development of multiple synchrophasor-based, production-grade software applications that will be purchased by utilities committed to installing these applications at their own expense. These applications will monitor and control the grid with advanced analysis, visualization, and decision-support tools, and will maximize the value of synchrophasor data now available to grid operators to improve reliability.

OE will also focus on inter-entity data exchange to ensure seamless and secure operations and operational planning. Although some neighboring utilities exchange real-time operational data, it is not done consistently or uniformly across interconnections. Moreover, exchanged data is often in a form that cannot readily be processed by neighbors' applications. This effort will develop an operational platform that enables neighboring utilities to exchange not only raw data but also the outputs of key applications including state estimation and contingency analysis. By accomplishing these objectives, Transmission Reliability promotes the transformation of the electricity transmission system from one based on models supported by few measurements to one based on direct real-time measurement with value-added models.

As synchrophasor data become available, Transmission Reliability accelerates the development of advanced operational tools that detect, analyze, and track grid dynamics and provide system operators with better monitoring through real-time visualization measurements of system conditions. These capabilities will continue to improve over time as more data are collected, thus feeding operator decision-support tools based on real-time measurement and advanced visualization. OE expects these advances to lead to automated system control applications and increased visibility for operators, resulting in measurable decreases in both the spread and duration of system outages by 2020.

Had PMUs been in place, the start of the 2003 blackout would have been detected by system operators 90 seconds prior to the initial event versus seven minutes later when the final cascading failure occurred on the system. PMUs provided immediately accessible data to conduct forensic analysis of the 2011 Southwest Blackout; in 2003, data had to be collected from each affected utility and the process took months. Thus investigators completed their work in weeks in 2011 rather than eight months as in 2003.

Transmission Reliability activities directly support the Grid Sensing and Measurement, and Design and Planning Tools pillars of the Grid Modernization crosscut. Success in this program is also essential to achieve the System Control and Power Flow goals of the Grid Modernization initiative.

**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **Transmission Reliability $17,424,000** | **$18,000,000** | **+$576,000** |
| • Continue technical support for the North American Synchrophasor Initiative (NASPI) and related efforts to publically document Smart Grid Investment Grant synchrophasor project results and benefits.<br>• Analyze the content of synchrophasor data to identify possible signatures characteristic of physical attacks, incipient equipment failures, and health on the transmission grid.<br>• Co-fund the National Science Foundation Center for Ultra-Wide-area Resilient Electric Energy Transmission Networks (CURENT) Engineering Research Center.<br>• Demonstrate a synchrophasor-based model-less state estimator.<br>• Continue development of the grid-planning tools using high-fidelity representations of the system rather than approximations as is the case today. | • Install PMU-based technology to perform on-line generator model validation that is required by NERC for all large generators.<br>• Continue support of NASPI to advance information sharing and joint problem-solving among utilities, vendors, universities, and the government, including two annual workgroup sessions.<br>• Co-fund National Science Foundation CURENT Engineering Research Center.<br>• Develop PMU-based algorithms that allow transmission operators to identify and react to incipient equipment malfunction, physical attacks, and geomagnetic disturbance events on the grid, thus improving system reliability and providing direct value to transmission system owners and operators. | • Increased support for value-added applications of synchrophasors for transmission asset owners.<br>• Expand analysis of potential applications of synchrophasor technology to local electric distributions systems with respect to emerging resources integration including microgrids, distributed generation and storage, demand response monitoring, and electric vehicle charging that is responsive to grid reliability and economic efficiency requirements. |

**Description**

The Advanced Modeling Grid Research subprogram supports research and development of more sophisticated, model-based analytical tools, which are necessary for effective planning and operations of the electric system. Research focuses on the modeling, computational, and mathematical advancements that are the foundation of energy management systems used by operators to plan, monitor, and control the electric system. This level of decision-making support requires integrating data-driven analytics, based on real-time operational measurements from across the electric system, with advanced modeling and simulation capabilities. Results inform control and protection approaches, as well as how information is displayed to operators to support timely decision making. Investments will increase the operational efficiency of the electric system, promote seamlessness between operations and operational planning, improve reliability, enhance resilience, and allow for visibility and control across the electricity transmission and distribution systems.

Advanced Modeling Grid Research will enhance reliability and enable advanced mitigation and recovery strategies, by:

- *Accelerating performance*—improving grid resilience to fast time-scale phenomena that drive cascading network failures and blackouts;
- *Developing predictive decision-support capabilities*—relying on high-fidelity measurements and improved models to represent the operational attributes of the electric system, improving prediction of system behavior and identification of system anomalies, assessing uncertainties, and proactively informing operator decision-making; and
- *Integrating model platforms*—capturing the interactions and interdependencies that improve operational planning, facilitating development and validation of new control and protection techniques, improving insight into the delicate balance between generation and load, and enabling dynamic reconfiguration of electric system elements to achieve both technical and economic objectives.

The program supports research and development in three major areas:

- **Data Management and Analytics.** These activities focus on the way data are collected, used, stored, and archived to facilitate the use of large, multi-source datasets to support operations and off-line planning.
- **Mathematical Methods and Computation.** These activities develop new algorithms and software libraries for use on high performance computing platforms, which leverage the investments of the Advanced Scientific Computing Research program in the Office of Science and work at ARPA-e in stochastic optimization. These new methods will form the foundation of the next generation of tools that operators and operational planners will use to manage the system.
- **Models and Simulations.** These activities perform research and development on new classes of models and fast simulations that are able to incorporate operational data, analyze potential futures, and guide decision making to ensure reliable operation in a large-scale, dynamic, and uncertain environment.

In FY 2016, the program plans to conduct a competitive solicitation to accelerate the transition of the foundational research in mathematics and models into industry-relevant applications to improve reliability and security.

Advanced Modeling Grid Research activities directly support a key pillar of the Grid Modernization cross cut: development of advanced Design and Planning tools. Success in this program is also essential to achieve the System Control and Power Flow goal of the Grid Modernization initiative, which is dependent on the mathematical and computational advances pursued by Advanced Modeling Grid Research.

**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **Advanced Modeling Grid Research $10,648,000** | **$15,000,000** | **+$4,352,000** |
| • Continue research to accelerate state estimation and contingency analysis, to achieve "faster than real-time" dynamic simulations, and to consolidate planning and system protection models.<br>• Continue development of a software repository for mathematical methods and solvers.<br>• Foster dissemination of open source software developed for power system applications.<br>• Construct a set of dynamic models for the Eastern Interconnection.<br>• Demonstrate a VAR planning tool using representative industry data.<br>• Validate prototype tool to assess the effect of extreme contingencies across wide areas. | • Expand mathematics and computational research to include uncertainty quantification, model formulation and reduction, and controls.<br>• Continue efforts in architecture and data analytics.<br>• Assess performance of open source mathematical methods and solvers (from the software repository) in prototype power system application.<br>• Characterize system performance under dynamic and abnormal conditions. Release competitive solicitation focused on demonstrating the capability to forecast grid behavior under uncertainty thus improving the ability of operators to respond to changes in the system. | • Increase reflects expansion of university research in mathematics for power systems, and a competitive solicitation focused on maturing basic research into industry applications to improve operational reliability and security. |

## Clean Energy Transmission and Reliability
## Energy Systems Risk and Predictive Capability[a]

### Description

The devastating effects of Superstorm Sandy in 2012, Hurricanes Gustav and Ike in 2008, Katrina and Rita in 2005, and the 2013-2014 western drought and accompanying wildfires illustrate the need for national capabilities to assess near- and long-term risks to energy infrastructures, the services they provide, risks, and reliability.

The Energy Systems Risk and Predictive Capability (ESRPC) subprogram performs predictive modeling and risk analyses on a system-level basis to assess how interdependent energy infrastructure systems are impacted by forecasted and unforeseen events. ESRPC builds and develops products that assess energy system risks from both natural and man-made threats. The products developed by ESRPC inform energy industry and government decision makers regarding how energy systems operate and respond to disturbances and provide analytical and modeling support to long-term planning activities.

ESRPC's goal is to advance risk informed decision making regarding energy systems. Potential near-term actions include developing strategies to reduce the risk of system interruptions due to extreme weather, while longer-term actions include identifying a portfolio of energy system improvements that could potentially reduce the system-wide risks from events. Developing a predictive capability is necessary because understanding potential impacts to the energy system in advance and communicating them to officials and responders in anticipation of a disruption can assist in near- and long-term planning and response, motivate system improvements that enhance reliability, and reduce vulnerability to other events

In FY 2016, ESRPC will focus on furthering the development of analytical tools that estimate seasonal and regional extreme weather risks to energy systems for stakeholders including the general public, the energy industry, and State and Federal partners. ESRPC focuses its risk analysis on events which affect large geographic areas including extreme temperature events, snow and ice storms, tropical cyclones (hurricanes), and drought-based events, including wildfires. Funding in FY 2016 will also be used to connect and further integrate the research outputs of the Transmission Reliability and Advanced Modeling Grid Research subprograms into the products developed by ESRPC.

ESRPC analyses generally will fall in one of three categories:

- **Analytical and predictive modeling products supporting emergency response.** Activities measurably improve the preparation for, response to, and recovery from disruptions to U.S. energy systems by providing real-time information regarding the extent of the disruption and likely near- and long-term effects. This capability develops analytical products that rely upon data-driven predictive analytics. ESRPC also assesses the performance of systems and predictive models after events.
- **Analytical products supporting risk-informed decision making in energy system planning**. ESRPC performs long-range modeling and analysis of U.S. energy infrastructure risks. The targeted decision time frame is 5 to 8 years in the future, which corresponds to the time frame that public and private decision makers approve and build expansion projects. However, because infrastructure decisions could last 30 years or more, appropriately communicating long-term uncertainty is essential to a successful process. The result is that the government, system owners and operators, and the public are able to make quantitative risk-informed tradeoffs regarding energy system investments, such that the performance of energy systems and the private and social benefits are clear. For example, in 2014 OE completed an analysis of the impact of sea-level rise on energy infrastructure in four cities.
- **Analytical tools supporting contingency planning from non-traditional events.** ESPC develops analytical tools and methods to support system planning and operations stakeholder evaluations of risk to energy systems from non-traditional sources of man-made risk (such as supply chain disruptions). The tools and methods provide system planners, system operators, and government stakeholders rigorous, consistent, and data-driven methods to evaluate risks to energy systems.

For ESRPC to achieve its goals, it is essential that it maintain strong partnerships with key decision makers. ESRPC maintains formal and informal partnerships with organizations that collect data on the U.S. energy system including the Energy Information Administration, the Federal Energy Regulatory Commission, and the North American Electric Reliability Corporation. ESPRC also maintains strategic relationships with the National Oceanic and Atmospheric Administration, the U.S. Department of Homeland Security, including the Federal Emergency Management Agency; the Department of

[a] The Energy Systems Risk and Predictive Capability subprogram was formerly named Energy Systems Predictive Capability.

Transportation; the Environmental Protection Agency, the Pipeline and Hazardous Materials Safety Administration; industry trade associations; owners and operators from the electricity, oil and natural gas sectors; universities and researchers; National Laboratories; and state and local governments.

ESRPC directly supports the Grid Security and Resilience pillar of the Grid Modernization crosscut by assessing and communicating risks to energy infrastructure systems.

**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **Energy System Risk and Predictive Capability** | | |
| **$6,190,000** | **$7,000,000** | **+$810,000** |
| • Validate and verify outputs developed using the analytical platform.<br>• Continue integration of historical and operational data feeds into the analytical platform.<br>• Provide analytic support for the OE's emergency response activities under ISER in advance of and following energy system events.<br>• Continue analyzing interdependent energy infrastructure risks.<br>• Test analytical capabilities to deliver risk and impact analysis of events that impact energy system reliability.<br>• Begin building a capability to analyze the performance of and risks to oil and natural gas infrastructure.<br>• Design an open-source representation of the electricity system for use in near- and long-term risk assessment, modeling, and simulation.<br>• Develop and pilot test a program which educates stakeholders how to understand, assess, and communicate risks to the energy system, thus advancing risk-informed decision making regarding energy infrastructure investment. | • Advance predictive analytics on interconnected energy infrastructure systems to include understanding of how historical performance predicts future system performance.<br>• Begin connecting research data from the Transmission Reliability and Advanced Modeling Grid Research subprograms to the ESRPC analytical platform.<br>• Advance real-time predictive analytics to enhance Federal, State, local, and industry knowledge for events.<br>• Continue to enhance and strengthen partnerships to ensure the program delivers value to all stakeholders.<br>• Begin wide-scale deployment of a program to educate stakeholders on how to understand, assess, and communicate risk to the energy system.<br>• Provide real time analysis support for all high profile events.<br>• Deploy a capability to assess risks to interdependent energy infrastructure. | • The increase will help connect and further integrate the research outputs of the Transmission Reliability and Advanced Modeling Grid Research subprograms into the products developed by ESRPC. |

## Clean Energy Transmission and Reliability
## Performance Measures

In accordance with the GPRA Modernization Act of 2010, the Department sets targets for, and tracks progress toward, achieving performance goals for each program.

| | FY 2014 | FY 2015 | FY 2016 |
|---|---|---|---|
| Performance Goal (Measure) | **Transmission Reliability**—Demonstrate and implement technologies and tools that improve the monitoring of transmission system health and the ability of operators to respond quickly and effectively to address issues. | | |
| Target | Demonstrate an Oscillation Detection System in the Eastern Interconnection. | Demonstrate an open-source, synchrophasor-based tool that can be used for demonstrating compliance with the frequency response requirements contained NERC Standard BAL-003. | Develop a prototype wide-area synchrophasor-based voltage stability tool. |
| Result | Met | | |
| Endpoint Target | Realization of a nationwide synchrophasor network with 100% sensor coverage of the transmission system by 2020, allowing for complete, real-time monitoring of transmission component health and system health and system status. | | |
| Performance Goal (Measure) | **Advanced Modeling Grid Research**—Development of capabilities in understanding, modeling, and predicting grid behavior in real-time. | | |
| Target | Demonstrate (at laboratory scale) fast state estimation, fitting steady-state model with 5-second SCADA data. | Demonstrate (at laboratory scale) high-performance dynamic simulation capability for assessing potentially destabilizing events. | Demonstrate simulation capabilities in a prototype operational tool that can be used in real-time to identify available operating margins. |
| Result | Met | | |
| Endpoint Target | Realization of advanced modeling capabilities, including dynamic operation, real-time analysis, and predictive response. | | |

| | FY 2014 | FY 2015 | FY 2016 |
|---|---|---|---|
| Performance Goal (Measure) | **Energy System Risk and Predictive Capability**—Provide Federal agencies, states, and sector stakeholders with independent and transparent analyses of risks to energy infrastructure systems and supply chain impacts. | | |
| Target | N/A | Validate and verify energy risk analysis products developed using the analytical framework. | Release products to stakeholders incorporating advanced predictive analytics on interconnected energy infrastructure systems to include understanding of how historical asset performance affects overall system performance. |
| Result | N/A | | |
| Endpoint Target | This subprogram develops tools and robust predictive analytic products which assist decision makers in assessing current and future risks to the reliability of inter-dependent energy systems. | | |

## Smart Grid Research and Development

### Overview

The Smart Grid program focuses primarily on the development of technologies, tools, and techniques to modernize the distribution portion of the electric delivery system: the infrastructure that takes power from the transmission system and delivers it to individual businesses and homes. Smart Grid pursues strategic investments to improve reliability, operational efficiency, and resiliency, and outage recovery, building upon previous and ongoing grid modernization efforts, including the American Recovery and Reinvestment Act of 2009 (ARRA) Smart Grid Investment Grants and Smart Grid Regional Demonstrations. Significant progress has been made towards grid modernization within the distribution infrastructure, but many technical challenges requiring continued Federal R&D investment remain.

One challenge driving distribution system modernization is the ever changing capabilities necessary to meet our Nation's the evolving electricity needs. These include accommodating greater numbers of customer owned distributed generation, including solar photovoltaics (PV); supporting the shift towards the electrification of transportation such as electric automobiles; enabling greater customer choice and control over electricity consumption; being more resilient to extreme weather events such as Superstorm Sandy; reducing the length and number of outages overall; and, at the same time, maintaining affordability.

Information and communication technology advances have initiated opportunities to leverage increased data volumes as never before possible to begin addressing many distribution grid operation technical challenges, including increased demand and supply variability; bi-directional power flow, data management, and security; interoperability between new and legacy technologies and devices; and the increasing interdependencies between distribution and transmission operations.

Microgrid research investments have shown success in addressing reliability, efficiency, emissions reduction, and resilience and will continue to be a major thrust within the Smart Grid program. New approaches and technologies will also be investigated, ranging from Advanced Distribution Management System (ADMS) enabling a whole new level of visibility and control across a utility's entire service territory, to transformative approaches in Market-Based Control paradigms that rely on competitive forces to control and optimize distribution assets, to the development of new applications leveraging system data for improved utility operations and to stimulate new products and services for consumers. Exploring innovative and transformative solutions based on data driven applications will continue to be the cornerstone of OE's Smart Grid Program.

### Highlights of the FY 2016 Budget Request

The FY 2016 request includes a new investment in developing the Advanced Distribution Management System. An initial version of an open source integrated software platform for varying vendor systems will be developed which supports the full suite of distribution management applications (such as voltage and reactive power optimization; fault location, isolation, and service restoration; economic dispatches; and optimization routines).[a] This integrated platform, based on specifications and requirements to be developed jointly with utilities, will allow information to flow between individual applications across the entire utility enterprise, enabling enhanced visibility and controllability of system assets. Development and evaluation of the ADMS platform will be conducted in a utility-centric environment, involving qualified system operators from distribution utilities of varying sizes, to ensure that the capabilities being developed are applicable to the largest possible cross section of utilities. Investments leveraging the increased types and volume of available system data, due to a recent surge in advanced technology deployments, will also be explored to develop new applications. These new applications will greatly enhance observability and controllability required to integrate large amounts of renewables in a safe and effective manner, utilize assets more efficiently during restorations, enable much wider range of choices for consumers, and maintain affordable electricity rates.

Smart Grid investments will also explore market-based controls in FY 2016. Coupling market-based control signals with electric distribution operations, generally known as transactive energy, will create value to both utilities and customers. This new control paradigm will enable utilities to balance supply and demand at all levels of the grid, by actively seeking

[a] Vendor systems for integration by ADMS include traditional DMS, geographic information systems, outage management systems, customer information systems, advanced metering infrastructure/automatic meter reading, and supervisory control and data acquisition (SCADA).

participation of customer-owned and third-party assets in grid services through transparent, competitive forces of demand and supply. The prices or incentives offered by market forces will engage the self-interest of customers and other third parties, and will also serve as a control signal to coordinate operations of their assets with the power grid. Hence, transactive energy will result in greatly increased flexibility needed for maintaining reliability in a low-carbon future, while allowing customers to fully participate in grid operations

Market-Based Control Signal activities in FY 2016 include developing simulation tools and test cases, as well as validating tools using the initial test cases that were developed under ARRA Grid Modernization projects. Transactive approaches developed by research organizations and industry will be evaluated to refine controllability, stability limits, and efficacy of operating distributed assets (end-use devices, distributed generation, batteries, PV solar systems, inverters, EV chargers, etc.) and networked communication systems.

Finally, Smart Grid will expand investments in activities to achieve the DOE 2020 microgrid performance targets and meet the R&D needs for a resilient electric distribution grid, both of which were formulated with engagement of a broad range of stakeholder groups.[a] FY 2016 Microgrid R&D activities support ongoing work to develop reliable and resilient microgrid concepts and will also include new projects to be awarded through a funding opportunity announcement (FOA) on networked microgrids, following the defined R&D pathway from single microgrids toward an integrated network of multiple microgrids as a building block for the smarter grid of the future. National laboratory R&D will continue, including completion of a second-generation Microgrid Design Toolset prototype for microgrid design analysis with enhanced features recommended by the Industry Advisory Group, and development of a grid interactive microgrid controller to support distribution system applications, while being visible to the transmission system operator.

Resilient Electric Distribution Grid R&D activities in FY 2016 will continue to support the Administration's initiatives to establish partnerships with U.S. cities and tribal communities on deployment of smart grids and microgrids for climate preparedness and resilience. Technical assistance from national labs will support the communities selected from the FY 2015 Resilient Electricity Delivery Infrastructure (REDI) FOA, encompassing risk assessment and management, resilient energy system analysis, and deployment of best practices/technologies/tools. National laboratory R&D will continue in developing a decision support analysis tool by leveraging models developed under the DHS National Infrastructure Simulation and Analysis Center to enable distribution grid planners to determine and prioritize system upgrades and expansions needed for enhanced resiliency. In addition, the Electric Resilience Assessment Program—Distribution (ERAP-D) tool prototype will be ready for use by distribution utilities to conduct holistic assessment of grid resilience through the synthesis of physical infrastructure information as well as company plans, policies, and procedures. The ERAP-D tool development builds on the resilience assessment tool developed under the DHS Regional Resiliency Assessment Program.

The planned FY 2016 Smart Grid investments in ADMS, Market-Based Controls, Microgrids, and Resilience Electric Distribution Grid R&D strengthen the resilience of electrical infrastructure against adverse effects of future extreme weather phenomena and other unforeseen occurrences, directly supporting the efforts to prepare the Nation for the impacts of climate change. Further, Microgrid R&D is a strategy element in the DOE Implementation of the President's Climate Action Plan. Smart Grid activities support the President's vision of generating 80 percent of America's electricity from clean sources by 2035. Lastly, Smart Grid activities respond to one of the four pillars, empowering consumers and enabling them to make informed decisions, identified in the Administration's report "*A Policy Framework for the 21st Century Grid: Enabling Our Secure Energy Future*" by the National Science and Technology Council.[b]

Within the FY 2016 Budget Request, Smart Grid supports the Departmental Grid Modernization crosscut. The Grid crosscut goal is to create tools and technologies that measure, analyze, predict, and control the grid of the future; focus on key policy questions related to regulatory practices, market designs, and business models; and collaborate with stakeholders to test and demonstrate combinations of promising new technologies. The entire Smart Grid program supports this crosscut.

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[a] The DOE 2020 microgrid performance targets and associated key R&D activities are documented in the 2012 *DOE Microgrid Workshop Summary Report*, available at http://energy.gov/oe/downloads/2012-doe-microgrid-workshop-summary-report-september-2012. Key R&D needs and projects for a resilient electric distribution grid are documented in the 2014 *DOE Resilient Electric Distribution Grid R&D Workshop Summary Report,* available at http://energy.gov/oe/articles/final-report-and-other-materials-2014-resilient-electric-distribution-grid-rd-workshop.

[b] http://www.whitehouse.gov/sites/default/files/microsites/ostp/nstc-smart-grid-june2011.pdf.

**FY 2016 Crosscuts ($K)**

| | Grid Modernization |
|---|---|
| **Smart Grid Research and Development** | **30,000** |

**Smart Grid Research and Development**
**Funding ($K)**

| | FY 2014 Enacted | FY 2014 Current[a] | FY 2015 Enacted | FY 2016 Request | FY 2016 vs FY 2015 |
|---|---|---|---|---|---|
| **Smart Grid Research and Development** | **14,592** | **14,125** | **15,439** | **30,000** | **+14,561** |

SBIR/STTR:

- FY 2014 Transferred: SBIR: $409; STTR: $58
- FY 2015 Projected: SBIR: $448; STTR: $62
- FY 2016 Request: SBIR: $900; STTR: $135

[a] Funding reflects the transfer of SBIR/STTR to the Office of Science.

**Smart Grid Research and Development**
**Explanation of Major Changes ($K)**

| | FY 2016 vs FY 2015 |
|---|---|
| The increase expands development of the Advanced Distribution Management System (ADMS) and Market-Based Control Signals. | **+14,561** |

**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **Smart Grid Research and Development $15,439,000** | **$30,000,000** | **+14,561,000** |
| • Launch a direct current (DC) microgrid initiative to achieve climate-neutral buildings with awards for new industry and national laboratory projects.<br>• Continue to support national laboratory microgrid R&D on developing a prototype Microgrid Design Toolset and an integrated microgrid controller, as well as for resiliency focusing on operational response to grid disturbances, and distribution system restoration and recovery.<br>• Continue to support resilient grid R&D by national labs, including development of a prototype of the optimal resilience tool for multiple hazards (ice and flooding in FY 2015) by leveraging models developed under the DHS National Infrastructure Simulation and Analysis Center, and the proof-of-concept Electric Resilience Assessment Program—Distribution tool that builds on the resilience assessment tool developed under the DHS Regional Resiliency Assessment Program.<br>• Establish partnerships with U.S. cities and tribal communities, through the Resilient Electricity Delivery Infrastructure (REDI) FOA, to deploy smart grids and microgrids for climate preparedness and resilience.<br>• Continue support of interoperability and conformance testing to promote standards acceptance by utilities. | • Award new projects in networked microgrid R&D through a FOA to achieve full integration of a network of multiple microgrids with distribution systems.<br>• Continue to support national laboratory microgrid R&D, including transitioning the Microgrid Design Toolset and a grid interactive microgrid controller to industry for microgrid planning/design and operations/control, respectively; DC microgrids for climate-neutral buildings; and microgrids as a grid resource for reliability and resilience.<br>• Continue to support national laboratory resilient grid R&D, including: further development of a decision support analysis tool for other extreme weather hazards; and transitioning of the ERAP-D tool for use by distribution utilities.<br>• Continue to support the REDI projects by providing technical assistance from national labs to awarded U.S. cities and tribal communities.<br>• Develop the specifications for an open source ADMS platform for interconnection and interoperability with various systems and applications.<br>• Begin work on ADMS test cases and an ADMS test bed for evaluation under operating environments; begin testing of ADMS platform utilizing the test bed and test cases. | The increase launches efforts in ADMS and Market-Based Control Signals.<br>In ADMS:<br>• Begin construction of an open source ADMS platform based on the specifications developed jointly with utilities.<br>• Develop utility defined use cases.<br>• Develop data analytics for large volumes of grid data from connected devices for enhanced visibility and for validation of distribution grid operations.<br>In Market-based Control Signals:<br>• Evaluate the performance of various transactive approaches developed by research organizations and industry; enhance existing tools to refine controllability, stability limits, and efficacy.<br>• Establish a standard means of quantifying the value of various grid services and determining the net value provided by the distributed assets. |

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes<br>FY 2016 vs FY 2015 |
|---|---|---|
| | • Launch research activities to develop new applications compatible with the open source ADMS platform that leverage the vast amounts of available system data for improved grid operations.<br>• Establish a standard means of quantifying the value of various grid services and determining the net value provided by the distributed assets.<br>• Develop control algorithms for end-use devices (water heaters, refrigerators, clothes dryers, and variable speed drives) to respond to market-based control signals for the provision of ancillary services.<br>• Evaluate transactive approaches developed by research organizations and industry, and enhance existing simulation and modeling tools to attain stable, predictable response with increased efficiency. | |

## Smart Grid Research and Development
## Performance Measures

In accordance with the GPRA Modernization Act of 2010, the Department sets targets for, and tracks progress toward, achieving performance goals for each program.

| | FY 2014 | FY 2015 | FY 2016 |
|---|---|---|---|
| Performance Goal (Measure) | Increase in load factor, reduction in outage durations (system average interruption duration index, or SAIDI) of the distribution system, and reduction in outage time of critical loads on smart microgrids. | | |
| Target | Demonstrate a grid-connected microgrid equipped with an advanced control algorithm, to achieve enhanced distribution system restoration. | Complete development of a prototype Microgrid Design Toolset that is used by at least one A&E firm for microgrid design analysis. | Complete development and pilot testing of a prototype Electric Resilience Assessment Program—Distribution tool to provide a holistic picture of grid resilience to utility owners and operators. |
| Result | Met | | |
| Endpoint Target | Achievement of a self-healing and resilient distribution grid, with integration of networked microgrids and market-based control signals operating under the ADMS, that allows for widespread deployment of distributed renewable and clean energy resources and demand response by 2030. | | |

## Cybersecurity for Energy Delivery Systems

### Overview

The energy sector, which includes both the electricity and oil and natural gas sectors, has been subjected to a dramatic increase in focused cyber probes, data exfiltration, and malware development for potential attacks in recent years. The sophistication and effectiveness of these intrusions mark the transition to an era of state actor level threats to the United States. As the energy sector-specific agency (SSA), DOE has the mission and domain expertise to work with industry to mitigate the risk resulting from the cyber-physical coupling within the energy environment. DOE's long history of collaboration with industry has created integral relationships to activities that expand situational awareness (e.g., data exfiltration) and information sharing to reduce cyber risk. Reliable and resilient energy infrastructure is essential to our economy, health and safety, and national security. Energy delivery system cybersecurity has emerged as one of the Nation's most vital grid modernization and infrastructure security issues. Innovative solutions designed to meet the unique requirements of high-reliability energy delivery systems are urgently needed to ensure the success of grid modernization and transformation of the Nation's energy systems to meet future needs for economic growth. Effective solutions must be based on industry best practices, sound risk management processes, and improved situational awareness, and will require multi-disciplinary collaborations and shared expertise in power systems engineering, computer science, and cybersecurity.

As the energy SSA, the Department's ongoing collaboration with vendors, utility owners, and operators of the electricity and oil and natural gas sectors strengthens the cybersecurity of critical energy infrastructure against current and future threats. Presidential Policy Directive 21, *Critical Infrastructure Security and Resilience*, directs the SSAs to serve as a day-to-day Federal interface for the dynamic prioritization and coordination of sector-specific activities; carry out incident management responsibilities consistent with statutory authority and other appropriate policies, directives, or regulations; and provide, support, or facilitate technical assistance and consultations for each sector to identify vulnerabilities and help prevent or mitigate the effects of incidents, as appropriate.[a] In meeting this requirement for the Department, OE's Cybersecurity for Energy Delivery Systems (CEDS) program is supporting cyber risk and incident management activities with four key objectives:

- accelerating information sharing to enhance situational awareness;
- expanding implementation of the Cybersecurity Capability Maturity Models and Risk Management Process;[b]
- research and develop technologies to improve energy reliability and resilience; and
- exercising and refining the energy sector's cyber incident response capabilities.

OE's mission to modernize the electric grid cannot be achieved without the research, development, and integration of secure energy delivery control systems. The FY 2016 request supports research and development (R&D) to enhance the reliability and resiliency of the Nation's energy infrastructure by reducing the risk of energy disruptions due to cyber attacks.

The CEDS program structure aligns with the *2011 Roadmap to Achieve Energy Delivery Systems Cybersecurity*, which presents a strategic framework and advances the vision that resilient energy delivery control systems are designed, installed, operated, and maintained to survive a cyber incident while sustaining critical functions.[c] The DOE-facilitated, energy sector-driven Roadmap strategic framework has five focus areas: build a culture of security, assess and monitor risk, develop and implement new protective measures to reduce risk, manage incidents, and sustain security improvements.

CEDS maintains a research, development, and operations portfolio that includes long-, mid-, and short-term efforts that address the long-, mid-, and short-term milestones in the energy sector's Roadmap. National laboratory participation in CEDS projects ensures critical skill sets remain current and sustain core capabilities, ensuring they can provide support to the energy sector in case of a cyber event. CEDS efforts engage energy sector stakeholders from the earliest stages and align with the Roadmap strategy to ensure that CEDS is working the right problems. This approach enables the continuous

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[a] Presidential Policy Directive 21: http://www.whitehouse.gov/the-press-office/2013/02/12/presidential-policy-directive-critical-infrastructure-security-and-resil

[b] Cybersecurity Capability Maturity Models: http://energy.gov/oe/services/cybersecurity/electricity-subsector-cybersecurity-capability-maturity-model; Risk Management Process: http://energy.gov/oe/services/cybersecurity/cybersecurity-risk-management-process-rmp

[c] *Roadmap to Achieve Energy Delivery Systems Cybersecurity*: http://energy.gov/sites/prod/files/Energy%20Delivery%20Systems%20Cybersecurity%20Roadmap_finalweb.pdf

transition of long-term innovative research from the national laboratories and academia into capabilities that the energy sector can put into practice to reduce cyber risk. The dynamic cyber threat landscape, continuous advances in energy delivery system technologies, and the use of legacy devices in ways not previously envisioned underscore the importance of this continuous transition. In addition, CEDS provides strategic leadership on cybersecurity aspects of the energy sector's operational security, asset protection, baseline practices, risk management, situational awareness, incident management, and other issues needed to achieve the Roadmap vision.

**Highlights of the FY 2016 Budget Request**

The FY 2016 request reflects the critical need to accelerate and expand efforts to strengthen the energy infrastructure against cyber threats. Working closely with the Energy Sector and our government partners, the request includes a continued focus in the following areas:

- **Accelerating information sharing to enhance situational awareness in the electricity and oil and natural gas sectors.** In FY 2014, the Cybersecurity Risk Information Sharing Program (CRISP) transitioned from a small DOE-funded electricity sector pilot to a private-sector program primarily funded and managed by the North American Electric Reliability Corporation (NERC) and the electricity subsector companies that participate in the program. NERC expanded its Electricity Sector Information Sharing and Analysis Center duties to include the management of the unclassified elements of CRISP, and DOE is expanding its capability to perform critical classified elements of CRISP. CRISP is a government–energy sector collaboration to facilitate the timely bi-directional sharing of classified and unclassified threat information and develop and deploy situational awareness tools to enhance the sector's ability to identify and mitigate threats and coordinate the protection of critical infrastructure. In FY 2016, unclassified analytic and situational awareness functions managed by NERC will continue to expand, while DOE continues to fund and perform its classified analytical and reporting role. In addition, DOE will issue a competitive solicitation to identify and fund commercially available technologies and services that can be incorporated into CRISP via operational pilots designed to enhance all aspects of the program. As the energy SSA, DOE will also work with the oil and natural gas sector to bring it into CRISP.
- **Expanding implementation of the Cybersecurity Capability Maturity Model and Risk Management Process for both the electricity and oil and natural gas sectors.** In FY 2016, CEDS is expanding online access to the Cybersecurity Capability Maturity Model (C2M2) and Risk Management Process (RMP) guidelines and conducting benchmarking and data analytics of C2M2 evaluation tool results. C2M2 was developed in 2012 with Federal and industry partners to encourage best practice adoption and inform cybersecurity investments. RMP was developed in 2012 with industry partners to enable effective and efficient risk management decisions. Both C2M2 and RMP help utilities improve their organizational and process level cybersecurity posture.
- **Researching, developing, and demonstrating cutting edge cybersecurity solutions in the electricity and oil and natural gas sector**. Energy delivery control systems are uniquely designed and operated to control real-time physical processes that deliver continuous and reliable power to support national and economic security. Cybersecurity technologies developed to protect business IT computer systems and networks can inadvertently damage energy delivery control systems, which require cybersecurity solutions meeting unique performance requirements and operational needs. For example, some energy delivery system communications must be fast, such as time-critical responses of less than four milliseconds for protective relaying. In addition, they must have high availability; they cannot be patched or upgraded without extensive testing and validation, normally planned weeks or months in advance, to ensure that the change does not jeopardize power system operations. In FY 2016, CEDS will issue a competitive solicitation for energy sector-led R&D to advance cybersecurity for energy delivery systems to transition mid-term R&D projects into real world cybersecurity capabilities that address the changing threat landscape. In addition, CEDS will continue to support applied research and strengthen the core capabilities at the national laboratories.
- **Exercising and refining the energy sector's cyber incident response capabilities.** CEDS is leading the Energy Sector-Cybersecurity Incident Management Capability effort to build effective, timely, and coordinated cyber incident management capabilities for operations, information exchange, and technology in the energy sector. In collaboration with DHS, the Federal Energy Regulatory Commission (FERC), the Electricity Sector Information Sharing and Analysis Center, and industry, DOE is leveraging governmental and non-governmental resources to create a suite of deliverables that will improve processes and enhance technologies for cybersecurity for energy delivery systems. In FY 2016 CEDS will enhance situational awareness with relevant local and Federal agencies and informational analysis centers through increased information sharing and collaborative regional exercises.

- **Establish a Virtual Energy Sector Advanced Digital Forensics Analysis Platform.** The energy sector is a prime target for malicious cybersecurity attacks, but most utilities and companies within the sector do not have post-incident analysis tools to distinguish between a normal system failure and malicious activity. The ability to detect and mitigate the malicious activity is critical. The development of a virtual environment for forensic analysis will enable analysts to safely inspect malware, zero-day vulnerabilities, and advanced threats across multiple stages and different vectors and test mitigations. In FY 2016, CEDS will conduct a competitive solicitation to establish a virtual collaborative environment for conducting real-time advanced digital forensics analysis for the energy sector. This environment could be used to analyze untested and untrusted code, programs, and websites without allowing the software to harm the host device. This initiative would be implemented over a two-year timeframe, after which it would transition to the private sector where it would become self-sustaining.

Within the FY 2016 Budget Request, CEDS supports two Departmental crosscuts: Grid Modernization and Cybersecurity. The Grid crosscut goal is to create tools and technologies that measure, analyze, predict, and control the grid of the future; focus on key policy questions related to regulatory practices, market designs, and business models; and collaborate with stakeholders to test and demonstrate combinations of promising new technologies. The Cybersecurity crosscut supports central coordination of the strategic and operational aspects of cybersecurity and facilitates cooperative efforts. The entire CEDS program supports both crosscuts.

**FY 2016 Crosscuts ($K)**

| | Grid Modernization | Cybersecurity | Total |
|---|---|---|---|
| **Cybersecurity for Energy Delivery Systems** | **52,000** | **52,000** | **52,000**[a] |

[a] The entire $52,000,000 request for the Cybersecurity for Energy Delivery Systems program is included within both the Cybersecurity and Grid Modernization crosscuts.

**Cybersecurity for Energy Delivery Systems**
**Funding ($K)**

| | FY 2014 Enacted | FY 2014 Current[a] | FY 2015 Enacted | FY 2016 Request | FY 2016 vs FY 2015 |
|---|---|---|---|---|---|
| **Cybersecurity for Energy Delivery Systems** | **43,476** | **42,301** | **45,999** | **52,000** | **+6,001** |

SBIR/STTR:

- FY 2014 Transferred: SBIR: $1,028; STTR: $147
- FY 2015 Projected: SBIR: $1,092; STTR: $151
- FY 2016 Request: SBIR: $900; STTR: $135

[a] Funding reflects the transfer of SBIR/STTR to the Office of Science.

**Cybersecurity for Energy Delivery Systems**
**Explanation of Major Changes ($K)**

| | FY 2016 vs FY 2015 |
|---|---|
| The increase establishes a virtual energy sector advanced digital forensics analysis platform | **+6,001** |

**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **Cybersecurity for Energy Delivery Systems** | | |
| **$45,999,000** | **$52,000,000** | **+$6,001,000** |
| • Develop a C2M2 web accessible portal that will have a benchmarking capability that will allow a utility to compare its self-evaluation against similar entities.<br>• Issue a competitive solicitation for an academic collaboration with expertise in power system engineering and cybersecurity computer science to innovate and transition cybersecurity capabilities to the energy sector to reduce the risk of power disruption resulting from a cyber incident.<br>• Issue a competitive solicitation for the energy sector to transition mid-term research and development projects into real world cybersecurity capabilities for the energy sector through industry-led cost-shared short-term research and development. Examples include advanced capabilities to detect compromise of supply chain integrity for energy delivery system cyber assets; identification of adversarial cyber activity that attempts to evade detection by exploiting allowed operation of power grid components; and ability to survive a cyber incident while sustaining critical energy delivery functions.<br>• Continue development of the Wireless Test Bed to address national challenges in infrastructure security, communications interoperability, spectrum utilization, and wireless technology reliability. | • Continue to fund the CRISP classified analytic and reporting functions.<br>• Issue a competitive solicitation to identify commercially available technologies and services to enhance CRISP capabilities.<br>• Expand online access to the C2M2 and RMP tools and conduct benchmarking and data analytics.<br>• Issue a competitive solicitation for energy sector-led R&D to advance cybersecurity for energy delivery systems to transition mid-term R&D projects into real world cybersecurity capabilities that address the changing threat landscape.<br>• Continue to support mid-term as well as long-term high-risk/high-payoff research and strengthen the core capabilities at the national laboratories through competitive processes.<br>• Enhance situational awareness with relevant local and Federal agencies and informational analysis centers through information sharing development and practicing regional cybersecurity incident response communications.<br>• Establish a Virtual Energy Sector Advanced Digital Forensics Analysis Platform through a competitive solicitation. | • Establish the capability of a virtual collaborative environment for conducting real-time advanced digital forensics analysis for the energy sector to detect and mitigate malicious activity. |

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| • Continue high risk/high payoff research at the national laboratories, including research areas such as analysis of the risk posed to the energy sector if energy delivery control systems were exploited by selected malware, and tailored trustworthy spaces that tailor cybersecurity protections to accommodate needs at different levels of the energy delivery system architecture. | | |

**Cybersecurity for Energy Delivery Systems**
**Performance Measures**

In accordance with the GPRA Modernization Act of 2010, the Department sets targets for, and tracks progress toward, achieving performance goals for each program.

| | FY 2014 | FY 2015 | FY 2016 |
|---|---|---|---|
| Performance Goal (Measure) | **Cybersecurity**—Demonstrate new protective measures to reduce risks from cyber incidents. | | |
| Target | Demonstrate a tool that designs-in enhanced communications security for one substation control system component | Demonstrate a tool that designs-in enhanced communications security between control centers | Demonstrate a tool that establishes a tailored trustworthy space for one energy delivery field device |
| Result | Met | | |
| Endpoint Target | By 2020, resilient energy systems are designed, installed, operated, and maintained to survive a cyber incident while sustaining critical functions. | | |

## Energy Storage

### Overview

The Energy Storage program supports the Secretary's strategy to support a more economically competitive, environmentally responsible, secure, and resilient U.S. energy infrastructure. The program is designed to develop and demonstrate new and advanced energy storage technologies that will enable the stability, resiliency, and reliability of the future electric utility grid as it transforms into a resilient grid. Additionally, Energy Storage enables increased deployment of variable renewable energy resources such as wind and solar power generation. The Energy Storage program focuses on accelerating the development and deployment of energy storage in the electric system through directly addressing the four principal challenges identified in the 2013 DOE Strategic Plan for Grid Energy Storage: cost competitive energy storage technology, validated reliability and safety, equitable regulatory environment, and industry acceptance.[a]

The deployment of grid-scale energy storage projects throughout the country is accelerating. For example, in 2013, the California Public Utility Commission mandated installation of 1.3GW of energy storage to compensate for variability accompanying increased renewable generation. Microgrids involving storage are being installed by the military for energy surety and by states, including New Jersey and Massachusetts, for emergency preparedness. In addition, the Federal Energy Regulatory Commission (FERC) has mandated fair pricing for frequency regulation, which would double the value of energy storage facilities offering this service. Many of these projects are based on technology developed under the Energy Storage program. However, storage technology still needs to make substantial improvements in safety, cycle life, energy density, and cost before becoming fully competitive.

Research and Development (R&D) activities focus on lowering cost while improving the value, performance, safety, and reliability of stationary energy storage technologies for utility-scale applications. Additionally, the program develops and demonstrates energy storage technologies, devices, and systems that can reduce power disturbances, improve system flexibility to better incorporate variable and intermittent renewable resources, reduce peak demand, and provide resiliency for the grid. Together these efforts are accelerating implementation of emerging storage technologies to advance the modernization of the electrical utility grid.

To maximize the benefits of energy storage, work must be done to address the goals of four focus areas:

- Cost Competitive Energy Storage—Develop material and system enhancements to resolve these key cost and performance challenges with respect to novel flow, lithium, sodium, magnesium, nitrogen-oxygen, and thermoelectrochemical batteries and associated electrodes, dielectrics, membranes, electrolytes, interconnects, and supporting power electronics.
- Validated Reliability and Safety—For energy storage systems to be ubiquitously accepted the technology must be demonstrated to be safe and reliable. This activity's goal is to develop a scientifically derived knowledge base that will improve understanding and predictability, engineer new safer more reliable systems, and ultimately lead to the development of new protocols, codes, and standards for safety and reliability.
- Regulatory Environment—Value propositions for grid storage depend on reducing institutional and regulatory hurdles to levels comparable with those of other grid resources. To accomplish this objective, the Energy Storage program is partnering with Federal, state and municipal entities using analyses of the use of energy storage systems, costs and benefits of energy storage, and development of tools for utility customers and regulatory agencies for planning and implementing the deployment and use of energy storage. This accelerates the community's ability to overcome regulatory hurdles and provides an environment where energy storage deployment and service opportunities are recognized, appropriately valued, and implemented.
- Industry Acceptance—Demonstrating the value, performance, and reliability of energy storage systems in both controlled and fielded deployments is critical to achieving industry acceptance. The Energy Storage program enables confident development, deployment, and operation of grid energy storage through the conduct of controlled testing of prototype commercial storage technologies (such as flow, zinc-nickel, lead-carbon, lithium-ion, and redox flow), through support, facilitation, monitoring, and reporting of results from field demonstrations of grid storage systems, and by development of tools for utility customers and regulatory agencies for planning, deployment, and use of energy storage.

[a] Grid Energy Storage:
http://energy.gov/sites/prod/files/2013/12/f5/Grid%20Energy%20Storage%20December%202013.pdf

**Highlights of the FY 2016 Budget Request**

Energy storage is a key component of a clean and cost-effective future grid. The FY 2016 request supports work on materials research, device development, demonstrations, and grid analysis. Efforts will be in collaboration with industry, states, and other Federal agencies.

Storage system R&D, which has been successful in developing technology for reducing cost and improving performance, will turn its focus toward new electrochemical systems and improved power conversion technologies. In particular, the electrochemical systems efforts will include new redox-flow battery chemistries where substantial improvements are expected. Work will include organic carbonyl/phenol systems; multi-variant redox couples; lithium, magnesium, and sodium metal–organic hybrids; and zinc-iodine hybrid flow systems that promise some ten times the density of current flow batteries. Research will also include the development of new low-cost sodium metal technologies capable of operating at room temperature (compared to current 250°C) for greater safety. Finally, the second use of EV/PHV batteries will be evaluated for stationary applications through experiments and analysis.

Power conversion systems are a significant cost element of grid-connected battery storage systems. The program will continue to develop advanced wide band gap electronic devices that allow considerable reduction in size as well as expanded operating range increase the overall power conversation efficiency and power density by 30 percent.

Safety and reliability are cornerstones to the acceptance of new technologies. The Energy Storage program, in close collaboration of utilities, vendors, regulatory agencies, and underwriters, will maintain a coordinated series of Stationary Energy Storage Safety and Reliability projects to assess potential failure modes, prepare mitigation measures, and develop guidelines for operation and incident preparedness. This work will maintain DOE's role as a leader in safety and reliability of energy storage and help accelerate invention and deployment.

Widespread deployment of storage would not be possible without standardization and extensive grid-scale testing in test-beds and field trials. OE will continue efforts to establish grid energy storage standards for performance, control interface, and grid interconnection, and to promulgate these standards internationally, to facilitate deployment of U.S. storage technologies domestically and abroad. Collaborative test-bed and field trial evaluation of new storage technologies will be undertaken in collaboration with states, utilities, and storage providers to elucidate storage benefits, integration challenges, and opportunities, and to build confidence regarding the safety and performance of deployed technologies. These activities influence the development of the regulatory environment and accelerate acceptance of these new technologies by industry.

Within the FY 2016 Budget Request, Energy Storage supports the Departmental Grid Modernization crosscut. The Grid crosscut goal is to create tools and technologies that measure, analyze, predict, and control the grid of the future; focus on key policy questions related to regulatory practices, market designs, and business models; and collaborate with stakeholders to test and demonstrate combinations of promising new technologies. The entire Energy Storage program supports this crosscut.

**FY 2016 Crosscuts ($K)**

| | Grid Modernization |
|---|---|
| **Energy Storage** | **21,000** |

**Energy Storage**
**Funding ($K)**

| | FY 2014 Enacted | FY 2014 Current[a] | FY 2015 Enacted | FY 2016 Request | FY 2016 vs FY 2015 |
|---|---|---|---|---|---|
| **Energy Storage** | **15,192** | **14,706** | **12,000** | **21,000** | **+9,000** |

SBIR/STTR:

- FY 2014 Transferred: SBIR: $425; STTR: $61
- FY 2015 Projected: SBIR: $348; STTR: $48
- FY 2016 Request: SBIR: $630; STTR: $95

[a] Funding reflects the transfer of SBIR/STTR to the Office of Science.

**Energy Storage**
**Explanation of Major Changes ($K)**

| | FY 2016 vs FY 2015 |
|---|---|
| Increase enables: | **+9,000** |

- Expanded efforts on energy storage safety to improve acceptance and speed deployment of storage, including a quarterly Energy Storage Safety Forum for the storage community;
- Initiation of energy storage reliability efforts with stakeholder workshop and research to improve operating lifetimes of energy storage systems;
- Growth of co-funded state and regional energy storage demonstrations to quantify storage performance and develop valuation tools under a wide variety of applications; and
- Acceleration of R&D efforts to advance new battery chemistries with the potential to dramatically improve cost/benefit ratio of storage.

**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **Energy Storage $12,000,000** | **$21,000,000** | **+$9,000,000** |
| • Maintain development of advanced redox flow batteries (RFB) and selected metal/metal-ion based batteries and license specific technologies to industry.<br>• Initiate research on emerging technologies such as non-aqueous redox battery and Na-based inorganic and organic batteries with potential for lower cost storage systems.<br>• Demonstrate 2nd use EV battery systems for grid application in a realistic field trial.<br>• Continue Grid-scale, test-bed evaluations of industry supplied energy storage systems.<br>• Monitor technical and economic performance data of energy storage demonstration projects constructed under ARRA.<br>• Promote the development of US and international energy storage safety codes and standards efforts. | • Accelerate development of next generation RFBs, with significant potential to provide lower cost systems.<br>• Conduct Grid-scale tests and collaborative field trials with states, utilities, and storage providers, to elucidate energy storage benefits, understand grid integration issues, and implement safety and performance protocols.<br>• Provide enhanced tools and data to U.S. industry for development and use of grid-scale batteries.<br>• Organize a Stationary Energy Storage Reliability workshop with industry, developer, and utility stakeholders.<br>• Demonstrate various capabilities and optimization of Distributed Energy Storage System aggregation in large-scale electrical distribution model.<br>• Develop characterization methods, test procedures, and understanding of failure and degradation phenomena enabling improved design and accelerated aging tests.<br>• Develop industry standards for safety, reliability, testing and evaluation, and promulgation to international standards bodies.<br>• Support and organize quarterly Energy Storage Safety Forum meetings for the energy storage community to increase acceptance of storage technologies.<br>• Continue development of power conversion systems (primarily power electronics) specifically for grid energy storage applications. | • Expanded efforts to ensure the safe design and operation of large-scale storage systems.<br>• Supports industry wide Energy Storage Safety Forum to develop uniform safety standards and identify key scientific developments required to speed adoption of storage technologies.<br>• Expansion of standards beyond battery performance testing to include safety, reliability, grid integration, control logic, and packaging.<br>• Establish Energy Storage Reliability thrust to determine reliability testing criteria, accelerated aging protocols, and understand fundamental degradation mechanisms impacting the useful lifetimes of energy storage systems<br>• Supports additional state and regional demonstrations by providing specific use case analysis and valuation methodologies.<br>• Broadens research into alternate battery chemistries with the potential to offer safer and more cost effective storage solutions.<br>• Expanded testing of advanced power conditioning systems for improved reliability. |

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| | • Perform analysis to select best carbon fiber product for flywheel production and application. | |

**Energy Storage**
**Performance Measures**

In accordance with the GPRA Modernization Act of 2010, the Department sets targets for, and tracks progress toward, achieving performance goals for each program.

| | FY 2014 | FY 2015 | FY 2016 |
|---|---|---|---|
| Performance Goal (Measure) | **Energy Storage**—Lower the cost of grid-scale (over 1 MW) energy storage technologies. | | |
| Target | 400 $/kWh for a 4 hour system | 325 $/kWh for a 4 hour system | 300 $/kWh for a 4 hour system |
| Result | Met | | |
| Endpoint Target | By 2020, improve the cost-benefit ratio of storage to compete with current peak generation resources and increase the commercial use of grid scale storage to buffer renewables to 5 percent. | | |

## Transformer Resilience and Advanced Components

### Overview

The Transformer Resilience and Advanced Components (TRAC) program supports modernization and resilience of the grid by addressing the unique challenges facing transformers and other critical components that are responsible for transporting electricity from where it is generated to where it is needed. As the electric power system evolves to enable a more resilient and clean energy future, R&D and testing will be needed to understand the physical impact these changes have on transformers and other vital grid components and to encourage adoption of new technologies and approaches.

Transformers and substation equipment are often exposed to the elements and are vulnerable to natural and man-made threats. To ensure a reliable and resilient power system, grid components need to be designed and built to withstand the impact of lightning strikes, extreme terrestrial or space weather events, electrical disturbances, accidents, equipment failures, and attacks. Currently, 70 percent of large power transformers (LPTs) are 25 years or older, 60 percent of circuit breakers are 30 years or older, and 70 percent of transmission lines are 25 years or older. The age of these components degrade their ability to withstand physical stresses and may result in higher failure rates. Failure of key components can lead to widespread outages and long recovery times. For instance, a single LPT that is damaged can temporarily disrupt power to 500,000 homes and, as a typically custom-designed piece of equipment weighing over 100 tons, it could take up to two years to manufacture and deliver a replacement.

Expanding on existing concerns of ground-induced currents (GIC) from a coronal mass ejection, the TRAC program will address the impact of geomagnetic disturbances (GMD), electromagnetic pulses (EMP), and other physical stressors on transformers and grid components in a systematic and comprehensive manner, in close cooperation with equipment manufacturers and electricity asset owners and operators. Additionally, increased deployment of distributed generation will introduce new challenges with reversed power flows, increased harmonics, and larger fault currents that can impact transformers and other grid components.

### Highlights of the FY 2016 Budget Request

This is a new funding line in FY 2016 to focus on transformers. Activities expand upon initial work funded in OE's Infrastructure Security and Emergency Response (ISER) program to monitor and analyze GIC impacts on the electric infrastructure and support power electronics activities.

This area will advance the understanding of risks associated with GMD/EMP and their impact on LPTs, the most critical pieces of equipment in the grid. Induced currents from GMD/EMP can overload LPTs, damaging internal components and increasing failure rates. However, the vulnerability of different types of transformers to GMD/EMP as well as the predictability of GMD phenomena is not well understood.

FY 2016 activities will support the Administration's strategy on resilience and physical security. Working with the National Aeronautics and Space Administration, National Oceanic and Atmospheric Administration, U.S. Geological Survey, National Institute of Standards and Technology, and National Science Foundation, OE will examine transformer failure mechanisms through multi-physics modeling and engaging in reduced- and full-scale physical testing. Assessing mitigation options such as testing of blocking devices, solid state solutions, conducting system-wide analyses, and monitoring GICs will be included.

This program will also address the research opportunities for additional components and power electronics systems identified as critical to the future grid and necessary for increasing system resilience.

Within the FY 2016 Budget Request, TRAC supports the Departmental Grid Modernization crosscut. The Grid crosscut goal is to create tools and technologies that measure, analyze, predict, and control the grid of the future; focus on key policy questions related to regulatory practices, market designs, and business models; and collaborate with stakeholders to test and demonstrate combinations of promising new technologies. The entire TRAC program supports this crosscut.

**FY 2016 Crosscuts ($K)**

| | Grid Modernization |
|---|---|
| **Transformer Resilience and Advanced Components** | **10,000** |

**Transformer Resilience and Advanced Components**
**Funding ($K)**

| | FY 2014 Enacted | FY 2014 Current | FY 2015 Enacted | FY 2016 Request | FY 2016 vs FY 2015 |
|---|---|---|---|---|---|
| **Transformer Resilience and Advanced Components** | **0** | **0** | **0** | **10,000** | **+10,000** |

SBIR/STTR:

- FY 2016 Request: SBIR: $300; STTR: $45

**Transformer Resilience and Advanced Components**
**Explanation of Major Changes ($K)**

| | FY 2016 vs FY 2015 |
|---|---|
| The FY 2016 request establishes the Transformer Resilience and Advanced Components program to address transformer testing, analysis and solutions. | **+10,000** |

**Transformer Resilience and Advanced Components**

**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **Transformer Resilience and Advanced Components $0** | **$10,000,000** | **+$10,000,000** |
| • Activities related to GMD impacts on electric infrastructure are included in ISER in FY 2015 (about $60,000). | • Begin modeling and testing of transformers to evaluate vulnerability to GMD/EMP.<br>• Evaluate GMD/EMP mitigation, blocking devices, and solid state solutions.<br>• Continue improvement of GIC monitoring, modeling, and prediction. | • This expanded program will address challenges facing transformers and other critical components. |

## National Electricity Delivery

### Overview

The National Electricity Delivery (NED) program helps states, regional, local and tribal entities to develop, refine, and improve their programs, policies, and laws related to electricity, facilitating the development and deployment of reliable and affordable electricity infrastructure, whether generation, transmission, storage, distribution, or demand side electricity resources.

The electric industry must respond to several major new challenges and opportunities including a changing electric generation mix, replacing aging infrastructure (transmission, storage, distribution, and generation), updating communication networks (e.g., analog to digital), and accommodating new end-use technologies such as distributed resources, planning for increased interdependencies between natural gas, water and electricity systems, and addressing business models that manage these challenges in providing reliable and affordable electricity service. All of this must be balanced against the need for cost control, physical security and cybersecurity, improved or sustained reliability and resiliency, and flexibility to deal with market uncertainties and a changing climate. Additional opportunities exist because of increasing natural gas production from shale and by cheaper information technologies that allow grid operators to better monitor and control the grid and customers to better manage usage.

NED's assistance helps identify approaches that encourage the development and deployment of reliable and affordable electricity infrastructure, whether generation, transmission, storage, distribution, or demand side electricity resources. OE's intent through this work is to support strengthening these individual systems, which in-turn strengthens the entire electricity infrastructure.

The types of technical and policy expertise provided to states, regions, localities and tribal entities spans a wide variety of current and future electricity-related issues, including:

- integrating new technologies (e.g., variable generation, smart grid/demand response, and distributed generation) into electric utility planning and operations and its regulation;
- the effects of increasing shale gas production and reducing base load coal and nuclear generation on utility resource planning and transmission requirements;
- gaining a better understanding of complex interdependencies (e.g., gas/electric and energy/water) germane to electric utility planning and operations and its regulation;
- implementing state renewable and energy efficiency mandates (portfolio and standards);
- new approaches to transmission planning;
- implications for regulation from evolving utility business models;
- management of risk by state electricity regulators and other state officials (e.g., electricity policy uncertainty, changing markets, and extreme weather); and
- the potential effect of Environmental Protection Agency regulations on system reliability.

In addition, NED plays important related roles at the Federal level involving government's role in electricity export authorization and permitting for the construction of transmission infrastructure across international borders; conducting a triennial national transmission congestion study; and helping better coordinate permitting of transmission on Federal lands—the last two in accordance with the Federal Power Act.

These important roles include the responsibility for DOE and interagency coordination on policy matters affecting the power industry. To implement OE's legal responsibilities surrounding the transmission infrastructure, NED carries out a range of activities that include:

- conducting and publishing the triennial *National Transmission Congestion Study*;
- preparing and publishing DOE's annual *Transmission Data Review*
- conducting environmental and technical analyses needed for Federal authorization of transmission projects that cross the Canadian and Mexican borders;
- coordinating Federal permitting by other agencies of new transmission that involves Federal lands, as required by section 216(h) of the Federal Power Act; and

- evaluating applications under Section 1222 of the Energy Policy Act of 2005, which authorizes DOE to participate in third-party-financed transmission projects within the Western Area Power Administration (WAPA) and the Southwestern Power Administration (SWPA) regions.

**Highlights of the FY 2016 Budget Request**

Provide Expertise to Assist States, Regions, Localities and Tribes

*Electricity-Related Laws, Regulations, and Policies*

The FY 2016 request supports providing policy expertise and technical assistance, upon request, to state public utility commissions, state legislatures, regional state associations, Governors' offices, localities, and tribes on the implementation of their jurisdictional electricity-related laws, regulations, and policies. These officials sometimes find themselves without sufficient resources to address electricity-related issues of state, regional, and, ultimately, national importance; it is in the national interest to provide targeted assistance on key topics.

*Support Transition to Performance-Based Regulation and Alternative Business Models for Utilities*

Traditionally, steady growth in electricity demand has enabled utilities to raise the capital needed for new investment. Now, however, many parts of the U.S. are experiencing low growth in electricity sales, due to modest economic growth and continued penetration of energy efficiency and customer-owned generation technologies. At the same time, the need for new infrastructure investment by utilities is increasing to replace aging assets and meet the needs associated with a more complex grid. Since many utilities' revenues are dependent chiefly on electricity sales volume, it can be difficult to finance new investments when revenues are stagnant or declining. Regulators in some states have begun to consider alternative ratemaking concepts and utility business models that link utility revenues to other performance indices, but this is a complex and controversial subject that will require sustained attention and analysis over the next several years. In FY 2016, NED will initiate an expanded effort in this area with exploratory efforts such as workshops and stakeholder discussions to determine how it can best assist regulators and stakeholders.

*Assisting States and Others to Develop Long-Term Energy System Reliability Plans*

The FY 2016 request supports two independent, but related, activities to facilitate comprehensive long-term plans for reliable and affordable energy infrastructure. First, NED will work with state-based organizations (for example, the National Association of State Energy Officials, Western Governors Association, and National Association of Regulatory Utility Commissioners) to engage public/private energy leaders and other stakeholders to identify best practices for a toolkit for states to use to prepare state energy profiles, needs assessments, long-term energy planning processes and market/policy design work. Technical assistance to customize and apply the toolkit will be supported.

Second, DOE will provide planning grants to states, localities, and tribes for long-term electricity transmission, storage, and distribution reliability planning. This activity is requested under the State Energy Reliability and Assurance Grants program.

Achieve Statutory Objectives

*Support for Timely Construction and Efficient Operation of Electric Transmission Capacity*

The FY 2016 request supports several statutes designed to facilitate timely construction and efficient operation of transmission capacity:

- drawing attention to areas of the country where transmission congestion is a significant concern with a triennial congestion study; ( Section 1221, EPAct 2005) and publication of DOE's annual *Transmission Data Review*;
- facilitating the coordinated review by multiple Federal agencies of permit applications for transmission lines affecting Federal land under the agencies' control; (Section 216 (h), Federal Power Act) and
- issuing Presidential permits for new transmission lines crossing U.S. borders with Canada or Mexico. (Executive Order 10485, as amended by Executive Order 12038)

*Completion of Integrated Interagency Pre-application Process for Improved Federal Agency Transmission Permitting*

The FY 2016 request continues to support coordination of permitting transmission infrastructure pursuant to section 216(h) of the Federal Power Act, which requires DOE to coordinate Federal permitting for new transmission projects involving Federal lands. In addition, the request builds on the progress made to achieve multi-agency recognition of an Integrated

Interagency Pre-Application (IIP) process for transmission projects requiring Federal authorizations. (As required by a June 7, 2013 Presidential Memorandum, *Transforming our Nation's Electric Grid Through Improved Siting, Permitting, and Review.*)

DOE's implementation of the IIP will be through regulations for revised Federal permitting of transmission infrastructure. Successful IIP implementation will improve coordination among project proponents and Federal agencies prior to formal application submission, leading to better applications and more efficient Federal permitting timelines. NED will also support the continued development of a transmission toolkit, providing valuable information to both project proponents and Federal agencies engaged in transmission permitting.

Support Informed Decision Making

*Access to Modeling and Analytical Tools*

Decision-making can be better informed by understanding the range of potential futures and their impacts before decisions are made. Expanded analytical tools can better support internal DOE decisions and could be made available to support other decision makers at the state, regional, and Federal levels. These tools can also help manage the complexity of the grid and the additional complexities associated with interdependent infrastructures such as electricity and gas, as well as energy and water. The capability to analyze infrastructure requirements on a range of potential futures is critical as it helps provide solutions to energy transmission infrastructure (e.g., wires and pipes) in a timely manner by quantifying the long-term benefits and costs of constructing long-lived assets, which markets may not adequately signal.

Two recent examples are: 1) NED funded the Western Electricity Coordinating Council, representing the Western Interconnection, to examine grid-water interfaces, and Sandia National Laboratory to create a compatible tool to allow water-energy needs at the county level to be assessed; and 2) NED supported Argonne National Laboratory's development of EZ Mapper, a GIS-based Energy Zone Mapping Tool for use by Eastern states and others to analyze options for shaping deployment of all types of clean energy generation, demand side resources, and corridors for transmission and pipelines. The tool now has over 1,000 registered users.

Analytical tools that can inform regulatory decisions fall into six broad areas: resource adequacy; system planning; grid operations and interactions; valuation of technologies in context of a given system; finance and markets, including rates; and designs and business models. Wherever possible, development of new tools should build on what is currently available and familiar to decision-makers and stakeholders. Tool development should be done making best use of code and capabilities developed for other tools. In FY 2016, NED will work with stakeholders to determine priorities as a first step in supporting tool development, and then work with experts from the national labs, universities, or elsewhere to develop and enhance tools.

Within the FY 2016 Budget Request, NED supports the Departmental Grid Modernization crosscut. The Grid crosscut goal is to create tools and technologies that measure, analyze, predict, and control the grid of the future; focus on key policy questions related to regulatory practices, market designs, and business models; and collaborate with stakeholders to test and demonstrate combinations of promising new technologies. The entire NED program supports this crosscut.

**FY 2016 Crosscuts ($K)**

| | Grid Modernization |
|---|---|
| **National Electricity Delivery** | **7,500** |

**National Electricity Delivery**
**Funding ($K)**

| | FY 2014 Enacted | FY 2014 Current | FY 2015 Enacted | FY 2016 Request | FY 2016 vs FY 2015 |
|---|---|---|---|---|---|
| **National Electricity Delivery** | **5,997** | **5,997** | **6,000** | **7,500** | **+1,500** |

**National Electricity Delivery**
**Explanation of Major Changes ($K)**

| | FY 2016 vs FY 2015 |
|---|---|
| The increase will strengthen the modeling and analytical tools available to state regulators/policymakers to assist states and others to develop long-term energy system reliability plans. | **+1,500** |

**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **National Electricity Delivery $6,000,000** | **$7,500,000** | **+$1,500,000** |
| • Structure the application requirements, terminology, and decision process for the 216(h), Presidential Permit and Section 1222 programs in a consistent manner to create more efficient reviews for potential applicants.<br>• Complete the Environmental Impact Statement for the Northern Pass cross-border Transmission Line Project. The applicant's proposed project as currently designed, would be capable of transmitting up to 1,200 megawatts (MW) of power in either direction (Canada to U.S. and U.S. to Canada).<br>• Provide technical assistance on electricity-related topics, upon request, to states, public utility commissions, tribes, and other regional and Federal entities.<br>• Continue coordinating and reviewing draft revisions of regulations for Presidential Permits and Export Authorizations.<br>• Revise proposed Integrated Interagency Pre-Application (IIP) Process based on comments from Request for Information in FY 2014. Draft revisions of regulations for better coordination of Federal permitting of transmission infrastructure pursuant to section 216(h). | • Expand suite of tools for grid scenario discussions at the federal, state and local levels.<br>• Provide technical assistance on electricity-related topics, upon request, to states, public utility commissions, tribes, and other regional and Federal entities.<br>• Conduct studies related to Performance Based Regulation (by states) and grid planning in the Eastern and Western Interconnections.<br>• Implement Integrated Interagency Pre-application process to improve Federal permitting of transmission infrastructure pursuant to section 216(h). | • Increase expands institutional support for activities needed to facilitate grid modernization, including strengthening the long-term integrated system reliability modeling and analytical tools available to states and others. |

## National Electricity Delivery
## Performance Measures

In accordance with the GPRA Modernization Act of 2010, the Department sets targets for, and tracks progress toward, achieving performance goals for each program.

| | FY 2014 | FY 2015 | FY 2016 |
|---|---|---|---|
| Performance Goal (Measure) | **National Electricity Delivery**—Number of states to which the program provides, upon request, assistance in designing and implementing electricity policies, statutes and regulations. | | |
| Target | 35 states/tribes assisted | 40 states/tribes assisted | 50 states/tribes assisted |
| Result | Met | | |
| Endpoint Target | Increased access to reliable, affordable and sustainable energy sources. | | |

## Infrastructure Security and Energy Restoration

### Overview

The Infrastructure Security and Energy Restoration (ISER) program leads national efforts, in cooperation with public and private sector stakeholders (including asset owners and operators), to enhance the reliability, survivability, and resiliency of the U.S. energy infrastructure (electricity, petroleum, and natural gas). The program's goals are to mitigate consumer energy disruptions and drive an efficient restoration process when energy emergencies occur. ISER key partners include industry and states.

The Nation's energy infrastructure is diverse and complex. It includes distributed networks, varied system structures (electricity, oil, and natural gas), operating models (public and private), and systems in both the physical space and cyberspace. The energy sector consists of thousands of electricity, oil, and natural gas assets that are geographically dispersed and provide for all nationally important systems and networks. Therefore, interdependency within the sector and across the Nation's critical infrastructure sectors is significant. Coordinating the security and resilience of energy assets is complicated by the borderless nature of energy and reliance on predominately privately-owned infrastructure. Unlike other sector specific agencies that have directive or regulatory authorities, ISER relies on public-private partnerships to facilitate efforts upgrading, restoring, or securing critical energy infrastructure. While ISER's primary responsibility is to help secure the U.S. energy infrastructure against all hazards, reduce the impact of disruptive events, and assist industry in quickly restoring energy, it also develops incident management tools and applies new technologies to enhance ISER capabilities for prevention, mitigation, response and recovery. In addition, ISER's efforts with state and local governments, responding to and recovering from energy disruptions, ensure seamless collaboration at all levels. In an effort to maximize its capabilities within an efficient framework, ISER aligns all of its activities under three focus areas:

- executing effective emergency preparedness, response, and restoration operations;
- providing reliable energy infrastructure tactical analysis (event analysis) and situational awareness to all stakeholders; and
- encouraging a risk-based approach to energy system assurance.

ISER provides long-term strategic actions to help secure the U.S. energy supply by addressing topics like high-impact, low-frequency (HILF) events. The ISER program continues to identify potential technical solutions and suppliers of prevention and mitigation technologies. Opportunities are also sought to facilitate the seamless integration of advanced technologies into an operational framework.

Upon request, ISER also provides technical assistance to international partners, in collaboration with U.S. Department of State, to analyze and secure energy assets. It conducts an initial engineering assessment to provide expert advice to key energy producing allies on securing their critical infrastructure, with any further international assistance provided on a cost reimbursable basis.

ISER approaches its responsibilities through the following major focus areas:

<u>Emergency Preparedness, Response, and Restoration</u>

- Influences national policy to better prepare for emergencies and improves mobilization of response teams, made up of Regional Coordinators and Voluntary Responders, to ensure rapid and coordinated response with Federal partners, affected states, and energy sector leaders.
- Defines prevention, protection, mitigation, response, and recovery options for existing, newly identified, and evolving threats.
- Conducts national and regional-level exercises, workshops, and forums to enhance information sharing with Federal, state, and industry partners in support of national preparedness mission areas (prevention, protection, mitigation, response, and recovery).
- Works closely with energy partners to enhance system preparedness, plan and conduct exercises, understand supply chain issues, and identify and implement mitigation solutions and lessons learned across the energy system.
- Provides the Secretary of Energy and key Federal agencies with situation awareness of the critical energy infrastructure and key resources, including the operational status of the system, the supply and delivery of energy and fuels (including electricity, oil, natural gas, coal, and other types of fuels), and near-term threat information provided by the U.S. intelligence community.

- Supports responses to energy emergency events including physical security events, wildfires, winter storms, fuel shortages, national security events, storms, and typhoons. ISER responded to 24 events during 2014.

Tactical Analysis and Situational Awareness

- Provides information to the public on the status of energy infrastructure and briefs senior government officials, the White House, and Congress.
- Provide Federal leadership and technical guidance by publishing analytic reports on issues of concern impacting the energy sector.
- Maintains energy system data sets to support impact projection prior to events, improves awareness of actual system impacts to support response operations, and facilitates the assessments of system conditions and influences in post-event forensics.

Energy Assurance

- Provides assistance to the states by working toward a standardized, comprehensive energy assurance and resilience approach that benefits localities, states, and the Nation. Objectives include gaining understanding of state and local needs; education and training on priority issues; assistance in building collaborative partnerships; provision of tools, templates, resource materials, and lessons learned from exercises and incidents; and promotion and facilitation of coordination and sharing of information including best practices.
- As the Energy Sector-Specific Agency (SSA), coordinates with private- and public-sector partners to take proactive steps to manage risk and strengthen the security and resilience of the Nation's critical energy infrastructure, provides technical assistance and consultations, and supports innovation of technology and strategies across the energy sector.
- Monitors and facilitates the exchange of actionable information with industry partners on new and evolving threats, vulnerabilities, and mitigation options. These exchanges are vital to the economy and public safety, and key stakeholders have come to rely upon them.
- Manages and coordinates the Department's activities under the 2010 DOE–DOD Energy Security Memorandum of Understanding (MOU). The MOU has led to several high-profile collaborations between the Departments to enhance national energy security and provide Federal leadership in transforming the U.S. energy system.

**Highlights of the FY 2016 Budget Request**

The FY 2016 budget request funds ISER activities necessary to continue executing emergency preparedness, response, and restoration missions while taking an all-hazards approach.

To further strengthen OE's ability to secure the U.S. energy infrastructure, the request continues to support the development of advanced mitigation solutions for hardening infrastructure against all hazards, natural and man-made. The primary focus will continue to be on those hazards posing the greatest risk to the Nation's energy infrastructure, including HILF events and more frequent physical threats such as devastating weather events. The request supports the development of technical specifications and other capabilities for security systems for high valued, critical energy infrastructure sites. It will also continue to fund the Department's engagement with private/public partners as part of the Energy SSA responsibilities.

The FY 2016 request will enable ISER to expand its strategy to build and sustain preparedness in light of new challenges that affect the Nation's critical energy infrastructure and systems by conducting site exercises. Challenges include more frequent, stronger, and more destructive weather events; increasing incidents of physical attacks; potential accidents as a result of aging infrastructure or human error; HILF threats such as a catastrophic earthquake and extended droughts; and the continuing cyber threat. These challenges are amplified by the increasing complexity of the energy infrastructure and systems and the interdependencies affecting other critical industries.

This strategy will increase the breadth and number of energy emergency preparedness exercises and those participating by expanding the focus to address physical security, energy cybersecurity, and HILF events impacting the energy critical assets. The request will also support energy-focused exercises for state, local, tribal and territorial entities to assess and strengthen their Energy Assurance Plans.

ISER will continue to provide reliable energy infrastructure tactical analysis and situational awareness to all stakeholders. The FY 2016 funding will also support activities that promote a risk-based approach to energy systems assurance with all

stakeholders, and further strengthen OE's monitoring and visualization capabilities. Those capabilities will be available for integration into a Department of Energy Response and Operations Center. (DOE-ROC)

The FY 2016 request will contribute to the Department's construction of a DOE-ROC. The request will also maintain OE's efforts at the DOE-ROC and the continued development and maintenance of real-time monitoring, visualization, and information sharing capabilities for the Department. The DOE-ROC, located within DOE's Washington, D.C. headquarters, will continue to be a steady-state operations center, where the Department monitors, receives and analyzes real-time threat and energy sector status and coordinates and shares this information with all energy sector stakeholders. During emergencies, the DOE-ROC will serve as the collaboration hub for DOE, other Federal agencies, and energy sector partners, including critical infrastructure owners and operators, and will be responsible for status and information sharing between DOE and other emergency operation centers (Federal and state) during emergencies. The DOE-ROC will fully support the continued presence of DOE's deployed Emergency Support Function 12 (ESF 12) personnel at the National Response Coordination Center, as well as applicable Regional Response Coordination Centers during events. The goal of OE's efforts through the DOE-ROC is to ensure faster restoration and recovery of energy infrastructure systems after disruptions. The OE Program Direction budget additionally includes 10 new FTEs who directly support incident response and recovery in the field in support of the ISER program.

Energy-Focused Preparedness Exercises

The FY 2016 request will enable ISER to develop and execute a strategy to build and sustain preparedness in light of the challenges that affect the Nation's energy infrastructure and systems as well as the independencies of all critical infrastructure with the energy sector.

This strategy will allow for a programmatic approach to a test, training, and exercise (TT&E) effort guided by a policy outlining the organization's internal and external requirements associated with training personnel, exercising plans, and testing activities and procedures. It will also Identify TT&E roles and responsibilities, establish an overarching TT&E schedule, and document the TT&E methodology, including design, development, conduct, and evaluation of TT&E events cumulating in a Corrective Action Program to document and track improvement plans and actions. The strategy will also increase the scope and number of energy focused exercises and those participating by expanding the focus to align with the core capabilities and all hazards methodology directed in the National Preparedness Goal as provided for by PPD-8, "National Preparedness."

Beginning in FY 2015, ISER is implementing the recommendation of the National Petroleum Council report on Emergency Preparedness, which included an extensive and progressive TT&E program to improve communications and information sharing between industry and the government both before and during significant emergency incidents. The request will appropriately support these government/industry efforts as well as supporting energy-focused exercises for state, local, tribal, and territorial entities to assess and strengthen their Energy Assurance Plans.

**Additional Information:**

- Presidential Policy Directive (PPD) 8, *National Preparedness*: http://www.dhs.gov/xabout/laws/gc_1215444247124.shtm
- PPD 21, Critical Infrastructure Security and Resilience: http://www.whitehouse.gov/the-press-office/2013/02/12/presidential-policy-directive-critical-infrastructure-security-and-resil
- Department of Homeland Security, National Infrastructure Protection Plan: http://www.dhs.gov/nipp
- National Mitigation Framework: http://www.fema.gov/media-library-data/20130726-1914-25045-9956/final_national_mitigation_framework_20130501.pdf
- National Response Framework: http://www.fema.gov/pdf/emergency/nrf/nrf-core.pdf
- National Disaster Recovery Framework: http://www.fema.gov/pdf/recoveryframework/ndrf.pdf
- National Protection Framework: https://s3-us-gov-west-1.amazonaws.com/dam-production/uploads/1406717583765-996837bf788e20e977eb5079f4174240/FINAL_National_Protection_Framework_20140729.pdf

Within the FY 2016 Budget Request, ISER supports the Departmental Grid Modernization crosscut. The Grid crosscut goal is to create tools and technologies that measure, analyze, predict, and control the grid of the future; focus on key policy questions related to regulatory practices, market designs, and business models; and collaborate with stakeholders to test and demonstrate combinations of promising new technologies. The entire ISER program supports this crosscut.

**FY 2016 Crosscuts ($K)**

| | Grid Modernization |
|---|---|
| **Infrastructure Security and Energy Restoration** | **14,000** |

**Infrastructure Security and Energy Restoration**
**Funding ($K)**

| | FY 2014 Enacted | FY 2014 Current | FY 2015 Enacted | FY 2016 Request | FY 2016 vs FY 2015 |
|---|---|---|---|---|---|
| **Infrastructure Security and Energy Restoration** | | | | | |
| Infrastructure Security and Energy Restoration | 5,997 | 5,997 | 6,000 | 14,000 | +8,000 |
| Operational Energy and Resilience[a] | 1,999 | 1,999 | 0 | 0 | 0 |
| **Total, Infrastructure Security and Energy Restoration** | **7,996** | **7,996** | **6,000** | **14,000** | **+8,000** |

[a] In FY 2015 and 2016, OER-related work is funded within the base Infrastructure Security and Energy Restoration program.

**Infrastructure Security and Energy Restoration**
**Explanation of Major Changes ($K)**

| | FY 2016 vs FY 2015 |
|---|---|
| Increase to ISER base program: | **+2,000** |
| • Continue to develop and implement sensor technologies and other procedural enhancements to address geomagnetic disturbances and the potential impact on grid resiliency through the information sharing/visualization portal for the geomagnetically induced current (GIC) nodes deployed for the SUNBURST program.<br>• Develop data collection and analytical processes for these specific sensor technologies. | |
| Conduct a series of regional energy assurance training workshops to assess state and local governments' response to energy events. | **+3,000** |
| Contribute to the DOE-ROC to create an operational environment with the technology, methods, and tools to enable analysts to, in real time, monitor, simulate, and track energy disruptions | **+3,000** |
| • Enhance operational capability in the DOE-ROC, including continuous development and maintenance of monitoring, visualization and information sharing capabilities<br>• Lay the groundwork for a pro-active, Infrastructure Hardening and Resiliency effort through direct engagement with Industry and states, identifying focused mitigation solutions and addressing any impediments to implementation.<br>• Enhancements to the Eagle-I situational awareness tool.<br>• Plan and conduct joint Industry and Government tests, training, and exercise events, including states as appropriate.<br>• Develop a Physical Security Capability and Maturity Model (PSCM2). | |
| **Total, Infrastructure Security and Energy Restoration** | **+8,000** |

**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs. FY 2015 |
|---|---|---|
| **Infrastructure Security and Energy Restoration** | | |
| **$6,000,000** | **$14,000,000** | **+$8,000,000** |
| • Train 100 percent of Regional Coordinators and 80 percent of Voluntary Responders on regional energy infrastructure; test training by participating in National Level Exercise 2015.<br>• Facilitate the necessary actions to bring together key oil and natural gas stakeholders for the establishment of an ISAC-like structure for information sharing and dissemination.<br>• Develop a structure for sharing physical security awareness of suspicious incidents, information alerts, and analysis at the local, regional, and federal level in coordination with the Electricity Subsector Coordinating Council.<br>• Develop improved U.S.-wide ground conductivity map, including comparisons of the effectiveness of using 3-dimensional models at coastal boundaries.<br>• Support development of Equipment Monitoring Applications using Phasor Measurement Units (PMU).<br>• Develop technical specs for security systems for high valued, critical energy infrastructure sites.<br>• Continue implementation of National Preparedness and Critical Infrastructure Security and Resilience mandates and the coordination of other national energy preparedness policies.<br>• Serve on the National I-MAT teams during an emergency, as required. | • Train 100 percent of Regional Coordinators and 85 percent of Voluntary Responders on regional energy infrastructure; test training by participating in National Level Exercise 2016 and selected Regional Exercises.<br>• Continue implementation of National Preparedness and Critical Infrastructure Security and Resilience mandates and the coordination of other national energy preparedness policies.<br>• Develop a Physical Security Capability and Maturity Model (P2CM2) and perform PSCM2 Assessments.<br>• Support NERC Reliability Standard to Enhance Physical Security Measures.<br>• Continue development of technical specifications for security systems for high valued, critical energy assets.<br>• Facilitate the necessary actions to expand the Oil and Natural Gas ISAC (expected to be created by industry in FY 2015) from cyber-focus to all-hazards focus.<br>• Continue to support development of Equipment Monitoring Applications using PMUs.<br>• Increase the breadth and number of energy emergency preparedness exercises by expanding focus to address all hazards impacting the energy critical assets. In addition the request will support energy-focused exercises for state, local, tribal and territorial entities to assess and strengthen their Energy Assurance Plans. | • Increased funding supports expanded energy-focused exercises to improve local, state and regional preparedness.<br>• FY 2016 funding supports general operations and maintenance costs of the operations center. |

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs. FY 2015 |
|---|---|---|
| | • Support the Department's construction of a DOE-ROC and continued development of a new generation of real-time monitoring, visualization and situation awareness capability.<br>• Continue to enhance the DOE-ROC's ability of receiving multiple and disparate near real-time data feeds, simultaneously visualizing and overlaying over the impacted area, so that decision makers can appropriately respond.<br>• Leverage on physical security work identified in ISER subprogram to identify efficient ways to monitor and develop appropriate situational awareness capabilities.<br>• Increase the ability for the monitoring and visualization technology to rapidly adapt, when possible, to new emerging threats.<br>• Providing mitigation solutions through enhanced awareness of infrastructure interdependencies and supply chain that impact energy assurance through a regional risk assessment focused on threats and gaps.<br>• Conducting a series of regional energy assurance training workshops using the state Energy Assurance Plans to assess state and local governments' response to energy events including fuel resiliency.<br>• Providing risk management support to strengthen the security and response to critical energy infrastructure.<br>• Validate analysis of the geoelectric field and GIC calculations through study of a few historically large, well-observed geomagnetic storms and comparison with storm-time GIC measurements, followed by detailed validation for 5–10 locations. | |

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs. FY 2015 |
|---|---|---|
| | • Install variometers at sites specifically targeted to GIC analysis and monitoring to better understand vulnerability of transformers to geomagnetic disturbances. | |

## Infrastructure Security and Energy Restoration
## Performance Measures

In accordance with the GPRA Modernization Act of 2010, the Department sets targets for, and tracks progress toward, achieving performance goals for each program.

| | FY 2014 | FY 2015 | FY 2016 |
|---|---|---|---|
| Performance Goal (Measure) | **Infrastructure Security and Energy Restoration**—Improve awareness of near real-time monitoring situational awareness tool, across the Federal Government ensuring that this tool is available to interagency partners for use in their operations centers and other appropriate situations. | | |
| Target | 45% situational awareness capability availability | 60% situational awareness capability availability | 70% situational awareness capability availability |
| Result | Met | | |
| Endpoint Target | Maintain the availability to near-real time energy situational awareness tools to interagency partners at greater than 90%. | | |

## State Energy Reliability and Assurance Grants

### Overview

State Energy Reliability and Assurance Grants is a new program in FY 2016 providing grants to states, localities, regions, and tribal entities (or groups of states and tribes). Under the programmatic heading are two new distinct grant programs: Grants for Electricity Transmission, Storage, and Distribution Reliability and Grants for Energy Assurance. States have significant jurisdiction over the electricity system and are excellent test beds for the evolution of the electric power system and, with federal support, can provide innovative ways to address new trends through more coordinated and efficient processes that allow the electric sector to reliably provide services that meet environmental, resiliency, efficiency, and energy assurance goals. Processes are in place for reliability, resiliency, efficiency and environmental planning and actions; however, they need to be integrated across programs within states and across states, and adequately funded. DOE has a long history of providing technical assistance to states on reliability, climate resiliency, energy and environmental planning and action. The Department is uniquely positioned to facilitate the coordination of these planning processes within states and across state lines.

Grants for Electricity Transmission, Storage, and Distribution Reliability

In FY 2016, an Electricity Transmission, Storage, and Distribution Reliability planning grants program is proposed to finance state, local, regional and tribal entities and including multi-state cooperation, to advance electric reliability planning and integrate it with environmental protection (including climate mitigation), climate resilience, and efficiency infrastructure planning and action. Building on a history of success working with states and leveraging previous technical support to states for planning tools development, DOE will provide planning grants to promote and integrate electricity reliability, efficiency, renewable energy, environmental protection (including climate adaptation), and climate resiliency planning and action.

The grants will be used for several activities germane to long-term electricity system reliability planning, including:

- integrating planning and action for transmission, storage, and distribution reliability, climate resiliency and environmental compliance;
- planning for the increasing interdependencies of electricity, natural gas and water systems;
- identifying and implementing regulatory reforms to enable transmission, storage and distribution investments that address the challenges and take advantages of the opportunities, including reforms to enable distributed generation and energy efficiency;
- developing climate resiliency metrics;
- identifying and planning upgrades of infrastructure to make it more resilient to climate change and extreme weather;
- developing incentives and enabling cost recovery for reliability and climate resiliency investments;
- collecting and sharing data on transmission, storage and distribution cost, environmental impacts, resiliency, reliability, and flexibility;
- valuing the availability of resources; and
- fostering multi-state cooperation.

The Nation’s energy infrastructure is undergoing a sweeping transformation. New technologies and changes in electricity flows including increased use of distributed resources, Internet-enabled demand response technologies, growing electric vehicle deployment, dramatic expansion of natural gas use, and integration of energy storage are placing increasing demands on the electric grid. Therefore, a more proactive and comprehensive approach to state energy market and policy designs is needed to address system interdependencies and scale up renewable integration.

Within the FY 2016 Budget Request, State Energy Reliability and Assurance Grants supports the Departmental Grid Modernization crosscut. The Grid crosscut goal is to create tools and technologies that measure, analyze, predict, and control the grid of the future; focus on key policy questions related to regulatory practices, market designs, and business models; and collaborate with stakeholders to test and demonstrate combinations of promising new technologies. Within State Energy Reliability and Assurance Grants, the Grants for Electricity Transmission, Storage, and Distribution Reliability program supports this crosscut.

**FY 2016 Crosscuts ($K)**

| | Grid Modernization |
|---|---|
| **State Energy Reliability and Assurance Grants** | **27,500** |

Grants for Energy Assurance

DOE's Energy Assurance planning work is aimed at improving the capacity of states, localities, and tribes to identify the potential for energy disruptions, quantify the impacts of those disruptions, and develop comprehensive plans responding to those disruptions and mitigating the threat of future disruptions. Building upon DOE's work across the states and U.S. territories, including the District of Columbia, on energy assurance planning, lessons learned include that energy assurance plans should be continually updated and exercised annually to reflect changing conditions and new threats and to maintain staff capacity to implement the plans. The new grant program will provide formula grants for states, local and tribal governments to update their energy assurance plans; require testing, training, and exercises; and ensure that plans and assessments are shared.

The goal of state and local energy assurance planning is to achieve a robust, secure, and reliable energy infrastructure that is also resilient—better able to withstand catastrophic events, able to restore services rapidly in the event of any disaster, and designed to diminish future vulnerabilities. The Federal government can help states and local governments—who are ultimately responsible for responding to disasters and disruptions—by building and maintaining preparedness and assurance capabilities.

The grants will be used for several activities relevant to short- and long-term energy assurance preparedness and planning:

- Creating and sustaining in-house expertise at the state and local level on energy assurance planning and resiliency, focusing on smart grid, critical infrastructure, interdependencies, cyber security, energy supply systems, energy data analysis, long-term risk and hazard identification and mitigation, and communications.
- Designating energy emergency assurance personnel.
- Developing new or refining existing Energy Assurance Plans to incorporate response actions to new energy portfolios, including smart grid technologies, infrastructure hardening, transportation fuel diversification, energy efficiency, distributed energy technologies, and other risk mitigation measures.
- Establishing energy emergency procedures that address multiple interdependencies across lifeline sectors (e.g., food, housing, and shelter).
- Revising appropriate policies, procedures, and practices to reflect the Energy Assurance Plans. States, localities and tribes should append the Energy Assurance Plan to the state energy plan and state hazard mitigation plan, as appropriate.
- Developing or refining a process or mechanism for tracking the duration, response, restoration and recovery time of energy supply disruption events, to include, as examples: contingency plans to ameliorate shortages of delivered fuels (e.g., propane, heating fuel, wind, natural gas); and contingency plans to accommodate interdependencies with associated sectors (e.g., telecommunications, health, and transportation).
- Training appropriate personnel on energy infrastructure and supply systems and the content and execution of energy assurance plans.
- Conducting energy emergency exercises (intra- and inter-state) to evaluate the effectiveness of the Energy Assurance Plans and to demonstrate coordination and communication strategies across government and industry and energy and interdependent sectors.
- Incorporating physical and cyber security measures and related guidance for critical energy and interdependent sectors
- Requiring annual updates to state, local and industry contacts lists.
- Leveraging other efforts such as fusion centers and regional planning and information-sharing groups to share information between state/Federal governments and the private sector to reduce risks

In FY 2016, a Grants for Energy Assurance program is proposed to finance state, local, and tribal governments to enhance resiliency through energy assurance planning and the test of, training to, and exercising of those plans. In support of these grants, ISER will continue to use its convening power to provide a forum for information and data sharing, which is critical to energy system resiliency. ISER will also engage other relevant agencies to ensure state energy assurance plans interface with state and local disaster and emergency response plans, private sector response plans, and the plans of neighboring states.

**State Energy Reliability and Assurance Grants**
**Funding ($K)**

| | FY 2014 Enacted | FY 2014 Current | FY 2015 Enacted | FY 2016 Request | FY 2016 vs FY 2015 |
|---|---|---|---|---|---|
| **State Energy Reliability and Assurance Grants** | | | | | |
| Grants for Electricity Transmission, Storage, and Distribution Reliability | 0 | 0 | 0 | 27,500 | +27,500 |
| Grants for Energy Assurance | 0 | 0 | 0 | 35,500 | +35,500 |
| **Total, State Energy Reliability and Assurance Grants** | **0** | **0** | **0** | **63,000** | **+63,000** |

**State Energy Reliability and Assurance Grants**
**Explanation of Major Changes ($K)**

| | FY 2016 vs FY 2015 |
|---|---|
| **Grants for Electricity Transmission, Storage, and Distribution Reliability**: The increase will provide grants to states and others to develop energy system reliability plans to advance electric reliability planning and integrate it with environmental protection (including climate adaptation), climate resiliency, and efficiency infrastructure planning and action. The plans would require cooperation among energy offices, state public utility commissions, environmental regulators, and others within each state, with their counterparts in other states, and with their reliability coordinators. Multi-state (and/or tribal) cooperation will be encouraged. State electricity reliability planning would include evaluation of transmission, storage, and distribution infrastructure necessary for managing new or retiring generation, planning for the increasing interdependencies of natural gas and electricity systems, and accounting for climate change and extreme weather risks in infrastructure investments. | **+27,500** |
| **Grants for Energy Assurance**: Provide formula grants to state, local, and tribal governments to enhance resiliency through energy assurance planning, compliance, and training, including exercises. | **+35,500** |
| **Total, State Energy Reliability and Assurance Grant Program** | **+63,000** |

## State Energy Reliability and Assurance Grants

**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs. FY 2015 |
|---|---|---|
| **Grants for Electricity Transmission, Storage, and Distribution Reliability $0** | **$27,500** | **+$27,500** |
| | • Provide grants to assist states and others to develop long-term energy system reliability plans that advance electric reliability planning and integrate it with planning and action for environmental protection, climate resiliency, and energy efficiency. | • This is a new activity in FY 2016. |
| **Grants for Energy Assurance $0** | **$35,500** | **+$35,500** |
| | • Provide energy assurance grants to improve the capacity of states, localities, and tribal governments to enhance resiliency through energy assurance planning, compliance, and training, including exercises. | • This is a new activity in FY 2016. |

## Program Direction

### Overview

Program Direction funds the costs associated with the Federal workforce, including salaries, benefits, travel, training, building occupancy, IT services, and other related expenses. It also provides for the costs associated with contractor services that, under the direction of the Federal workforce, support OE's mission.

**Salaries and Benefits** support 128 FTEs who provide executive management, programmatic oversight, and analysis for the effective implementation of the OE program. 29 of the FTEs supporting and funded by OE are employees of the Office of Fossil Energy (FE) located at the National Energy Technology Laboratory (NETL) and are included in FE's FTE totals. The remaining 99 FTEs are located in DOE headquarters and are OE employees.

The funding increase in FY 2016 Program Direction supports the addition of 16 FTEs. 10 of the new FTEs directly support incident response and recovery in the field in support of the ISER program. 4 of the FTEs will provide real-time monitoring, analytics, and information sharing in support of the Department of Energy Response and Operations Center (DOE-ROC). The remaining 2 FTEs will provide support for the new state grant activities proposed in the 2016 request.

**Travel** includes transportation, subsistence, and incidental expenses that allow OE to effectively manage research and development programs and projects in the field; to provide the Department's electricity-related outreach to regions, states, and tribes with regard to planning needs and issues, policies, siting protocols and new energy facilities; and to assist the Department of Homeland Security, the Department of State and local governments, and the private sector to help protect against and recover from disruptions in the energy infrastructure through ISER.

**Support Services** include contractor support directed by the Federal staff to perform administrative tasks and provide analysis to management. These efforts include such needs as issue-oriented support on science, engineering, environment, and economics that benefit strategic planning; technology and market analysis to improve strategic and annual goals; development of management tools and analyses to improve overall Office efficiency; assistance with communications and outreach to enhance OE's external communication and responsiveness to public needs; development of program-specific information tools that consolidate corporate knowledge, performance tracking and inventory data, improve accessibility to this information, and facilitate its use by the entire staff; and also may include support for post-doctoral fellows (e.g., AAAS fellows) and Intergovernmental Personnel Act (IPA) assignments.

**Other Related Expenses** includes corporate IT support and Working Capital Fund expenses, such as rent, supplies, copying, graphics, mail, printing, and telephones. It also includes equipment upgrades and replacements, commercial credit card purchases using the simplified acquisition procedures to the maximum extent possible, and other needs.

### Highlights of the FY 2016 Budget Request

The funding request for Program Direction provides for implementation and oversight of the range of program activities in support of OE's critical mission. Program Direction reflects a funding increase to support 16 additional Federal personnel.

## Program Direction
## Funding ($K)

| | FY 2014 Enacted | FY 2014 Current | FY 2015 Enacted | FY 2016 Request | FY 2016 vs FY 2015 |
|---|---|---|---|---|---|
| **Program Direction Summary** | | | | | |
| **Washington Headquarters** | | | | | |
| Salaries and Benefits | 12,871 | 12,871 | 13,092 | 16,001 | +2,909 |
| Travel | 650 | 650 | 650 | 715 | +65 |
| Support Services | 2,906 | 2,906 | 2,905 | 3,292 | +387 |
| Other Related Expenses | 4,241 | 4,241 | 4,214 | 5,467 | +1,253 |
| **Total, Washington Headquarters** | **20,668** | **20,668** | **20,861** | **25,475** | **+4,614** |
| **National Energy Technology Laboratory** | | | | | |
| Salaries and Benefits | 5,890 | 5,890 | 5,700 | 5,720 | +20 |
| Travel | 300 | 300 | 300 | 350 | +50 |
| Support Services | 500 | 500 | 500 | 655 | +155 |
| Other Related Expenses | 248 | 248 | 245 | 400 | +155 |
| **Total, National Energy Technology Laboratory** | **6,938** | **6,938** | **6,745** | **7,125** | **+380** |
| **Total Program Direction** | | | | | |
| Salaries and Benefits | 18,761 | 18,761 | 18,792 | 21,721 | +2,929 |
| Travel | 950 | 950 | 950 | 1,065 | +115 |
| Support Services | 3,406 | 3,406 | 3,405 | 3,947 | +542 |
| Other Related Expenses | 4,489 | 4,489 | 4,459 | 5,867 | +1,408 |
| **Total, Program Direction** | **27,606** | **27,606** | **27,606** | **32,600** | **+4,994** |
| **Federal FTEs** | **80** | **80** | **83** | **99** | **+16** |
| Additional FE FTEs at NETL supporting OE[a] | 31 | 31 | 29 | 29 | 0 |
| Total OE-funded FTEs | 111 | 111 | 112 | 128 | +16 |

[a] OE funds 29 FTEs at FE's National Energy Technology Laboratory who support OE activities. The 29 FTEs are in FE's FTE totals and are not included in the OE FTE totals shown on the "Federal FTEs" line.

| | FY 2014 Enacted | FY 2014 Current | FY 2015 Enacted | FY 2016 Request | FY 2016 vs FY 2015 |
|---|---|---|---|---|---|
| **Support Services** | | | | | |
| Technical Support | 1,317 | 1,317 | 1,318 | 1,580 | +262 |
| Management Support | 2,089 | 2,089 | 2,087 | 2,367 | +280 |
| **Total, Support Services** | **3,406** | **3,406** | **3,405** | **3,947** | **+542** |
| | | | | | |
| **Other Related Expenses** | | | | | |
| Other Support Services | 855 | 855 | 855 | 1,260 | +405 |
| DOE/CO | 500 | 500 | 500 | 700 | +200 |
| Working Capital Fund (WCF) | 3,134 | 3,134 | 3,104 | 3,907 | +803 |
| **Total, Other Related Expenses** | **4,489** | **4,489** | **4,459** | **5,867** | **+1,408** |

**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 Enacted |
|---|---|---|
| **Program Direction $27,606,000** | **$32,600,000** | **+$4,994,000** |
| **Salaries and Benefits $18,792,000** | **$21,721,000** | **+$2,929,000** |
| Salaries and Benefits support 112 FTEs at HQ and NETL that provide executive management, programmatic oversight, and analysis for the effective implementation of the OE program. | Salaries and Benefits support 128 FTEs at HQ and NETL that provide executive management, programmatic oversight, and analysis for the effective implementation of the OE program. | Increase reflects 16 FTEs supporting new state grant activities and incident response and recovery in support of the ISER program. |
| **Travel $950,000** | **$1,065,000** | **+$115,000** |
| Travel includes transportation, subsistence, and incidental expenses that allow OE to effectively facilitate its mission. | Travel includes transportation, subsistence, and incidental expenses that allow OE to effectively facilitate its mission. | The increase for travel supports OE's mission work, including the expanded resiliency efforts. |
| **Support Services $3,405,000** | **$3,947,000** | **+$542,000** |
| Support Services includes contractor support directed by the Federal staff to perform administrative tasks and provide analysis to management. Support Services may include support for post-doctoral fellows and Intergovernmental Personnel Act (IPA) assignments. | Support Services includes contractor support directed by the Federal staff to perform administrative tasks and provide analysis to management. Support Services may include support for post-doctoral fellows and IPA assignments. | The increase in supports services is due to escalation of management and technical support related to the increase in FTEs. |
| **Other Related Expenses $4,459,000** | **$5,867,000** | **+$1,408,000** |
| Other Related Expenses includes corporate IT support and working capital expense, such as rent, supplies, copying, graphics, mail, printing, and telephones. It also includes equipment upgrades and replacements, commercial credit card purchases using the simplified acquisition procedures to the maximum extent possible, and other needs. | Other Related Expenses includes corporate IT support and working capital expense, such as rent, supplies, copying, graphics, mail, printing, and telephones. It also includes equipment upgrades and replacements, commercial credit card purchases using the simplified acquisition procedures to the maximum extent possible, and other needs. | Increase primarily reflects growth in Working Capital Fund requirements due to an increase of 16 FTEs in FY 2016. |

**Electricity Delivery and Energy Reliability**
**Research and Development ($K)**

| | FY 2014 Current[a] | FY 2015 Enacted | FY 2016 Request | FY 2016 vs FY 2015 |
|---|---|---|---|---|
| Basic | 3,846 | 6,208 | 5,100 | -1,108 |
| Applied | 55,885 | 54,264 | 59,660 | +5,396 |
| Development | 32,129 | 32,696 | 52,040 | +19,344 |
| Total, R&D | 91,860 | 93,168 | 116,800 | +23,632 |

[a] Funding reflects the SBIR/STTR amounts transferred to the Office of Science

**Electricity Delivery and Energy Reliability**
**Small Business Innovative Research/Small Business Technology Transfer (SBIR/STTR) ($K)**

| | FY 2014 Transferred | FY 2015 Projected | FY 2016 Request | FY 2016 vs FY 2015 |
|---|---|---|---|---|
| Clean Energy Transmission and Reliability | | | | |
| SBIR | 795 | 814 | 990 | +176 |
| STTR | 114 | 112 | 149 | +37 |
| Smart Grid Research and Development | | | | |
| SBIR | 409 | 448 | 900 | +452 |
| STTR | 58 | 62 | 135 | +73 |
| Cybersecurity for Energy Delivery Systems | | | | |
| SBIR | 1,028 | 1,092 | 900 | -192 |
| STTR | 147 | 151 | 135 | -16 |
| Energy Storage | | | | |
| SBIR | 425 | 348 | 630 | +282 |
| STTR | 61 | 48 | 95 | +47 |
| Transformer Resilience and Advanced Components | | | | |
| SBIR | 0 | 0 | 300 | +300 |
| STTR | 0 | 0 | 45 | +45 |
| **Total, SBIR** | **2,657** | **2,702** | **3,720** | **+1,018** |
| **Total, STTR** | **380** | **373** | **559** | **+186** |

**Department Of Energy**

**FY 2016 Congressional Budget**

**Funding By Appropriation By Site**

**($K)**

| Electricity Delivery and Energy Reliability | FY 2014 Current | FY 2015 Enacted | FY 2016 Request |
|---|---|---|---|
| **Ames Laboratory** | | | |
| **Electricity Delivery and Energy Reliability** | | | |
| Clean Energy Transmission and Reliability | 100 | 0 | 0 |
| Cybersecurity for Energy Delivery Systems | 0 | 50 | 0 |
| **Total, Electricity Delivery and Energy Reliability** | **100** | **50** | **0** |
| **Total, Ames Laboratory** | **100** | **50** | **0** |
| **Argonne National Laboratory** | | | |
| **Electricity Delivery and Energy Reliability** | | | |
| Clean Energy Transmission and Reliability | 2,085 | 1,525 | 1,691 |
| Smart Grid | 300 | 1,200 | 1,720 |
| Cybersecurity for Energy Delivery Systems | 2,037 | 100 | 300 |
| National Electricity Delivery | 420 | 171 | 100 |
| **Total, Electricity Delivery and Energy Reliability** | **4,842** | **2,996** | **3,811** |
| **Total, Argonne National Laboratory** | **4,842** | **2,996** | **3,811** |
| **Brookhaven National Laboratory** | | | |
| **Electricity Delivery and Energy Reliability** | | | |
| Clean Energy Transmission and Reliability | 250 | 0 | 0 |
| Smart Grid | 0 | 351 | 0 |
| Infrastructure Security & Energy Restoration | 0 | 50 | 50 |
| Cybersecurity for Energy Delivery Systems | 0 | 50 | 0 |
| **Total, Electricity Delivery and Energy Reliability** | **250** | **451** | **50** |
| **Total, Brookhaven National Laboratory** | **250** | **451** | **50** |
| **Chicago Operations Office** | | | |
| **Electricity Delivery and Energy Reliability** | | | |
| Clean Energy Transmission and Reliability | 75 | 0 | 0 |
| **Total, Chicago Operations Office** | **75** | **0** | **0** |
| **Idaho National Laboratory** | | | |
| **Electricity Delivery and Energy Reliability** | | | |
| Clean Energy Transmission and Reliability | 0 | 0 | 100 |
| Smart Grid | 0 | 0 | 350 |
| Energy Storage | 0 | 500 | 0 |
| Cybersecurity for Energy Delivery Systems | 5,819 | 5,050 | 1,300 |
| Transformer Resilience and Advanced Components | 0 | 0 | 5,000 |
| **Total, Electricity Delivery and Energy Reliability** | **5,819** | **5,550** | **6,750** |
| **Total, Idaho National Laboratory** | **5,819** | **5,550** | **6,750** |

**Department Of Energy**

**FY 2016 Congressional Budget**

**Funding By Appropriation By Site**

**($K)**

| Electricity Delivery and Energy Reliability | FY 2014 Current | FY 2015 Enacted | FY 2016 Request |
|---|---|---|---|
| **Lawrence Berkeley National Laboratory** | | | |
| **Electricity Delivery and Energy Reliability** | | | |
| Clean Energy Transmission and Reliability | 3,070 | 3,900 | 4,450 |
| Smart Grid | 350 | 655 | 1,800 |
| Infrastructure Security & Energy Restoration | 0 | 50 | 50 |
| Energy Storage | 0 | 50 | 0 |
| Cybersecurity for Energy Delivery Systems | 1,200 | 0 | 200 |
| National Electricity Delivery | 2,655 | 2,229 | 2,500 |
| **Total, Electricity Delivery and Energy Reliability** | **7,275** | **6,884** | **9,000** |
| **Total, Lawrence Berkeley National Laboratory** | **7,275** | **6,884** | **9,000** |
| **Lawrence Livermore National Laboratory** | | | |
| **Electricity Delivery and Energy Reliability** | | | |
| Clean Energy Transmission and Reliability | 500 | 900 | 0 |
| Infrastructure Security & Energy Restoration | 225 | 75 | 75 |
| Cybersecurity for Energy Delivery Systems | 358 | 0 | 200 |
| **Total, Electricity Delivery and Energy Reliability** | **1,083** | **975** | **275** |
| **Total, Lawrence Livermore National Laboratory** | **1,083** | **975** | **275** |
| **Los Alamos National Laboratory** | | | |
| **Electricity Delivery and Energy Reliability** | | | |
| Clean Energy Transmission and Reliability | 1,800 | 1,320 | 2,464 |
| Smart Grid | 150 | 252 | 470 |
| Cybersecurity for Energy Delivery Systems | 2,970 | 50 | 200 |
| **Total, Electricity Delivery and Energy Reliability** | **4,920** | **1,622** | **3,134** |
| **Total, Los Alamos National Laboratory** | **4,920** | **1,622** | **3,134** |
| **National Energy Technology Lab** | | | |
| **Electricity Delivery and Energy Reliability** | | | |
| Program Direction | 6,938 | 6,745 | 7,125 |
| Clean Energy Transmission and Reliability | 1,645 | 7,524 | 14,679 |
| Smart Grid | 7,445 | 7,900 | 7,200 |
| Infrastructure Security & Energy Restoration | 0 | 600 | 600 |
| Cybersecurity for Energy Delivery Systems | 11,121 | 34,957 | 38,600 |
| National Electricity Delivery | 650 | 1,029 | 1,500 |
| **Total, Electricity Delivery and Energy Reliability** | **27,799** | **58,755** | **69,704** |
| **Total, National Energy Technology Lab** | **27,799** | **58,755** | **69,704** |

**Department Of Energy**

**FY 2016 Congressional Budget**

**Funding By Appropriation By Site**

**($K)**

| Electricity Delivery and Energy Reliability | FY 2014 Current | FY 2015 Enacted | FY 2016 Request |
|---|---|---|---|
| **National Renewable Energy Laboratory** | | | |
| **Electricity Delivery and Energy Reliability** | | | |
| Clean Energy Transmission and Reliability | 0 | 400 | 545 |
| Smart Grid | 545 | 225 | 2,300 |
| Infrastructure Security & Energy Restoration | 0 | 50 | 50 |
| Cybersecurity for Energy Delivery Systems | 0 | 50 | 0 |
| National Electricity Delivery | 760 | 771 | 1,000 |
| **Total, Electricity Delivery and Energy Reliability** | **1,305** | **1,496** | **3,895** |
| **Total, National Renewable Energy Laboratory** | **1,305** | **1,496** | **3,895** |
| **Oak Ridge National Laboratory** | | | |
| **Electricity Delivery and Energy Reliability** | | | |
| Clean Energy Transmission and Reliability | 3,804 | 2,221 | 4,018 |
| Smart Grid | 275 | 600 | 900 |
| Infrastructure Security & Energy Restoration | 0 | 50 | 50 |
| Energy Storage | 1,031 | 500 | 1,474 |
| Cybersecurity for Energy Delivery Systems | 2,998 | 50 | 1,300 |
| National Electricity Delivery | 0 | 429 | 500 |
| **Total, Electricity Delivery and Energy Reliability** | **8,108** | **3,850** | **8,242** |
| **Total, Oak Ridge National Laboratory** | **8,108** | **3,850** | **8,242** |
| **Pacific Northwest National Laboratory** | | | |
| **Electricity Delivery and Energy Reliability** | | | |
| Clean Energy Transmission and Reliability | 5,415 | 5,250 | 5,427 |
| Smart Grid | 765 | 2,391 | 12,420 |
| Infrastructure Security & Energy Restoration | 525 | 125 | 125 |
| Energy Storage | 5,116 | 3,500 | 7,955 |
| Cybersecurity for Energy Delivery Systems | 6,236 | 175 | 2,000 |
| **Total, Electricity Delivery and Energy Reliability** | **18,057** | **11,441** | **27,927** |
| **Total, Pacific Northwest National Laboratory** | **18,057** | **11,441** | **27,927** |
| **Richland Operations Office** | | | |
| **Electricity Delivery and Energy Reliability** | | | |
| Infrastructure Security & Energy Restoration | 1,660 | 1,152 | 1,152 |
| **Total, Richland Operations Office** | **1,660** | **1,152** | **1,152** |

**Department Of Energy**

**FY 2016 Congressional Budget**

**Funding By Appropriation By Site**

**($K)**

| Electricity Delivery and Energy Reliability | FY 2014 Current | FY 2015 Enacted | FY 2016 Request |
|---|---|---|---|
| **Sandia National Laboratories** | | | |
| **Electricity Delivery and Energy Reliability** | | | |
| Clean Energy Transmission and Reliability | 400 | 700 | 809 |
| Smart Grid | 1,785 | 861 | 900 |
| Infrastructure Security & Energy Restoration | 125 | 0 | 0 |
| Energy Storage | 8,274 | 7,450 | 11,571 |
| Cybersecurity for Energy Delivery Systems | 3,356 | 50 | 500 |
| National Electricity Delivery | 150 | 257 | 100 |
| **Total, Electricity Delivery and Energy Reliability** | **14,090** | **9,318** | **13,880** |
| **Total, Sandia National Laboratories** | **14,090** | **9,318** | **13,880** |
| **Savannah River National Laboratory** | | | |
| **Electricity Delivery and Energy Reliability** | | | |
| Clean Energy Transmission and Reliability | 0 | 50 | 0 |
| Cybersecurity for Energy Delivery Systems | 0 | 50 | 0 |
| **Total, Electricity Delivery and Energy Reliability** | **0** | **100** | **0** |
| **Total, Savannah River National Laboratory** | **0** | **100** | **0** |
| **Washington Headquarters** | | | |
| **Electricity Delivery and Energy Reliability** | | | |
| Program Direction | 20,668 | 20,861 | 25,475 |
| Clean Energy Transmission and Reliability | 12,330 | 10,472 | 5,817 |
| Smart Grid | 2,510 | 1,004 | 1,940 |
| Infrastructure Security & Energy Restoration | 5,461 | 3,848 | 11,848 |
| Energy Storage | 285 | 0 | 0 |
| Cybersecurity for Energy Delivery Systems | 6,206 | 5,367 | 7,400 |
| National Electricity Delivery | 1,362 | 1,114 | 1,800 |
| State Energy Reliability and Assurance Grants | 0 | 0 | 63,000 |
| Transformer Resilience and Advanced Components | 0 | 0 | 5,000 |
| **Total, Electricity Delivery and Energy Reliability** | **48,822** | **42,666** | **122,280** |
| **Total, Washington Headquarters** | **48,822** | **42,666** | **122,280** |
| **Total, Electricity Delivery and Energy Reliability** | **144,205** | **147,306** | **270,100** |

# Nuclear Energy

# Nuclear Energy

**Nuclear Energy**

**Table of Contents**

## Nuclear Energy
## Proposed Appropriation Language

For Department of Energy expenses including the purchase, construction, and acquisition of plant and capital equipment, and other expenses necessary for nuclear energy activities in carrying out the purposes of the Department of Energy Organization Act (42 U.S.C. 7101 et seq.), including the acquisition or condemnation of any real property or any facility or for plant or facility acquisition, construction, or expansion, *and the purchase of no more than three emergency service vehicles for replacement only,* [$913,500,000] *$907,574,000* to remain available until expended, of which $24,000,000 shall be derived from the Nuclear Waste Fund: Provided, That, of the amount made available under this heading $80,000,000, shall be available until September 30, [2016] *2017,* for program direction [including official reception and representation expenses not to exceed $10,000: Provided further, That of the funds made available under this heading in prior years, $80,000,000 of unobligated balances is hereby rescinded, including up to $18,000,000 from funds provided for program direction activities: Provided further, that no amounts may be rescinded from amounts that were designated by the Congress as an emergency requirement pursuant to a concurrent resolution on the budget or the Balanced Budget and Emergency Deficit Control Act of 1985].

### Explanation of Changes

Changes in appropriation language relate to the number of vehicles to be acquired, the lack of requirement for new reception and representation funding in FY 2016, and for the deletion of prior year balances rescission.

**Public Law Authorizations**
42 U.S.C. 10101, Nuclear Waste Policy Act of 1982

## Nuclear Energy

**($K)**

| FY 2014 Enacted[1] | FY 2014 Current | FY 2015 Enacted[2] | FY 2016 Request |
|---|---|---|---|
| 888,376 | 877,620 | 913,500 | 907,574 |

**Overview**

The primary mission of the Nuclear Energy (NE) program is to advance nuclear power as a resource capable of contributing toward the Nation's energy supply, environmental, and national security needs. To ensure that nuclear energy remains a viable energy option for the Nation, NE supports research, development, and demonstration activities, when appropriate, designed to resolve the technical, cost, safety, waste management, proliferation resistance, and security challenges of increased use of nuclear energy. NE leads the Federal research effort to develop nuclear energy technologies, including generation, safety, waste storage and management, and security technologies to help meet energy security, proliferation resistance, and climate goals.

Within the FY 2016 Budget request, NE funds the following major programs: Reactor Concepts Research, Development and Demonstration; Fuel Cycle Research and Development; Nuclear Energy Enabling Technologies; Radiological Facilities Management; Idaho Facilities Management; Idaho Sitewide Safeguards and Security; Small Modular Reactor (SMR) Licensing Technical Support; Supercritical Transformational Electric Power Generation (STEP) Research and Development; International Nuclear Energy Cooperation; and Program Direction.

A prerequisite to the continued use of nuclear power is public confidence in the safety of nuclear plants and commercial confidence that the plants can be operated safely, reliably, and economically. The Department will explore improvements to light water reactor systems and fuel forms to further enhance safety and reliability under severe accident conditions. Our research and development (R&D) efforts will be coordinated with reactor vendors, utilities, universities, regulators, and the international community to ensure that lessons learned from the events at Fukushima, Japan are appropriately incorporated and that these efforts are integrated and efficient.

The safe, long-term management and disposal of used nuclear fuel and high-level radioactive waste is critical to maintaining nuclear power as part of our diversified clean-energy portfolio. In January 2013, the Administration released its *Strategy for the Management and Disposal of Used Nuclear Fuel and High-Level Radioactive Waste (Strategy)*. This Strategy lays out a broad outline for a stable, integrated system capable of transporting, storing, and disposing of high-level nuclear waste from civilian nuclear power generation, defense, national security, and other activities. In FY 2016, through NE's Used Nuclear Fuel Disposition (UNFD) subprogram, the Budget requests $30.0 million, including $24.0 million from the Nuclear Waste Fund, for generic process development and other non-R&D activities related to storage, transportation, disposal, and consent-based siting and $75.4 million for related generic R&D. The Department is also requesting $3.0 million within UNFD for activities associated with exploring potential alternative disposal options for some DOE- managed high level waste and spent nuclear fuel.

To support the nuclear waste management program over the long term, it is necessary to reform the current funding arrangement and the Administration believes the funding system should consist of the following elements: ongoing discretionary appropriations, access to annual fee collections provided in legislation either through their reclassification from mandatory to discretionary or as a direct mandatory appropriation, and eventual access to the balance or "corpus" of the Nuclear Waste Fund. The FY 2016 Budget request includes a proposal to implement such reform. Discretionary appropriations are included and continue for the duration of the effort. In FY 2016, these funds are found in the Used Nuclear Fuel Disposition subprogram. Discretionary funding would support expenses that are regular and recurring, such as program management costs, which include administrative expenses, salaries and benefits, studies, and regulatory interactions. Mandatory appropriations in addition to the discretionary funding are proposed to be provided annually, beginning in 2019, to fund the balance of the annual program costs. The sooner that legislation enables progress on implementing a nuclear waste management program, the lower the ultimate cost will be to the taxpayers.

[1] FY 2014 Enacted column reflects a rescission of $814,100 of FY 2014 appropriations as identified within Section 317 of Public Law 113-76.

[2] FY 2015 Enacted column does not reflect rescissions of $80,121,000 of prior year appropriations as identified in Public Law 113-235.

**Highlights and Major Changes in the FY 2016 Budget Request**

The FY 2016 Request continues ongoing emphasis on researching responses to Nuclear Energy fuel safety and waste streams (Fuel Cycle Research and Development, +$20.8 million), including funding to continue implementation of the Integrated Waste Management Program, the large-diameter, deep bore hole research and development effort, maintaining the schedule for selecting and certifying accident tolerant fuel, and activities associated with exploring potential alternative disposal options for some DOE- managed high level waste and spent nuclear fuel. Emphasis is also placed on ensuring that the Idaho National Laboratory continues to be available to provide safe, secure, efficient, and effective research and development services for national energy and security missions (Idaho Facilities Management +$5.8 million, Idaho Sitewide Safeguards and Security +$22.2 million).

Consistent with its program plan, $62.5 million is requested for SMR Licensing Technical Support program (+$8.0 million).

Within Nuclear Energy Enabling Technologies, the Department is establishing a new subprogram, NE Traineeships, to prioritize DOE science, technology, engineering, and mathematics (STEM) nuclear energy workforce needs. NE traineeships will focus on advancing critical STEM disciplines and competencies related to radiochemistry to support NE mission responsibilities (+$2.0 million).

Nuclear Energy supports the Secretary's Clean Energy Manufacturing Initiative (CEMI), a comprehensive DOE-wide approach to increase U.S. competitiveness in clean energy manufacturing while progressing toward the nation's energy goals. The Clean Energy Manufacturing Initiative supports research, development, and addressing market barriers that will help companies competitively manufacture clean energy technologies in the U.S., while increasing U.S. manufacturing competitiveness across the board by increasing energy productivity.

The NE FY 2016 Budget request includes funding in three of the crosscutting initiatives as discussed below.

**Supercritical CO2:** The supercritical carbon dioxide (sCO2) based power generation effort is a technology-focused crosscutting initiative that will facilitate industry's transition to realize power cycles based on sCO2 as the working fluid. Building on industry outreach and focused R&D efforts in FY 2015, the major thrusts of the crosscut in FY 2016 are a coordinated R&D effort in high temperature technology development/component validation, and the Supercritical Transformational Electric Power Generation (STEP) initiative to design, construct and operate a 10-MW pilot test bed. Demonstrating and developing this power cycle has the potential to revolutionize electric power generation for fossil, concentrating solar, geothermal, nuclear and waste heat recovery applications in a way that is cleaner and more efficient, and which reduces cost.

**Subsurface Engineering**: Over 80 percent of our total energy supply comes from the subsurface, and this importance is magnified by the ability to also use the subsurface to store and sequester fluids and waste products. The subsurface crosscut, SubTER, will address identified challenges in the subsurface through highly focused and coordinated research in Wellbore Integrity, Stress State and Induced Seismicity, Permeability Manipulation, and New Subsurface Signals to ensure enhanced energy security, material impact on climate change via CO2 sequestration, and significantly mitigated environmental impacts from energy-related activities and operations.

**Cybersecurity**: DOE is engaged in three categories of cyber-related activities: protecting the DOE enterprise from a range of cyber threats that can adversely impact mission capabilities; bolstering the U.S. Government's capabilities to address cyber threats; and, improving cybersecurity in the electric power subsector and the oil and natural gas subsector. The cybersecurity crosscut supports central coordination of the strategic and operational aspects of cybersecurity and facilitates cooperative efforts such as the Joint Cybersecurity Coordination Center for incident response and the implementation of Department-wide Identity Credential and Access Management.

**NE Participation in FY 2016 DOE Crosscutting Initiatives ($K)**

| | sCO2 | Subsurface Engineering | Cyber security | Total |
|---|---|---|---|---|
| **STEP R&D** | 5,000 | 0 | 0 | **5,000** |
| **Reactor Concepts RD&D** | 3,300 | 0 | 0 | **3,300** |
| **Fuel Cycle R&D** | 0 | 39,500 | 0 | **39,500** |
| **Idaho Sitewide S&S** | 0 | 0 | 14,466 | **14,466** |
| **Total, Crosscuts** | **8,300** | **39,500** | **14,466** | **62,266** |

**Nuclear Energy University Program**

NE designates up to 20 percent of the funds appropriated to its R&D programs to be applied to university-led R&D and associated infrastructure projects to be performed at universities and collaborating research institutions. These R&D projects are awarded through an open, competitive solicitations process; and managed by the Nuclear Energy University Programs (NEUP).

(dollars in thousands)

| | FY 2014 Current | FY 2015 Enacted | FY 2016 Request |
|---|---|---|---|
| Reactor Concepts Research, Development and Demonstration | 19,519 | 23,000 | 19,500 |
| Fuel Cycle Research and Development | 30,239 | 33,000 | 27,500 |
| Nuclear Energy Enabling Technologies | 2,587 | 4,750 | 4,000 |
| Total, NEUP | 52,345 | 60,750 | 51,000 |

## Funding by Congressional Control ($K)

| | FY 2014 Enacted | FY 2014 Current[1] | FY 2015 Enacted | FY 2016 Request | FY 2016 vs FY 2015 |
|---|---|---|---|---|---|
| **Integrated University Program** | **5,500** | **5,500** | **5,000** | **0** | **-5,000** |
| **STEP R&D** | **0** | **0** | **5,000** | **5,000** | **+0** |
| **SMR Licensing Technical Support** | **110,000** | **110,000** | **54,500** | **62,500** | **+8,000** |
| **Reactor Concepts Research, Development and Demonstration** | **112,822** | **109,212** | **133,000** | **108,140** | **-24,860** |
| **Fuel Cycle Research and Development** | **186,205** | **181,207** | **197,000** | **217,760** | **+20,760** |
| **Nuclear Energy Enabling Technologies** | **71,109** | **68,833** | **101,000** | **86,387** | **-14,613** |
| **Radiological Facilities Management** | **24,968** | **24,968** | **25,000** | **6,800** | **-18,200** |
| **Idaho Facilities Management** | | | | | |
| Operations & Maintenance | 179,878 | 179,878 | 200,631 | 209,826 | +9,195 |
| 13-D-905, Remote Handled Low-Level Waste Disposal Project, INL | 16,398 | 16,398 | 5,369 | 0 | -5,369 |
| 16-E-200, Sample Preparation Laboratory | 0 | 0 | 0 | 2,000 | +2,000 |
| **Total, Idaho Facilities Management** | **196,276** | **196,276** | **206,000** | **211,826** | **+5,826** |
| **Idaho Sitewide Safeguards and Security** | **94,000** | **94,000** | **104,000** | **126,161** | **+22,161** |
| **International Nuclear Energy Cooperation** | **2,496** | **2,496** | **3,000** | **3,000** | **+0** |
| **Program Direction** | **90,000** | **90,000** | **80,000** | **80,000** | **+0** |
| **Subtotal, Nuclear Energy** | **893,376** | **882,492** | **913,500** | **907,574** | **-5,926** |
| Transfer from Department of State | 0 | 128 | 0 | 0 | +0 |
| Use of Prior Year Balances | -5,000 | -5,000 | 0 | 0 | +0 |
| Rescission of Prior Year Balances | 0 | 0 | -80,121 | 0 | +80,121 |
| **Total, Nuclear Energy** | **888,376** | **877,620** | **833,379** | **907,574** | **+74,195** |
| Federal FTEs | 394 | 394 | 394 | 394 | +0 |

SBIR/STTR:

- FY 2014 Transferred: SBIR $9,524; STTR $1,360
- FY 2015 Projected: SBIR $11,992; STTR $1,654
- FY 2016 Request: SBIR $11,529; STTR $1,729

[1] Funding reflects the SBIR/STTR amounts transferred to the Office of Science.

## Integrated University Program

**Overview**

Consistent with the Administration's STEM reorganization efforts, no funding is being requested in FY 2016 for the Integrated University Program (IUP).

All awards under this program are fully funded in the year funding was received. As a result, multi-year student research fellowships do not require support by out-year funds after the appropriation year.

**Integrated University Program**
**Funding ($K)**

| | FY 2014 Enacted | FY 2014 Current | FY 2015 Enacted | FY 2016 Request | FY 2016 vs FY 2015 |
|---|---|---|---|---|---|
| **Integrated University Program** | | | | | |
| Integrated University Program | **5,500** | **5,500** | **5,000** | **0** | **-5,000** |
| **Total, Integrated University Program** | **5,500** | **5,500** | **5,000** | **0** | **-5,000** |

| Integrated University Program<br>Explanation of Major Changes ($K) | FY 2016 vs FY 2015 |
|---|---|
| **Integrated University Program:** Consistent with the Administration's STEM reorganization efforts, no funding is requested to continue this program in FY 2016. | **-5,000** |
| **Total, Integrated University Program** | **-5,000** |

## Integrated University Program

**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **Integrated University Program** | | |
| **$5,000,000** | **$0** | **-$5,000,000** |
| • $5.0 million appropriation will support nuclear science and engineering study and research by fully funding approximately 30 multi-year student fellowships and 46 single-year scholarships in the nuclear energy field of study. | • Consistent with the Administration's STEM reorganization efforts, no funding is requested to continue this program in FY 2016. | • No funding is requested to continue this program in FY 2016. |

## SMR Licensing Technical Support

**Overview**

The development of safe, clean, affordable nuclear power options is a key element of the Department of Energy's Office of Nuclear Energy (DOE-NE) *Nuclear Energy Research and Development Roadmap.* As a part of this strategy, accelerating the timelines for the commercialization and deployment of small modular reactor (SMR) technologies through the SMR Licensing Technical Support (LTS) program has been a high priority of the Department. The program supports first-of-a-kind costs associated with design certification and licensing activities for SMR designs through cost-shared arrangements with industry partners (industry contributions are a minimum of 50% of the cost). If industry chooses to widely deploy these technologies in the U.S., SMRs could help meet the Nation's economic, energy security, and climate change goals. The goal of the program is to provide technical assistance that leads to risk reduction for industry first-movers completing the design development, certification, and licensing of SMR deployment in the early to mid-2020s. The Department's cooperative agreements awarded under this program will support the domestic development of innovative nuclear technologies, subsequently strengthening American manufacturing capabilities and the associated nuclear supply chain, improving the domestic job outlook, and creating important export opportunities for the U.S.

SMR Licensing Technical Support is planned as a $452.0 million, six-year program (through 2017). The Department made two key industry awards under this program through two separate Funding Opportunity Announcements (FOAs). The initial FOA provided cost-shared technical support for both the design certification and site licensing applications to establish the licensing blueprint for subsequent SMR license applications. The second SMR FOA solicited innovations that can improve SMR safety, operations, and economics through lower core damage frequencies, longer post-accident coping periods, enhanced resistance to hazards presented by natural phenomena, and potentially reduce emergency planning zones and workforce requirements. The award under the second FOA provides funding only for the selected vendor organization to execute the first-of-a-kind engineering, design development, and associated design certification application and regulatory review efforts because it targets more innovative designs that are in earlier stages of development.

In November 2012, the Department selected the mPower America team under the initial SMR FOA. The mPower America team is an industry partnership consisting of Babcock & Wilcox (B&W), Bechtel, and the Tennessee Valley Authority (TVA). The purpose of the cost-shared arrangement was to support the development of the mPower SMR design and the certification and licensing documentation that would lay the groundwork for its deployment at the TVA-owned Clinch River site near Oak Ridge, Tennessee.

In February 2014, B&W made a corporate decision to reduce funding to the mPower project, citing lack of investors and committed customers. At that time, the Department took action to limit the Government's financial exposure and provided limited extensions of the cooperative agreement through November 2014 during B&W's search for and negotiations with potential investors. The Department maintains the option of continuing the mPower award at some level leading up to 2017 and within the remaining amount of the original $452 million program funding envelope.

In December 2013, DOE selected NuScale Power for the second SMR Licensing Technical Support program award as the design that represented the best option for meeting the criteria for innovation and deployment potential. The NuScale design is an innovative, factory-built, transportable, scalable SMR technology that is expected to achieve levels of safety performance exceeding currently certified reactor designs. The NuScale design is based on proven light water reactor technology that incorporates several features that reduce complexity and improve safety. NuScale Power has developed a comprehensive schedule that describes the activities required to design, engineer, and develop a design certification application to meet program goals. The Department is currently providing technical support funding for NuScale's Nuclear Regulatory Commission (NRC) licensing activities.

The Department also believes that the establishment of SMR-specific site licensing methodologies and processes is an important aspect in the development of commercialization potential of SMR technologies. The Department's FY 2016 Budget Request allows for ongoing recipients and an electricity provider partnered with NuScale to receive funding for site permitting and related licensing activities within existing program funding amounts.

In addition to the specific industry partnerships, the Department supports focused projects that provide generic benefit to the SMR industry by addressing issues common to SMR designs and providing tools to facilitate commercialization and

deployment. In FY 2016, the SMR LTS program management will consider additional analytical efforts that may be able to provide value to the overall program goals within the current program budget.

**Highlights of the FY 2016 Budget Request**

This request supports the award to NuScale Power. In FY 2016, NuScale Power is expected to be conducting resource-intensive engineering, analysis, and testing activities in support of their design certification application to NRC. The SMR LTS FY 2016 request also includes funding for site permitting and related licensing activities for ongoing partners and for an electricity provider partnered with NuScale. The award will continue to be funded by at least a 50% industry cost-share.

**SMR Licensing Technical Support**
**Funding ($K)**

| | FY 2014 Enacted | FY 2014 Current | FY 2015 Enacted | FY 2016 Request | FY 2016 vs FY 2015 |
|---|---|---|---|---|---|
| **SMR Licensing Technical Support** | | | | | |
| SMR Licensing Technical Support | 110,000 | 110,000 | 54,500 | 62,500 | +8,000 |
| **Total, SMR Licensing Technical Support** | **110,000** | **110,000** | **54,500** | **62,500** | **+8,000** |

**SMR Licensing Technical Support**
**Explanation of Major Changes ($K)**

| | FY 2016 vs FY 2015 |
|---|---|
| **SMR Licensing Technical Support:** The increase from $54,500,000 to $62,500,000 is consistent with the funding requirements to fund the spend plans for the NuScale cooperative agreement, including site permitting and related licensing activities for ongoing partners and for an electricity provider partnered with NuScale, and analyses that promote generic SMR commercialization potential. | **+8,000** |
| **Total, SMR Licensing Technical Support** | **+8,000** |

## SMR Licensing Technical Support

**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **SMR Licensing Technical Support $54,500,000** | **$62,500,000** | **+$8,000,000** |
| • **NuScale Power** – NuScale Power continues activities to design, engineer, and develop certification documentation for FY 2017 submission to the NRC, including:<br>• Completing helical coil steam generator (HCSG) testing.<br>• Submitting final fuel design report to the NRC. | • **NuScale Power** – NuScale Power continues activities to design, engineer, and develop certification documentation for FY 2017 submission to the NRC, including:<br>• Completion of integral systems testing at the *NuScale Integral Systems Test* Facility in Corvallis, Oregon.<br>• Completing safety analysis and probabilistic risk assessment.<br>• Completing final draft of design certification application. | • Funding increase is consistent with NuScale requirements in FY 2016 and site permitting and related licensing activities for ongoing partners and an electricity provider partnered with NuScale. |
| • **mPower America** – No additional FY 2015 government cost-share will be provided.<br>• mPower takes action to stabilize certification documentation and data.<br>• mPower continues engineering and certification efforts at a reduced rate consistent with the B&W corporate decision to reduce funding. | | |
| • **Site Permitting and Licensing**<br>• The TVA completes Clinch River Site flood analysis in support of early site permit requirements.<br>• The TVA completes the Clinch River Site seismic analysis in support of early site permit requirements.<br>• DOE engages NuScale partners for site permitting and licensing agreement. | • **Site Permitting and Licensing**<br>• Advance site permitting and related licensing activities for ongoing partners and for an electricity provider partnered with NuScale. | |
| • **Program Management** – DOE will continue analyses and studies important to improving SMR licensing and commercialization potential. | • **Program Management** – DOE will continue analyses and studies important to improving SMR licensing and commercialization potential. | |

**SMR Licensing Technical Support**
**Performance Measures**

In accordance with the GPRA Modernization Act of 2010, the Department sets targets for, and tracks progress toward, achieving performance goals for each program.

| | FY 2014 | FY 2015 | FY 2016 |
|---|---|---|---|
| Performance Goal (Measure) | **SMR - Licensing Technical Support Program - Enable submission of license application documentation to the Nuclear Regulatory Commission by SMR vendors and utility partners by supporting design, engineering, certification, and licensing efforts for selected SMR projects** | | |
| Target | Complete FY 2014 planned milestones | Complete FY 2015 planned milestones | Complete FY 2016 planned milestones |
| Result | Two out of four quarterly milestones completed. | N/A | N/A |
| Endpoint Target | Provide risk reduction to industry first-movers for the completion of design development, certification and licensing in a timeframe that supports SMR deployment in the early to mid-2020s. | | |

## Supercritical Transformational Electric Power Research and Development

**Overview**

The Supercritical Transformational Electric Power Research and Development (STEP R&D) initiative is a collaborative Department of Energy (DOE) project to develop and scale up advanced Supercritical Carbon Dioxide ($sCO_2$) Brayton cycle energy conversion technology to facilitate commercial development. This program supports the STEP R&D initiative through engagement with industry and the broader stakeholder community to develop an effective public-private cost-shared $sCO_2$ Brayton cycle demonstration program, including research and development of $sCO_2$ technologies.

This transformative technology has the potential to significantly reduce costs of energy production by improving the efficiency of converting thermal energy to electrical energy using traditional steam-Rankine cycle systems, which are used for roughly 80% of the world's electricity generation. $sCO_2$ Brayton cycle technology utilizes smaller equipment and will be simpler to operate compared to Rankine cycle technology, resulting in lower capital and operating costs. These improvements could make advanced nuclear energy technologies more cost competitive. Maturing this promising technology supports the Administration's "all of the above" energy strategy. If industry were to commercialize and deploy the matured technology, it could contribute towards meeting national climate and energy goals, promote domestic job creation, and facilitate industrial competitiveness. STEP R&D is intended to provide additional support needed to encourage further technology development and near-term commercialization of $sCO_2$ Brayton cycle energy conversion technology.

A unique aspect of this conversion technology is that it can be used by nuclear, solar, and fossil energy plants to improve energy generation efficiency. As a result, this continues to be a collaborative DOE project among the Offices of Fossil Energy (FE), Energy Efficiency and Renewable Energy (EERE), and Nuclear Energy (NE) to further develop the technology by establishing cost shared pre-commercial pilot demonstration, while continuing to leverage the technical expertise and capabilities of the national laboratories. STEP R&D focuses on $sCO_2$ components and technologies common to solar, nuclear, fossil, and geothermal heat sources to secure end-user confidence for a commercial $sCO_2$ power cycles.

**Highlights of the FY 2016 Budget Request**

The FY 2015 Omnibus directed the Department to engage with the appropriate stakeholders to gather information with the goal of developing an effective solicitation for a public-private cost-shared $sCO_2$ demonstration program. In FY 2016, NE activities will support the solicitation, evaluation and competitive award(s) for the STEP pilot scale demonstration facility, which will be funded and directed primarily by FE because the near-term deployment and potential market applications for commercial $sCO_2$ power cycles are primarily in the fossil energy area.

In FY 2016, stakeholder engagement will continue through the establishment of a stakeholder consortium to support $sCO_2$ commercialization activities. The consortium is envisioned to include participation by industry technology vendors, utilities, national labs, other research organizations, and academia. Targeted research and technology development activities will be conducted to address critical risk areas and industry needs specifically related to the STEP pilot scale demonstration facility.

Both FY 2015 and FY 2016 activities in this budget element will be coordinated and fully integrated through the Department's $sCO_2$ Crosscut, involving the Offices of Fossil Energy (FE), Energy Efficiency and Renewable Energy (EERE), and Nuclear Energy (NE).

Within the FY 2016 Budget Request, STEP R&D supports one Departmental Crosscut: Supercritical $CO_2$.

**Supercritical $CO_2$:** The goal of STEP R&D is to support FE's development and implementation of a successful public-private partnership to design and build a pilot scale $sCO_2$ Brayton cycle energy conversion demonstration facility. This will be accomplished through information gathering, analysis and evaluation, stakeholder outreach and engagement, and specific research and technology development activities to identify and retire risks associated with commercial deployment.

**FY 2016 Crosscuts ($K)**

| | $sCO_2$ | Total |
|---|---|---|
| **STEP R&D** | **5,000** | **5,000** |

**Supercritical Transformational Electric Power Research and Development**
**Funding ($K)**

| | FY 2014 Enacted | FY 2014 Current[1] | FY 2015 Enacted | FY 2016 Request | FY 2016 vs FY 2015 |
|---|---|---|---|---|---|
| **Supercritical Transformational Electric Power Research and Development** | | | | | |
| Supercritical Transformational Electric Power Research and Development | 0 | 0 | 5,000 | 5,000 | - |
| **Total, Supercritical Transformational Electric Power Research and Development** | **0** | **0** | **5,000** | **5,000** | **+0** |

SBIR/STTR:

- FY 2014 Transferred: SBIR $0; STTR $0
- FY 2015 Projected: SBIR $145; STTR $20
- FY 2016 Request: SBIR $150; STTR $23

[1] Funding reflects the transfer of SBIR/STTR to the Office of Science.

**Supercritical Transformational Electric Power Research and Development**
**Explanation of Major Changes ($K)**

| | FY 2016 vs FY 2015 |
|---|---|
| **Supercritical Transformational Electric Power Research and Development:** Funding remains constant from FY 2015 to FY 2016 although the emphasis of activities will shift from preparing for the establishment of an effective public-private partnership in FY 2015 to implementing and supporting the partnership in FY 2016. These activities will support FE and coordinated across the applied energy programs, as appropriate. | **0** |
| **Total, Supercritical Transformational Electric Power Research and Development** | **+0** |

## Supercritical Transformational Electric Power Research and Development

**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **Supercritical Transformational Electric Power Research and Development** | | |
| **$5,000,000** | **$5,000,000** | **$0** |
| • Gather information and engage industry to develop an effective solicitation.<br>• Solicit the development of conceptual designs or other information to improve the fidelity of demonstration facility alternatives and associated cost estimates.<br>• Conduct specific R&D and technology development activities. | • Support FE's implementation of the STEP pilot scale demonstration project.<br>• Evaluate options to reduce technical risks and reduce cost for the STEP demonstration facility.<br>• Conduct specific R&D and technology development activities. | • Activities shift from preparing for the establishment of an effective public-private partnership in FY 2015 to implementing and supporting the partnership in FY 2016. |

## Reactor Concepts Research, Development and Demonstration

**Overview**

The Reactor Concepts Research, Development and Demonstration (RD&D) program develops new and advanced reactor designs and technologies to further the state of reactor technology, to improve its competitiveness, and to help advance nuclear power as a resource capable of meeting the Nation's energy, environmental, and national security needs. Program activities are designed to address technical, cost, safety and security issues associated with advanced reactor technologies such as fast reactors using liquid metal coolants and high temperature reactors using helium or liquid salt coolants.

Additionally, Reactor Concepts RD&D will conduct research and development (R&D) on advanced technologies that improve the reliability, sustain the safety, and extend the life of the current light water reactor (LWR) fleet.

In maximizing the benefits of nuclear power, work must be done to address the following challenges:

- Improving affordability of nuclear energy;
- Addressing the management of nuclear waste;
- Minimizing proliferation risks of nuclear materials; and
- Further enhancing safety and incorporating lessons learned from Fukushima.

**Highlights of the FY 2016 Budget Request**

The Light Water Reactor Sustainability (LWRS) subprogram is focusing research on material aging issues where research results will help support subsequent license renewal applications expected from industry around 2018. Activities in the Reactor Safety Technologies area are addressing opportunities to enhance the safety profile of the domestic reactor fleet by examining lessons learned from the Fukushima Daiichi accident. These include evaluation of instrumentation needs to better monitor and manage accident conditions, improved modeling of accident progression, and preparation and planning efforts in support of eventual examination of the damaged reactors.

The Advanced Reactor Technologies (ART) subprogram will continue R&D on advanced reactor technologies and will support work on generic topics that can apply to various advanced reactor concepts. This program focuses on efforts in the following areas: advanced reactor coolants, safety and technology for advanced reactors, advanced energy conversion, advanced instrumentation and controls, support to the Nuclear Regulatory Commission (NRC) in the development of an advanced reactor licensing framework, liquid metal reactor component testing, TRISO fuel and graphite material qualification, advanced materials development and codification, continued international collaborations, and cost-shared industry R&D collaborations. Research results from this program are expected to help reduce design and construction costs, contribute data to the technical bases for the operation of safety systems, improve proliferation resistance, and provide critical insights to help solve key feasibility and performance challenges.

Reactor Concepts RD&D supports the Departments Clean Energy Manufacturing Initiative (CEMI), a comprehensive DOE-wide approach to increase U.S. competitiveness in clean energy manufacturing while advancing progress toward the nation's energy goals. In FY 2016, ART will fund approximately $7.0 million for reactor-related advanced materials manufacturing research that will lead to results also benefitting advanced manufacturing, with a focus on materials for extreme environments.

**Supercritical $CO_2$:** Within the Reactor Concepts RD&D program Supercritical $CO_2$ is supported by the ART subprogram. In FY 2016 ART will fund approximately $3.3 million for the development and operational performance testing of high efficiency Brayton cycle turbo-machinery and the conduct of experiments to explore liquid metal / $sCO_2$ heat exchanger performance.

**FY 2016 Crosscuts ($K)**

| | $sCO_2$ | Total |
|---|---|---|
| **Reactor Concepts RD&D** | **3,300** | **3,300** |

## Reactor Concepts Research, Development and Demonstration
## Funding ($K)

| | FY 2014 Enacted[1] | FY 2014 Current[2] | FY 2015 Enacted | FY 2016 Request | FY 2016 vs FY 2015 |
|---|---|---|---|---|---|
| **Reactor Concepts Research, Development and Demonstration** | | | | | |
| Advanced Small Modular Reactor R&D | 22,964 | 22,229 | 0 | 0 | - |
| Light Water Reactor Sustainability | 29,953 | 28,995 | 35,000 | 33,275 | -1,725 |
| Advanced Reactor Technologies | 59,905 | 57,988 | 98,000 | 74,865 | -23,135 |
| **Total, Reactor Concepts Research, Development and Demonstration** | **112,822** | **109,212** | **133,000** | **108,140** | **-24,860** |

SBIR/STTR:

- FY 2014 Transferred: SBIR $3,159; STTR $451
- FY 2015 Projected: SBIR $3,857; STTR $532
- FY 2016 Request: SBIR $3,244; STTR $487

[1] FY 2014 Enacted column reflects a rescission of $178,400 as identified within Section 317 of Public Law 113-76.

[2] Funding reflects the transfer of SBIR/STTR to the Office of Science.

**Reactor Concepts Research, Development and Demonstration**
**Explanation of Major Changes ($K)**

| | FY 2016 vs FY 2015 |
|---|---|
| **Light Water Reactor Sustainability:** The decrease from $35,000,000 to $33,275,000 reflects a focus on the most important research activities in the Materials Aging and Degradation area in support of the first subsequent license renewal applications expected to be submitted by industry to the NRC in 2018. | **-1,725** |
| **Advanced Reactor Technologies:** The decrease from $98,000,000 to $74,865,000 reflects the transfer of system studies related to hybrid energy systems development to Nuclear Energy Enabling Technologies and completing the FY 2015 industry-led advanced reactor concept development. | **-23,135** |
| **Total, Reactor Concepts Research, Development and Demonstration** | **-24,860** |

**Description**

In FY 2015, the AdvSMR R&D subprogram was consolidated into the ART subprogram.

**Reactor Concepts Research, Development and Demonstration**
**Light Water Reactor Sustainability**

**Description**

The existing U.S. commercial nuclear fleet has an excellent safety and performance record and today accounts for about 20% of the U.S. electricity supply and more than 60% of the low greenhouse-gas-emitting, domestic electricity production. However, with the 60-year operating licenses beginning to expire in 2029 and with the long planning horizon required to place new generation capabilities in service, utilities are beginning the planning process to obtain a license for operation of existing nuclear plants beyond 60 years. The first relicensing applications are expected in the 2018 time frame. Extending operating licenses beyond 60 years would enable existing plants to continue to provide safe, clean, and economical electricity without significant greenhouse gas emissions, while reducing the pressure to bring new non-greenhouse-gas-emitting capacity on line. The LWRS program has partnered with industry and the NRC to closely coordinate research needs and share costs. Industry will primarily address the near-term research needs and the LWRS program, along with industry and the NRC, will make progress on the long-term research needs. This research will form the technical basis for age-related material degradation management and inform major component refurbishment and replacement strategies related to Instrumentation and Control systems, and safety margin characterization. Given the nature of the work done by this program cost-sharing is of particular importance. The program will ensure appropriate cost-sharing arrangements for its activities according to Section 988 of the Energy Policy Act of 2005. Cost-sharing with industry is currently conducted primarily through specifically identified coordinated or collaborative research projects with the Electric Power Research Institute as documented in a joint research and development plan. Cost sharing with other industry partners is documented in project work agreements.

After the Fukushima Daiichi accident the nuclear community has been reassessing safety assumptions and nuclear plant safety performance. As a part of this, NE has initiated research within the LWRS program to develop a fuller understanding of the accident and its consequences with an eye toward how technological advancements can help address emergent safety concerns. Research activities include assessing the validity of modeling and simulation tools using information from Fukushima; working with industry to develop new technologies that could be used to prevent accidents, mitigate consequences, or provide reliable information during accidents; and working with Japan and the international community to conduct forensics on the Fukushima event and provide data to industry so that they can incorporate lessons learned and improve safety. These activities are expected to lead to the enhancement of the accident tolerance of current and future light water reactors and the enhancement of accident response capabilities.

Execution of the LWRS subprogram activities will follow a stepwise process that includes feedback, critical industry involvement and cost-sharing, and a focus on efficiency and cost-effectiveness to ensure maximum usefulness and applicability of results. All activities will be reviewed, revisited, and revised, as necessary, in the annual budget development and program planning processes.

**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **Light Water Reactor Sustainability** | | |
| **$35,000,000** | **$33,275,000** | **-$1,725,000** |
| • Materials Aging and Degradation Assessment – Develop a mechanistic understanding of irradiation-assisted stress corrosion cracking (IASCC) including crack initiation, swelling, and phase transformations. Assess the long-term performance of cables and concrete, including the collection of samples from aging plants. Develop new non-destructive examination (NDE) techniques for concrete and cables. Conduct irradiation effects experiments on concrete. Collect data on the thermal aging of cast stainless steels in service beyond 40 years. Develop a mechanistic understanding of environmental fatigue. Develop a mechanistic model for reactor pressure vessel (RPV) irradiation attenuation effects through the vessel wall.<br>• Safety Margin Characterization – Work with industry to demonstrate the use of the coupled RELAP-7/RAVEN software safety analysis tool. Demonstrate the use of the Risk-informed Safety Margin Characterization (RISMC) methodology to conduct safety margin quantifications of boiling water reactor station blackout scenarios. Expand the Grizzly component aging model to include concrete degradation.<br>• Instrumentation and Controls - Complete human factors evaluations and guidance | • Materials Aging and Degradation – Complete progress report on mechanistic testing for IASCC research. Deliver a mechanistic understanding of crack initiation susceptibility in Ni-based alloy components. Deliver a predictive capability for swelling in Light Water Reactor core components. Develop an initial physically-based thermodynamic and kinetic model of precipitate phase stability and formation in Alloy 316. Deliver report describing Reactor Pressure Vessel (RPV) sections received from the Zion Nuclear Power Plant. Complete an initial model of alkali-silica reaction degradation and demonstrate a prototype proof-of-concept system for Non-Destructive Examination (NDE) of concrete sections. Deliver updated knowledge gap assessment for irradiation effects in concrete and updated joint research plan to resolve any remaining issues. Deliver an updated gap assessment of remaining cable insulation degradation research needs and develop a prototype system for NDE of cable insulation. Demonstrate, on a laboratory scale, advanced weld repair techniques for highly irradiated materials. Deliver results of ion-irradiation campaign on advanced radiation-resistant materials and criteria for selecting advanced alloys. Develop an initial model for environmentally-assisted fatigue in Light Water Reactor components.<br>• Safety Margin Characterization – In collaboration with industry, complete a full-scope margins analysis of a commercial reactor power uprate scenario. Release the second beta version of the Grizzly code (component aging model) that includes the aging of concrete. Demonstrate margins analysis techniques, including a fully coupled RISMC toolkit, for performance-based Emergency Core Cooling System cladding acceptance criteria and for enhanced external hazard analyses (seismic and flooding). Develop an initial margin analysis tool to evaluate reactor containment | • The decrease reflects a focus on the most important research activities in the Materials Aging and Degradation area in support of the first subsequent license renewal applications submitted by industry to the Nuclear Regulatory Commission, expected in 2018. |

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| for pilot plant projects related to the use of computer based procedures; the use of mobile technologies that support real-time automated field work packages; and an advanced alarm system. Continue work on a prototype hybrid (analog and digital) control room design. Initiate new pilot plant projects on the use of advanced on-line monitoring systems and advanced outage risk monitor systems.<br>• Systems Analysis and Emerging Issues – Address emerging issues that could influence the continued viability of the existing nuclear power plants, such as water usage issues and economic viability assessments.<br>• Reactor Safety Technologies – Perform a severe accident instrument needs evaluation for all major domestic plant types and identify instrument research gaps. Initiate research into seismic base isolation system to improve plant response to seismic events. Develop severe accident models and test plans for molten core experiments. Conduct failure evaluation of safety components under severe accident conditions. Initiate research on new technologies that could be used to prevent accidents, mitigate consequences, or provide reliable information during accidents. In collaboration with Japan and the international community, develop a plan for inspection of damaged Fukushima Daiichi reactors and associated systems. | performance to evaluate the reliability of proposed industry BWR hardened venting systems. Complete the initial verification and validation of the RELAP-7 code. Extend RAVEN to provide an emulator capability for complex systems and an optimization search support for risk-informed margin recovery. Complete the optimized and validated version of RELAP-7 that provides coupled RAVEN tool and to other applications, used to perform as a balance-of-plant capability for the multidimensional core simulators.<br>• Instrumentation and Controls – Publish a technical report on computer-based procedures that enhances worker productivity, human performance, configuration control, risk management, regulatory compliance, and safety. In collaboration with industry, develop an end-state vision and strategy for a modernized, hybrid (mixed analog-digital) control room. Complete a progress report on an industry collaboration to develop an on-line monitoring capability for passive components.<br>• Systems Analysis and Emerging Issues – Address emerging issues that could influence the continued viability of existing plants, such as the implementation of flexible operations within an integrated grid.<br>• Reactor Safety Technologies – Collaborate with the Japanese and the international community to develop a priority list of forensic activities for a Fukushima inspection matrix. Use the MELCOR-MAAP code comparisons with uncertainties to aid in developing a diagnostic tool to inform Severe Accident Management Guidelines (SAMGs). In collaboration with industry, develop a plan to determine long-term cooling capability for Pressurized Water Reactor (PWR) and Boiling Water Reactor (BWR) current plant designs such as Reactor Core Isolation Cooling (RCIC) pump performance during beyond design basis events. | |

## Reactor Concepts Research, Development and Demonstration
## Advanced Reactor Technologies

**Description**

The Advanced Reactor Technologies (ART) subprogram will support the development of innovative reactor technologies that may offer improved safety, functionality and affordability, and build upon existing nuclear technology and operating experience. The ART subprogram supports research to reduce long-term technical barriers for advanced nuclear energy systems by addressing advanced reactor technologies. The ART subprogram will continue support for international activities in the Generation IV International Forum, and international collaborations on advanced reactor operations and safety. This subprogram will be focused on high value research for long-term concepts, R&D needs of promising mid-range concepts, the development of innovative technologies that benefit multiple advanced reactor concepts, and stimulation of new ideas for transformational future concepts. Near-term emphasis is on advanced reactor components and technologies to support advanced small modular reactors. The ART subprogram also supports R&D for more efficient energy conversion, increased proliferation resistance, and security. In addition, the ART subprogram supports laboratory/university and industry projects to conduct nuclear technology R&D, including the development of codes and standards, sensors and instrumentation, probabilistic risk assessments (PRA) methods, and other technologies that are unique and would be useful to support development of advanced reactor systems. In FY 2015, the Advanced Small Modular Reactor subprogram was consolidated into the ART subprogram.

Advanced reactor technologies considered in this program reside at different maturity levels. R&D efforts are mainly focused on three advanced concepts: fast reactors using liquid sodium (SFRs), and high temperature reactors (fluoride salt-cooled high temperature reactors (FHRs), and high temperature gas-cooled reactors (HTGR)). High temperature reactor R&D includes qualification of TRISO coated particle fuel and graphite used in both FHRs and HTGRs. In addition, advanced reactor technology R&D is being pursued that could provide wide benefits across many different advanced reactor systems (e.g., nuclear materials qualified for high temperature and fast reactor environments, energy conversion technologies and instrumentation and controls). The ART subprogram will continue to solicit and evaluate new ideas in order to encourage innovation, incorporation of technology advances, and to enhance the safety, as well as performance, of these systems. The ART subprogram is continuing engagement with industry by evaluating advanced reactor technologies through the Technical Review Panel (TRP) process. The ART subprogram will use the TRP process to identify R&D opportunities and help inform R&D investment decisions with a view toward long-term commercialization by industry.

R&D activities within the ART subprogram will follow a stepwise process that includes feedback and a focus on efficiency and cost-effectiveness to ensure maximum usefulness and applicability of results. All activities will be reviewed, revisited, and revised as necessary in the annual budget development and program planning processes.

**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **Advanced Reactor Technologies** | | |
| **$98,000,000** | **$74,865,000** | **-$23,135,000** |
| • Fast Reactor Technologies – Complete Mechanism Engineering Test Laboratory (METL) construction and commissioning. Complete engineering analyses on first gear test assembly innovations and conduct initial operational tests using METL.<br>• High Temperature Reactor Technologies – Perform post-irradiation examination (PIE) of AGR-2 and AGR-3/4 fuel experiments. Complete the design of the AGR-5/6/7 experiment. Perform irradiation of AGC-4 graphite experiment in ATR and perform post-irradiation examination of AGC-2 graphite experiment. Complete Reactor Cavity Cooling System decay heat removal test matrix on partial and full system failures in ANL Natural Circulation Shutdown Heat Removal Test Facility (NSTF) in air-cooled configuration.<br>• Advanced Reactor Generic Technologies – Conduct advanced reactor materials research including completion of ASME Code Qualification case proposals for selected materials and properties enhancement testing of high temperature steel. Continue development and operational performance testing on heat exchangers and modeling for high efficiency Brayton cycle energy conversion technology. Continue bi-lateral, Generation IV International Forum (GIF), | • Fast Reactor Technologies – Continue testing of gear-on-gear test assembly in liquid sodium in METL. Evaluate concepts for SFR control rod drive mechanisms.<br>• High Temperature Reactor Technologies – Continue PIE of the AGR-3/4 fuel experiment for fission product transport data. Complete AGR-5/6/7 experiment preparations for final TRISO fuel tests. Continue PIE of AGC-2 and -3 graphite experiments and continue irradiation of AGC-4 experiment in ATR. Complete reconfiguration of ANL Natural Circulation Shutdown Heat Removal Test Facility (NSTF) from air cooled to water cooled to test alternative configuration effectiveness. Continue severe accident analytical methods validation using the Oregon State High Temperature Test Facility.<br>• Advanced Reactor Generic Technologies – Continue ASME code case activities for high temperature steel. Continue development of advanced alloy code case for fast reactor use. Continue development and in-sodium tests of linear array waveguide transducers, brush-type waveguide phased array, and very high temperature transducers for under sodium viewing. Continue international benchmarking activities to validate advanced reactor safety codes and methods. Continue development and operational performance testing on heat exchangers and modeling for high efficiency Brayton cycle energy conversion technology. Continue bilateral and multi-lateral (e.g., Generation IV International Forum) efforts on advanced reactor safety, thermohydraulics, facilities, and other collaborative research.<br>• Advanced Reactor Regulatory Framework – Continue engagement with the NRC to develop guidance on advanced reactor design criteria. Implement a regulatory technology development strategy to address outstanding regulatory issues related to advanced reactor technologies. | • The decrease from $98,000,000 to $74,865,000 reflects the transfer of system studies related to hybrid energy systems development to Nuclear Energy Enabling Technologies and completing the FY 2015 industry-led advanced reactor concept development. |

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| and trilateral efforts on advanced reactor safety, thermohydraulics, facilities, and other collaborative research.<br>• Advanced Reactor Regulatory Framework– Provide technical reports to NRC on General Design Criteria related topics and advanced reactor technologies to support the NRC's establishment of an advanced reactor licensing framework. Complete development of a database that captures historical SFR equipment performance data which will be used to support the risk and safety analysis of future advanced reactors.<br>• Advanced Reactor System Studies – Conduct an advanced test/demonstration reactor planning study. Conduct an analysis of Hybrid Energy Systems in concert with the Office of Energy Efficiency and Renewable Energy. Continue economic analysis study including capital, operations, and fuel costs.<br>• Industry Engagement - Continue cost-shared technology development projects with industry in alignment with the TRP results. Make new cost-shared awards to industry for development of two advanced reactor concepts. | • Advanced Reactor System Studies – Continue advanced test/demonstration reactor planning study. Continue economic analysis study including capital, operations, and fuel costs. | |

## Reactor Concepts Research, Development and Demonstration
## Performance Measures

In accordance with the GPRA Modernization Act of 2010, the Department sets targets for, and tracks progress toward, achieving performance goals for each program.

| | FY 2014 | FY 2015 | FY 2016 |
|---|---|---|---|
| Performance Goal (Measure) | **Advanced Reactor Technologies - Complete 90% of annual program milestones to support research to support the development of innovative reactor technologies that may offer improved safety, functionality and affordability, and build upon existing nuclear technology and operating experience.** | | |
| Target | 90% | 90% | 90% |
| Result | 88% | N/A | N/A |
| Endpoint Target | Performance endpoints range from the mid-term (2030s) to long term and are focused on high value research for long term concepts, R&D needs of promising mid-range concepts, and development of innovative technologies that benefit multiple advanced reactor concepts and stimulation of new ideas for transformational future concepts. | | |
| Performance Goal (Measure) | **Light Water Reactor Sustainability – Complete 90% of planned milestones to support development of scientific knowledge to extend existing nuclear power plant operating life beyond the current 60 year limit.** | | |
| Target | 90% | 90% | 90% |
| Result | 100% | N/A | N/A |
| Endpoint Target | NE-developed tools and assessments will help establish the scientific bases for existing plants to apply for license extensions from the NRC in the 2030 timeframe. | | |

## Fuel Cycle Research and Development

**Overview**

The Fuel Cycle Research and Development (FCR&D) program conducts generic research and development (R&D) and generic non-R&D activities related to used nuclear fuel (UNF), nuclear waste management and disposal issues. The program also conducts R&D on advanced sustainable fuel cycle technologies that have the potential to improve resource utilization and energy generation, reduce waste generation, enhance safety, and limit proliferation risk. In addition, the program is laying the ground work for implementation of the Administration's *Strategy for the Management and Disposal of Used Nuclear Fuel and High-Level Radioactive Waste (Strategy)*. The program employs a long-term, science-based approach to foster innovative, transformational technology solutions to achieve this mission. Advancements in fuel cycle technologies and solutions support the enhanced availability, affordability, safety, and security of nuclear-generated electricity in the U.S.

The FCR&D program participates in world-class R&D and employs internationally renowned technical experts. All FCR&D subprograms leverage their technical expertise by participating in international collaborations through bilateral and multilateral technical agreements. The program's most active partners include France, Japan, China, the Republic of Korea, and the United Kingdom. The program also participates in projects sponsored by the International Atomic Energy Agency (IAEA) and the Organisation for Economic Cooperation and Development/Nuclear Energy Agency (OECD/NEA).

**Highlights of the FY 2016 Budget Request**

The Advanced Fuels subprogram continues to make progress towards its goal to demonstrate one or more light water reactor fuel concepts with significantly enhanced accident tolerance in a commercial nuclear power plant. A major activity in 2016 will be the "downselection/prioritization" of the industrial accident tolerant fuel concepts that will be pursued in the next phase of the program; leading up to the irradiation of a lead fuel rod or fuel assembly in a commercial power reactor in 2022.

FCR&D's Used Nuclear Fuel Disposition (UNFD) subprogram will continue to conduct scientific research and technology development to enable storage, transportation, and disposal of UNF and wastes generated by existing and future fuel cycles. Because of the evolution of the domestic UNF inventory, special emphasis is placed on understanding the behavior of high-burnup fuels. In FY 2016, funding increases significantly for R&D on the concept of waste disposal in deep boreholes in crystalline basement rock. The Department will initiate a field test that will include the drilling of a characterization borehole at a volunteer site that will be selected in the future.

In January 2013, the Administration released its *Strategy for the Management and Disposal of Used Nuclear Fuel and High-Level Radioactive Waste (Strategy)*. In FY 2016, the budget requests $30.0 million in the integrated waste management system element of the UNFD subprogram to support preliminary generic process development and other non-R&D activities related to storage, transportation, and consent-based siting, including $24.0 million from the Nuclear Waste Fund. In addition, for the R&D element of the UNFD subprogram, the Department requests $75.4 million for storage, transportation, and disposal related research and development.

An effective, long-term nuclear waste management program requires the restructuring of the current funding arrangement. The Administration recommends the new funding arrangement include the following elements: ongoing discretionary appropriations; access to annual fee collections provided in legislation, either through their reclassification from mandatory to discretionary, or as a direct mandatory appropriation; and eventual access to the balance or "corpus" of the Nuclear Waste Fund. The FY 2016 Budget Request includes a proposal to implement such reform. Discretionary appropriations are included for the duration of this effort. These funds would support expenses that are regular and recurring, such as program management costs, which include administrative expenses, salaries and benefits, studies, and regulatory interactions. In FY 2016, these funds will be for ongoing studies and outreach efforts associated with transportation and storage through the UNFD's integrated waste management system subprogram. Mandatory appropriations in addition to the discretionary funding are proposed to be provided annually starting in FY 2019 to fund the balance of the annual program costs.

Over the next ten years, the program reflected in the FY 2016 budget begins operation of a pilot interim storage facility, advances toward the siting and licensing of a larger interim storage facility, and makes demonstrable progress on the siting and characterization of geologic repository sites.

In FY 2016, the Department requests $3.0 million for a new UNFD subprogram element: DOE-Managed High-Level Radioactive Waste (HLW) and Spent Nuclear Fuel (SNF). This new subprogram element will include activities associated with exploring potential alternative disposal options for some DOE-managed HLW and SNF.

Fuel Cycle supports the Clean Energy Manufacturing Initiative (CEMI), a comprehensive DOE-wide approach to increase U.S. competitiveness in clean energy manufacturing while advancing progress toward the nation's energy goals. Within the FCR&D program, CEMI is supported by the Advanced Fuels subprogram. In FY 2016, Advanced Fuels will fund approximately $11.0 million for fuels-related advanced materials manufacturing research that will lead to results also benefitting advanced manufacturing, with a focus on materials for extreme environments.

In the FY 2016 Budget Request, DOE continues to support crosscutting programs that coordinate across the Department and leverage DOE's expertise in multiple disciplines to effectively and efficiently address U.S. energy, environmental, and national security challenges.

**Subsurface Engineering**: DOE's subsurface cross-program crosscut, SubTER, aims to address identified challenges in the subsurface through highly focused and coordinated research in Wellbore Integrity, Stress State and Induced Seismicity, Permeability Manipulation, and New Subsurface Signals to ensure enhanced energy security, material impact on climate change via $CO_2$ sequestration, and dramatically mitigated environmental impacts from energy related activities and operations.

The FY 2016 Budget supports the following activities: a field test to support R&D on the concept of waste disposal in deep boreholes in crystalline basement rock and R&D on characterization and performance of generic mined geologic repository media and concepts for disposal of high-level radioactive waste and used nuclear fuel.

**FY 2016 Crosscuts ($K)**

| | Subsurface Engineering | Total |
|---|---|---|
| **Fuel Cycle Research and Development** | **39,500** | **39,500** |

**Fuel Cycle Research and Development**
**Funding ($K)**

| | FY 2014 Enacted[1] | FY 2014 Current[2] | FY 2015 Enacted | FY 2016 Request | FY 2016 vs FY 2015 |
|---|---|---|---|---|---|
| **Fuel Cycle Research and Development** | | | | | |
| Material Recovery and Waste Form Development | 34,300 | 34,170 | 35,300 | 35,300 | - |
| Advanced Fuels | 60,100 | 58,177 | 60,100 | 48,700 | -11,400 |
| Systems Analysis and Integration | 19,605 | 18,977 | 16,900 | 11,200 | -5,700 |
| Materials Protection, Accounting & Control Technology | 7,600 | 7,358 | 7,600 | 8,600 | +1,000 |
| Used Nuclear Fuel Disposition | 60,000 | 59,040 | 71,500 | 108,360 | +36,860 |
| Fuel Resources | 4,600 | 3,485 | 5,600 | 5,600 | - |
| **Total, Fuel Cycle Research and Development** | **186,205** | **181,207** | **197,000** | **217,760** | **+20,760** |

SBIR/STTR:

- FY 2014 Transferred: SBIR $4,374; STTR $625
- FY 2015 Projected: SBIR $5,061: STTR $698
- FY 2016 Request: SBIR $5,543: STTR $831

[1] FY 2014 Enacted column reflects a rescission of $295,000 as identified within Section 317 of Public Law 113-76.
[2] Funding reflects the transfer of SBIR/STTR to the Office of Science.

**Fuel Cycle Research and Development**
**Explanation of Major Changes ($K)**

| | FY 2016 vs FY 2015 |
|---|---|
| **Advanced Fuels:** The decrease from $60,100,000 to $48,700,000 reflects funding provided in the FY 2015 Omnibus above the FY 2015 Budget Request. This allows accelerated and expanded testing of fuel concepts with enhanced accident tolerance in FY 2015. | **-11,400** |
| **Systems Analysis and Integration:** The decrease from $16,900,000 to $11,200,000 reflects a focus on fewer of the most promising fuel cycle options, as well as the completion of the effort to develop and populate the Fuel Cycle Catalog analysis tool in FY 2015. | **-5,700** |
| **Materials Protection, Accounting & Control Technology:** The increase from $7,600,000 to $8,600,000 supports the advancement of R&D of non-proliferation technologies. | **+1,000** |
| **Used Nuclear Fuel Disposition:** The increase from $71,500,000 to $108,360,000 is to fund significant increases in the following activities:<br>• Initiate a field test to examine the viability of large diameter, deep borehole disposal of high-level waste (+$18,000,000). The field test will include the drilling of an experimental borehole at a volunteer site that will be selected in the future. The additional funding is required for drill site preparations, permitting, drilling operations (contractor, equipment, and crew), and down-hole scientific testing.<br>• Initiate facility modifications to an INL facility in order to handle and examine existing on-site large dry storage casks (+$8,000,000). Preliminary analysis of an INL facility indicates that it has capability to handle those casks. The feasibility studies and conceptual design studies will be completed in FY 2015. Once completed and if successful, the Department proposes to continue to the next stage of activities in FY 2016; including modifications to the receiving area, primary containment structure, and fuel-handling cave.<br>• Expand integrated waste management system activities (+$7,500,000) to support the Administration's *Strategy for the Management and Disposal of Used Nuclear Fuel and High-Level Radioactive Waste (Strategy)*.<br>• Initiate a new UNFD subprogram for activities associated with exploring potential alternative disposal options for some DOE-managed HLW and SNF. (+$3,000,000). | **+36,860** |
| **Total, Fuel Cycle Research and Development** | **+20,760** |

**Description**

The Material Recovery and Waste Form Development (MRWFD) subprogram's primary mission is to develop advanced material recovery as well as advanced waste form development technologies that could improve current fuel cycle performance and enable a sustainable fuel cycle with minimal processing, waste generation, and potential for material diversion. MRWFD continues to apply the expertise and technical capabilities gained over the years to a broader range of applications. In addition to separations, MRWFD provides solutions for environmental remediation, national security missions, as well as civilian nuclear applications.

Regarding civilian nuclear applications, the ability to sustainably and economically recycle light water reactor (LWR) fuels and advanced reactor fuels is partially dependent on the ability to separate the various elements from the UNF into material for reuse and for disposal. The ability to engineer, produce, and manage fuel cycle waste forms that are chemically and structurally stable over relevant periods of time from decades to hundreds of thousands of years (depending on the radioisotope) would be critical for any advanced fuel cycle.

Joint Fuel Cycle Studies (JFCS) is a key activity within MRWFD. In collaboration with the Republic of Korea, the JFCS is assessing the technical and economic feasibility and nonproliferation acceptability of electrochemical recycling and other options for managing UNF. JFCS is a ten-year effort that is divided into three phases. In FY 2016, the JFCS will be in its second phase, which is the determination of reliable integrated process operation with used LWR fuel.

**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **Material Recovery and Waste Form Development** | | |
| **$35,300,000** | **$35,300,000** | **$0** |
| • Develop minor actinide separation methods to support development/testing of reference process(es) for homogenous (grouped actinides extraction as an example, U, Pu, and the Minor actinides (MA)) or heterogeneous (U, Pu, and Np selective extraction followed by Am and Cm extraction) separation methods and of high potential alternatives that could provide significant improvement over a separation case study.<br>• Development of effective methods to capture and immobilize gaseous fission products Iodine-129 (I-129), Carbon-14 (C-14), Krypton-85 (Kr-85) and Tritium (H-3) released from fuel treatment under a range of various fuel cycle options. Demonstration of an integrated suite of advanced processes using new and innovative adsorbents such as metal organic framework (MOF), silver zeolites, or silver aerogels to effectively capture and immobilize volatile and semi-volatile radionuclides to the extent necessary to meet or exceed the regulatory requirements to protect the environment and personnel.<br>• Develop integrated off-gas flowsheet that includes tritium capture and seeks to maintain separation between iodine and tritium.<br>• Investigate thermodynamics and kinetics of reference process(es) to better characterize operating window and optimize process performance.<br>• Continue development of atomistic models for waste form performance over geologic timescales to include corrosion processes and radiation | • Continue preparations for laboratory scale demonstration of single step process (homogenous) or two-step process (heterogeneous) separations, by addressing flowsheet design and testing, and further development of the most promising alternative processes.<br>• Develop and demonstrate fission gas capture and immobilization technologies, focusing on iodine, krypton, and tritium and to evaluate carbon-14 management requirements and technology options.<br>• Investigate thermodynamics and kinetics of case study process(es) to better characterize operating window and optimize process performance.<br>• Continue development of U/TRU recovery technologies on solid cathode. Fabricate equipment for solid cathode demonstration at kg scale with actual fuel following JFCS Integrated Recycling Test (IRT) testing.<br>• Perform lab-scale testing with simulants of candidate aqueous processes.<br>• Continue to develop solvent degradation (radiolysis and hydrolysis) evaluations.<br>• Provide software tools and analysis for the tracking of material at risk (MAR) during operations of the Integrated Recycling Test (IRT) in the Hot Fuel Examination Facility (HFEF).<br>• Provide for the design, fabrication, qualification, and installation of remote, kilogram-scale process equipment in the HFEF.<br>• Investigate critical technical topics (related to fuel fabrication) to enable the success of the Integrated Recycling Test (IRT), or to enable determination of the long-term technical and economic feasibility and non- | • There is increased funding to allow for testing advanced on-line process monitoring at H-Canyon and to establish the technical basis for an international consensus glass corrosion rate. This is offset by focused funding for waste form characterization activities and modeling and simulation activities in separations and in waste form degradation. |

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| stability.<br>• Continue progress on development of plant scale model framework and model integration; hydraulic modeling of centrifugal contactors, including generation of data to support model development; modeling of reference flow sheet to develop/determine waste compositions; and product compositions and waste quantities.<br>• Begin defining and developing process parameters and testing plans for reference process(es).<br>• Testing of solvent degradation mechanisms (due to radiolysis and hydrolysis) and by-products formation for reference processes and support international collaboration on solvent induced radiolysis degradation with France.<br>• Perform lab-scale chemistry testing of reference process(es) using simulants and actual fuel, perform flowsheet testing of reference processes on simulants.<br>• Continue development of uranium/transuranic drawdown technologies on solid cathode.<br>• Complete hot demonstration of zirconium purification from hulls.<br>• Develop alternative glass ceramic waste forms, epsilon metals in undissolved solids and alternative crystalline ceramic waste forms.<br>• Begin to develop engineering data for advanced waste-form processing using the advanced cold crucible induction melter technology. | proliferation acceptability of electrochemical recycling.<br>• Establish the technical basis for an international consensus glass corrosion rate for reference glass.<br>• Explore advanced on-line process monitoring at H-Canyon. | |

## Fuel Cycle Research and Development
## Advanced Fuels

**Description**

The development of improved and advanced nuclear fuels is a major objective for existing light water reactors (LWR) and future sustainable fuel-cycle options. Advanced Fuels is pursuing two major paths: 1) the development of next generation LWR fuels with enhanced performance and accident tolerance, and 2) the development of transmutation fuels with enhanced proliferation resistance and resource utilization over the long term. The Advanced Fuels subprogram sustains core development and experimental capabilities that support the nuclear reactor technologies described in the Reactor Concepts Research, Development, and Demonstration program.

In FY 2016, the program continues to support accident tolerant fuel (ATF) and clad concepts R&D. This includes fuel fabrication and testing involving irradiations in DOE's Advanced Test Reactor (ATR) and foreign reactors (Halden), steam environments, furnaces, and mechanical property testing. These feasibility and assessment activities also include establishing modeling capabilities for these new concepts, using existing models as the bases for development; as well as studies of impacts on economics, the fuel cycle, operations, safety, and the environment. These evaluations will inform decisions about future activities in this subprogram. The Department also plans to establish the capability for pressurized loop testing in the ATR and transient testing in the Transient Reactor Test Facility (TREAT), both at the Idaho National Laboratory (INL).

A major activity in 2016 will be the "downselection/prioritization" of the industrial accident tolerant fuel concepts that will be pursued in the next phase of the program; leading up to the irradiation of a lead fuel rod or fuel assembly in a commercial power reactor. The Department will also continue the long-term development of transmutation fuel that includes irradiations, enhanced material testing capability enhancement, associated model development, and coordination with the NE nuclear model and instrument development programs.

The Department will pursue opportunities to collaborate with U.S. universities and academic institutions through the Nuclear Energy University Program (NEUP) that supports the FCR&D program and advanced fuel development priorities.

**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **Advanced Fuels $60,100,000** | **$48,700,000** | **-$11,400,000** |
| • Perform R&D across multiple laboratory organizations supporting the development of innovative accident tolerant fuel for LWRs.<br>• Develop metrics, performance assessment, and characterization for LWR accident tolerant fuel to inform next steps for the program.<br>• Test accident tolerant fuel irradiation capsule in Idaho National Laboratory's (INL) Advanced Test Reactor (ATR).<br>• Support international activities including acquisition of neptunium dioxide for support to the Global Actinide Cycle International Demonstration Project.<br>• Acquire, prepare, characterize, and maintain the uranium and actinide feedstocks.<br>• Continue development of fabrication processes for minor actinide-bearing metal fuel.<br>• Characterize minor actinide bearing metal alloy fuel composition for mechanical, physical, and thermal properties.<br>• Support advanced post-irradiation examination equipment at the INL.<br>• Establish an independent ATF technical review committee to support ATF downselection/prioritization in CY 2016.<br>• Initiate testing of ATF technology in the Halden reactor.<br>• Initiate irradiation of a second set of candidate ATF fuel pins in ATR.<br>• Issue ATR ATF loop conceptual design report.<br>• Initiate designs of ATF TREAT experiment capsules and water loop. | • Initiate post irradiation examination on first set of industry-led ATF-1 fuel-clad samples.<br>• Demonstrate advanced sintering process at laboratory scale of first generation lab-led fuel.<br>• Select and prioritize ATF technologies for phase 2 development and qualification towards lead fuel rod or lead fuel assembly irradiation.<br>• Finalize design basis accident analysis including fuel performance using BISON and other advanced tools.<br>• Demonstrate remote casting of metallic fuel samples.<br>• Complete post irradiation examination (PIE) on PHENIX-irradiated advanced cladding materials (total dose up to 70 dpa) and FUTURIX-FTA baseline PIE.<br>• Initiate Am-target irradiation tests in ATR in collaboration with Commissariat à l'Énergie Atomique et aux Énergies Alternatives.<br>• Start China Experimental Fast Reactor irradiation of advanced cladding materials through U.S.-China bilateral.<br>• Release BISON application for ternary metallic fuels.<br>• Analyze separate effects test data for irradiation induced creep and incorporate results to fuel performance code.<br>• Demonstrate electron probe micro-analyzer capability on irradiated fuel in IMCL.<br>• Complete design of test train for irradiation of ATF concepts in ATR Loop 2A.<br>• Initiate fabrication of ATR loop experiment hardware.<br>• Complete conceptual design of TREAT water loop.<br>• Initiate acquisition of TREAT experiment support hardware. | • The reduction in Advanced Fuels reflects funding provided in the FY 2015 Omnibus above the FY 2015 Budget Request. This allows accelerated and expanded testing of fuel concepts with enhanced accident tolerance in FY 2015. |

## Fuel Cycle Research and Development
## Systems Analysis and Integration

**Description**

The Systems Analysis and Integration subprogram provides the critical capability needed to analyze complex fuel cycle system options, assess overall performance under various scenarios, and improve understanding of the interdependencies between various subsystems and associated technologies. The objective is to develop and implement analysis processes and tools, and perform integrated fuel cycle evaluations that help inform the decision makers on the overall FCR&D priorities and program direction. In addition, information gleaned from these processes will provide valuable insights into how to best integrate activities through R&D efforts with common fuel cycle goals.

The Systems Analysis and Integration subprogram also provides support in knowledge management, communications, fostering innovation, quality controls, project controls, and program integration.

**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **Systems Analysis and Integration $16,900,000** | **$11,200,000** | **-$5,700,000** |
| • Conduct analyses of transitions from current fuel cycle to the much smaller set of "most promising" fuel cycles as defined by the evaluation and screening activity, including development of timelines and estimated costs.<br>• Develop communication products for the results of the evaluation and screening, focusing on the identification of potential R&D directions.<br>• Provide for fuel cycle catalog evolution and continued development to be available to the Fuel Cycle Research & Development (FCR&D) program and others as a resource of fuel cycle knowledge.<br>• Examine the nuclear energy system impacts of using accident tolerant fuel, including the effects on resources, economics, and potential impacts to the other parts of the fuel cycle, depending on the accident tolerant fuel and the fuel cycle being considered.<br>• Provide supporting analyses of fuel cycle options to promote integration of FCR&D program activities.<br>• Prepare an addendum to the Fuel Cycle Cost Basis Report.<br>• Develop Fuel Cycle Data Packages to support population of the Fuel Cycle Catalog.<br>• Continue to reevaluate and refine the specific credible fuel cycle options working with the R&D campaigns as the FCR&D program directions are defined, and as results are obtained.<br>• Respond to evolving program needs for systems-level examinations of fuel cycle performance and integration of program activities. | • Continue analysis of transition and growth projections from the current fuel cycles to the smaller set of promising fuel cycles as identified by the Evaluation and Screening Study.<br>• Study of options that may affect transition time using fissile materials from existing stockpiles or recovered from existing used fuel, use of legacy waste (and its fissile content), fast reactor conversion ratio, and use of enriched uranium to start the transition.<br>• Continue global impacts/benefits analyses tying nuclear energy to reducing greenhouse gas emissions.<br>• Identify what is needed to support credible fuel cycle cost estimates and evaluation of financial risk and perform cost analyses to support systems studies and identify where additional R&D could provide significant impact.<br>• Analyze fuel cycles using small modular reactors (LWR, HTGR, SFR) in the transition period for fuel cycle deployment for the promising options identified by the Evaluation and Screening Study.<br>• Working with R&D campaigns, analyze specific technology options to narrow the R&D focus.<br>• Ensure the research and development pathways being explored by the various campaigns within the FCR&D subprograms are well integrated, executed effectively, and aligned with the overall mission of the Office of Nuclear Energy. | • The decrease in Systems Analysis and Integration reflects a focus on fewer of the most promising fuel cycle options, as well as the completion of the effort to develop and populate the Fuel Cycle Catalog analysis tool in FY 2015. |

**Description**

The Materials Protection, Accounting and Control Technology (MPACT) subprogram develops the technologies and analysis tools to support the next generation of nuclear materials management and safeguards for future U.S. nuclear fuel cycles. It also includes assessing vulnerabilities and security of the consolidated storage of used nuclear fuel, and managing and minimizing proliferation and terrorism risk. Addressing the energy security needs of the country will require innovative approaches to materials control and accounting to ensure that nuclear material is not misused, diverted, or stolen.

NE works closely with the National Nuclear Security Administration (NNSA), the Department of State, and the Nuclear Regulatory Commission (NRC) on issues related to nuclear nonproliferation. NNSA has broad responsibilities in international nonproliferation and security matters for the present and into the future. MPACT is focused on research and development (R&D) as it relates to potential future fuel cycle facilities in the U.S.

Challenges facing nuclear materials accountancy generally include:

- Limitations of accuracy and timeliness of detection especially in high radiation fields.
- New reactor designs and fuel cycle concepts that require new nuclear material management approaches (Small Modular Reactors, Gas-Cooled Reactors, Thorium, etc.).
- Traditional material control and accountability challenges, such as uncertainty in large throughput facilities.

**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **Materials Protection, Accounting and Control Technology $7,600,000** | **$8,600,000** | **+$1,000,000** |
| • Develop analyses and technologies to address security of used fuel extended storage (publish guidance documents, develop and apply risk-informed nuclear security analytical methods, perform threat assessments, develop innovative security technologies).<br>• Develop and demonstrate innovative new methods for proliferation and terrorism risk assessment (adversary analysis, decision analysis, game theory, and prototypic evaluations building on existing risk assessment methods).<br>• Develop analysis tools to enable next generation nuclear materials management (fundamental models and signature development, statistical inference and methodology, facility-level performance models).<br>• Develop and demonstrate sensors to fill gaps in nuclear materials protection, accounting and control emphasizing electrochemical processing (microfluidic sampling, potentiometric sensor, level and density sensor, product assay).<br>• Support the Department's *Strategy for Management and Disposal of Used Nuclear Fuel and High-Level Radioactive Waste (Strategy)* through Safeguards and Security by Design.<br>• Test next generation nuclear materials management technologies and approaches as opportunities arise.<br>• Address safeguards and security issues associated with technology development in other Campaigns.<br>• Support NRC rulemaking through engagement and data generation. | • Develop and demonstrate advanced sensors and instrumentation to fill gaps in materials protection, accounting and control.<br>• Develop and demonstrate an integrated suite of sensors and instruments (e.g., actinide sensor, level/density sensor, microfluidic sampler), analysis and performance assessment tools (e.g., fundamental models, pattern recognition and statistical inference methods, facility performance models) for electrochemical processing.<br>• Development and demonstrate concepts and approaches, and associated technologies and analysis tools for safeguards and security of used fuel extended storage.<br>• Evaluate additional process monitoring (voltammetry) for safeguards utilization.<br>• Develop advanced sensors for neutron detection (e.g., solid state) applicable to both monitoring and assay applications.<br>• Continue international engagement to help influence and support the advanced safeguards of the nuclear energy enterprise. | • In FY 2016, the Materials Protection, Accounting and Control Technology subprogram continues to expand its support of extended storage of used nuclear fuel. It also focuses on developing its most promising advanced instrumentation concepts. |

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| • Continue international engagement to help influence and support nuclear energy enterprise. | | |

**Fuel Cycle Research and Development**
**Used Nuclear Fuel Disposition**

**Description**

The Used Nuclear Fuel Disposition subprogram is organized into three distinct elements: 1) research and development (R&D) to identify alternatives and conduct scientific research and technology development to enable storage, transportation, and disposal of used nuclear fuel and wastes generated by existing and future nuclear fuel cycles, 2) activities that lay the groundwork and develop options for decision makers on the design of an integrated waste management system with specific emphasis on development of a consolidated storage facility and associated transportation, and 3) activities associated with exploring potential alternative disposal options for some DOE-managed high-level radioactive waste and spent nuclear fuel.

*Research and Development*

Used Nuclear Fuel (UNF) Disposition – Scientific research and technology development to enable storage, transportation, and disposal of UNF and wastes generated by existing and future fuel cycles.

Disposal R&D – Activities continue to further the understanding of long-term performance of disposal systems in three main geologic rock types: clay/shale, salt, and crystalline rock. These activities include collaborations with international partners to leverage and integrate applicable R&D being conducted by other countries into the U.S. disposal R&D portfolio. Also, evaluations will be completed to determine the feasibility of directly disposing existing single (storage only) and dual-purpose (storage and transportation) used-fuel canisters in a mined repository.

Deep Boreholes –The borehole disposal concept is to drill a borehole (or array of boreholes) into crystalline basement rock to a depth below surface of about 5,000 meters (greater than 3 miles). Waste canisters would be emplaced in the lower 2,000 meters of the borehole, with sealing of appropriate portions of the upper 3,000 meters of the borehole. In FY 2016, the Department will begin a field test that will include drilling a characterization borehole at a volunteer site that will be selected in the future.

Full-Scale Storage Cask Demonstration – Although the nuclear power industry has used dry storage for many years, this storage option has been for low-burnup fuel; therefore, there is limited data available on more contemporary high-burnup fuels. To address this data gap, the Department of Energy (DOE), the Nuclear Regulatory Commission (NRC), and nuclear industry have a collaborative agreement to investigate extended storage of high-burnup fuels (≥ 45 GWd/MTHM). DOE, in cooperation with NRC and industry, is preparing for a full-scale demonstration of storage for high-burnup fuel that will be beneficial by: 1) benchmarking the predictive models and empirical conclusions developed from short-term laboratory testing, and 2) building confidence in the ability to predict the performance of these systems over extended time periods.

Storage and Transportation R&D – In addition to the Full-Scale Storage Cask project, DOE will continue to support other lab testing, field studies, and modeling R&D related to the storage and transport of high-burnup fuel includes: testing of cladding response with hydride reorientation and embrittlement; the effects of atmospheric corrosion on storage welds; measuring the embrittlement of elastomer seals; determining thermomechanical degradation of bolts, welds, seals and poisons; analyzing thermal profiles of stored fuels; determining the stress profiles of fuels and casks; evaluating cask drying processes; laboratory post-irradiation examination of the fuel; and the development of sensors for internal and external cask monitoring. R&D will focus on contributing to the technical knowledge to support long-term storage and eventual transportation of high-burn-up fuels.

*Integrated Waste Management System*

In FY 2012, the Department began to plan and lay the groundwork that could lead to one or more facilities for used fuel management under a consent-based siting program and prepare for large-scale transport of used fuel. In January 2013, the Administration released its *Strategy for the Management and Disposal of Used Nuclear Fuel and High-Level Radioactive Waste (Strategy);* all of the activities being performed under this subprogram support this Strategy.

An effective, long-term nuclear waste management program requires the restructuring of the current funding arrangement. The Administration recommends the new funding arrangement to include the following elements: ongoing discretionary appropriations; access to annual fee collections provided in legislation, either through their reclassification from mandatory to discretionary, or as a direct mandatory appropriation; and eventual access to the balance or "corpus" of the Nuclear Waste Fund.

The FY 2016 budget request includes a proposal to implement such reform. Discretionary appropriations are included for this new program for the duration of the effort. These funds would be used for expenses that are regular and recurring, such as program management costs, including administrative expenses, salaries and benefits, studies, and regulatory interactions. In FY 2016, the budget includes $30.0 million for integrated waste management system activities, including $24.0 million from the Nuclear Waste Fund, to support preliminary generic process development and other non-R&D activities related to storage, transportation, and consent based siting. Mandatory appropriations in addition to the discretionary funding are proposed to be provided annually beginning in FY 2019 to fund the balance of the annual program costs.

*DOE-Managed HLW and SNF*

In FY 2016, the budget includes a new subprogram element for activities associated with exploring potential alternative disposal options for some DOE-managed HLW and SNF. These activities will help inform decisions going forward.

**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **Used Nuclear Fuel Disposition $71,500,000** | **$108,360,000** | **+$36,860,000** |
| *Research and Development activities ($49,000,000)*<br>• Develop the technical knowledge and the capability to examine high-burnup UNF to support NRC licensing for long-term storage. This activity involves the following:<br>o Support for industry testing of canister material performance in situ at three additional Independent Spent Fuel Storage Installation sites in collaboration with the Electric Power Research Institute to obtain environmental samples and canister performance data.<br>o Develop advanced instrumentation: Explore the development of nondestructive evaluation/examination and long-term online monitoring technologies for DCSS integrity assessments including crucial physical parameters such as temperature, pressure, leakage and structural integrity in general.<br>o Conduct tests: Conduct additional shaker table tests on industry-supplied dummy fuel assemblies. Test high-burnup cladding and stainless steel canisters for corrosion. Test measurement of loads on fuel assemblies during transportation.<br>• Continue R&D work to explore the possibility of direct disposing existing loaded dual purpose canisters in a repository.<br>• Evaluate alternative design concepts for deep borehole disposal. Start to implement the deep borehole demonstration and participate in DOE's Subsurface Crosscut tasks. | *Research and Development activities ($75,360,000)*<br>• Collaborate with industry in designing and fielding a dry demonstration cask. The focus is on support to finalize the industry test plan, selecting fuel for the demo, and identifying and assessing technologies for monitoring gasses and temperature inside the canister during storage.<br>• Lead the interface with DOE and industry for issues related to fuel transfer, instrumentation, and analysis support for the industry-led full-scale high-burnup dry storage demonstration. Ensure this plan meets the requirements of the campaign, DOE, and industry.<br>• Assess the technical feasibility of direct disposal of dual-purpose canisters, and single-purpose (storage-only) canisters, used for dry storage of used nuclear fuel.<br>• Development of thermodynamic databases and models to evaluate the stability of barrier materials and their interactions with fluids at various physico-chemical conditions relevant to subsurface repository environments.<br>• Develop modeling approach and toolset for modeling of fuel and cladding in in storage and transportation environments and uncertainty quantification (UQ) methodology to quantify degradation mechanisms during storage and transportation of high-burnup fuels.<br>• Evaluate regional and sub-regional geotechnical and other information for a drilling project including the development of reference designs for disposal of alternative waste forms and borehole seals research and planning. | *Research and Development activities(+$26,360,000)*<br>• The increase is to fund significant increases in two ongoing R&D activities:<br>o Initiate a field test to examine the viability of large diameter, deep borehole disposal of high-level waste (+$18,000,000). The field test will include the start of drilling an experimental borehole at a volunteer site to be determined. The additional funding is required for drill site preparations, permitting, drilling operations (contractor, equipment, and crew), and down-hole scientific testing.<br>o Develop advanced design and facility modifications to existing INL facilities in order to handle and examine existing on-site large dry storage casks (+$8,000,000). An INL facility is being assessed for the capability to handle those casks. Preliminary analysis of that facility indicates that it would be capable of handle those casks. The feasibility studies and conceptual design studies will be completed in FY 2015, and if successful, it is proposed to move forward to building modifications in FY 2016. |

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| • Continue evaluating 3 main geologic rock types: crystalline, clay/shale, and salt. Analyses, lab and field tests will be conducted for all three rock types as appropriate. | • Initiate a field test to examine the viability of large diameter, deep borehole disposal of high-level waste, including the start of drilling an experimental borehole at a volunteer site to be determined.<br>• Conduct analyses, lab and field tests, including collaborations with international partners, to evaluate three main rock types for geologic disposal: crystalline, clay/shale, and salt.<br>• Perform experiments to develop the technical bases for the extended storage and transportation of used nuclear fuel, especially high-burnup (HBU) fuel.<br>• Perform analysis and experiments to evaluate fuel rod performance during truck and rail transport, collaborating with industry to ship an instrumented surrogate PWR assembly to conduct a shaker test.<br>• Develop a disposal system modeling and analysis capability that supports the prioritization of Disposal Research (DR) R&D and the evaluation of disposal system performance, including uncertainty, for a range of disposal options (e.g., salt, argillite, crystalline, deep borehole).<br>• In FY 2016 begin facilities modifications to the receiving area, primary containment structure, and fuel handling cave. | |
| *Integrated waste management system activities ($22,500,000)*<br>• Maintain and expand the unified and integrated UNF database and analysis system to characterize the input to the waste management system.<br>• Prepare for large-scale transportation of UNF and high-level radioactive waste to a pilot interim storage facility with focus on UNF at shutdown reactor sites. Engage with State Regional Groups, tribes and other stakeholders, revise National Transportation Plan, prepare to implement the Nuclear Waste Policy Act Section 180(c) pilot | *Integrated waste management system activities ($30,000,000)*<br>• Plan for the implementation of interim storage as a planned part of the waste management system, with an initial focus on a pilot interim storage facility (ISF) accepting used nuclear fuel (UNF) from shut-down reactor sites. This will include evaluation of design and operational concepts for storage and transportation.<br>• Continue development of plans for a consent-based siting process.<br>• Prepare for large-scale transportation of UNF and | *Integrated waste management system activities (+$7,500,000)*<br>• This increase expands integrated waste management system activities to continue to support the Administration's *Strategy for the Management and Disposal of Used Nuclear Fuel and High-Level Radioactive Waste (Strategy).* Significant increases are proposed for evaluating shutdown sites, transportation planning and rail car development, and the generic design of a pilot interim storage facility. |

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| program, initiate efforts to develop railcars per Association of American Railroads standard, and initiate efforts according to hardware acquisition strategy.<br>• Evaluate integrated approaches to storage, transportation, and disposal in the waste management system with an emphasis on providing flexibility, including evaluation of standardization of dry cask storage and transportation systems.<br>• Develop a generic topical safety analysis report for a pilot integrated storage facility, including cask receipt and handling facilities, and engage with NRC on their review.<br>• Complete expanded system architecture studies, expanded organizational infrastructure for document control and UNF data/knowledge management, and expanded efforts to support licensing and UNF acceptance.<br>• Complete enveloping generic specification of small and medium size Standardized Transportation Aging and Disposal canisters.<br>• Continue existing work in development of advanced modeling tools for systems-level analysis of repository concepts.<br>• Verify and establish the next-generation waste management systems logistics analysis tool to enable the transition from legacy tools. | HLW to facilitate the acceptance of UNF at a pilot ISF within the next 10 years.<br>• Work with State Regional Groups and Tribes to plan transportation activities including evaluation of approaches to implement Nuclear Waste Policy Act requirements to provide funds and training to public safety officials of units of government through whose jurisdiction UNF may be transported.<br>• Continue and expand the evaluation of shut-down sites to prepare for and enable transportation; refine routing studies and capabilities; develop plans and cost estimates for "campaigning" fuel shipments; develop and maintain transportation system functional requirements.<br>• Continue activities related to acquisition of transportation rolling stock, transportation casks, and ancillary equipment, including preliminary design and acquisition of prototype rail cars for testing.<br>• Identify and evaluate opportunities for standardization and integration within the nuclear waste management system, including developing design options for multi-purpose storage, transportation, and disposal components and systems.<br>• Expand and maintain the Used Nuclear Fuel Storage, Transportation & Disposal Analysis Resource and Data System (UNF-ST&DARDS) database.<br>• Complete a Topical Safety Analysis Report for a generic design of a pilot interim storage facility and prepare to respond to requests for additional information from the NRC. | |

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| *DOE-Managed HLW and SNF ($0)*<br>• This is a new UFD Disposition subprogram element introduced in FY 2016. | *DOE-Managed HLW and SNF ($3,000,000)*<br>• Activities associated with exploring potential alternative disposal options for some DOE-managed HLW and SNF. These activities will help inform decisions going forward. | *DOE-Managed HLW and SNF (+$3,000,000)*<br>• This is a new UFD Disposition subprogram element introduced in FY 2016 for activities associated with exploring potential alternative disposal options for some DOE-managed HLW and SNF. |

**Description**

The Fuel Resources subprogram supports activities that will assure economic nuclear fuel resources remain available. The program will evaluate nuclear fuel resources and develop economic means of extracting uranium from seawater. A key objective is to develop advanced adsorbent materials that can simultaneously enhance uranium sorption capacity, selectivity, kinetics, and materials durability; thereby, reducing the development costs and uncertainties.

New developments in high performance computing, advanced characterization instruments, and nanoscience and nanomanufacturing technology will be fully integrated into technology development activities. The technology-driven, science-based R&D efforts are focused on: simulating and predicting structural and functional relationships using modern computational tools; applying advanced quantum beam characterization tools to understand dynamic chemical processes at the atomic and molecular levels; and synthesizing novel nanoscale adsorbent materials with architectures tailored for specific chemical performance.

**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **Fuel Resources $5,600,000** | **$5,600,000** | **$0** |
| • Continue improving adsorbent processing technology to reduce cost and increase performance.<br>• Continue utilizing nanosynthesis and nanomanufacturing techniques to develop new polymer sorbents.<br>• Continue optimizing synthesis and the design of new functional ligands via computational tools.<br>• Optimize the development design of braided fiber adsorbents by increasing loop length, loop density and loop numbers.<br>• Conduct sorption and uranium recovery experiments in a marine environment to provide data for scale-up and evaluation of marine deployment.<br>• Conduct cost and energy analyses and developed cost/energy models to include newly developed adsorbents and technologies to aid in focusing R&D efforts.<br>• Continue material durability evaluation. | • Prepare polymer-based adsorbents by irradiation (e-beam) induced and chemical grafting methods to increase the uranium sorption capacity and selectivity for screening and marine testing.<br>• Use computational modeling to identify promising ligands for increased uranium capacity and selectivity.<br>• Utilize data from the marine testing of developed adsorbents at marine test sites to formulate engineering models of kinetic and equilibrium mechanisms.<br>• Evaluation of desorption methods and characterize the recycling of adsorbent materials and mechanisms of degradation.<br>• Develop adsorbent materials on high-surface area nanoporous substrates containing functional ligands for selective sorption of uranium from seawater. | • The subprogram surpassed its initial goal to double the world's best uranium adsorption capacity. Its main focus now is to take advantage of high performance computing, advanced characterization instruments, and nanotechnologies to seek out further technical breakthroughs.<br>• The durability/recyclability of the adsorbent material under lab-scale natural seawater conditions will be evaluated. |

## Fuel Cycle Research and Development Capital Summary ($K)

| | Total | Prior Years | FY 2014 Enacted | FY 2014 Current | FY 2015 Enacted | FY 2016 Request | FY 2016 vs FY 2015 |
|---|---|---|---|---|---|---|---|
| **Capital Operating Expenses Summary (including (Major Items of Equipment (MIE))** | | | | | | | |
| Capital Equipment > $500K (including MIE) | n/a | n/a | 0 | 3,150 | 2,300 | 0 | -2,300 |
| Plant Projects (GPP and IGPP) (<$10M) | n/a | n/a | 822 | 0 | 0 | 0 | - |
| Accelerator Improvement Projects (AIP) (<$5M) | n/a | n/a | 0 | 0 | 0 | 0 | - |
| **Total, Capital Operating Expenses** | **n/a** | **n/a** | **822** | **3,150** | **2,300** | **0** | **-2,300** |
| **Capital Equipment > $500K (including MIE)** | | | | | | | |
| Electron Probe Micro-Analyzer | 4,500 | n/a | 0 | 2,500 | 1,300[1] | 0 | -1,300 |
| Glovebox and hoods | 1,650 | n/a | 0 | 650 | 1,000 | 0 | -1,000 |
| **Total, Capital Equipment (including MIE)** | **6,150** | **n/a** | **0** | **3,150** | **2,300** | **0** | **-2,300** |
| **Plant Projects (GPP and IGPP) (Total Estimated Cost (TEC) <$10M)** | | | | | | | |
| Total Plant Projects (GPP/IGPP) (Total Estimated Cost (TEC) <$5M) | 822 | n/a | 822 | 0 | 0 | 0 | - |
| High Density Fuel Glovebox | 822 | n/a | 822 | 0 | 0 | 0 | - |
| **Total, Plant Projects (GPP/IGPP) (Total Estimated Cost (TEC) <$10M)** | **822** | **n/a** | **822** | **0** | **0** | **0** | **+0** |
| **Total, Capital Summary** | **6,972** | **n/a** | **822** | **3,150** | **2,300** | **0** | **-2,300** |

[1] The FY 2015 equipment purchase will be funded as follows: $1,300,000 from Nuclear Energy, $600,000 from Science, and the balance of $1,000,000 is from non-federal WFO sponsor.

## Fuel Cycle Research and Development
## Performance Measures

In accordance with the GPRA Modernization Act of 2010, the Department sets targets for, and tracks progress toward, achieving performance goals for each program.

| | FY 2014 | FY 2015 | FY 2016 |
|---|---|---|---|
| Performance Goal (Measure) | **Fuel Cycle R&D - Complete 90% of annual program milestones to support the long-term mission to develop fuel cycle technologies.** | | |
| Target | 90% | 90% | 90% |
| Result | 98% | N/A | N/A |
| Endpoint Target | The R&D milestones represent progress toward several key fuel cycle outcomes: (1) Support the Administration's *Strategy for the Management and Disposal of Used Nuclear Fuel and High-Level Waste* to begin operation of a pilot interim storage facility by 2021 and a larger interim storage facility by 2025, and making demonstrable progress to facilitate the availability of a geologic repository by 2048. (2) Conduct feasibility studies on accident tolerant fuel, down select promising advanced fuel concepts, and qualify the fuel that would lead to lead fuel rod or assembly irradiation in a commercial power reactor. (3) Perform long-term R&D on advanced technologies that could lead to the next generation of sustainable fuel cycle options. | | |

## Nuclear Energy Enabling Technologies

### Overview

The Nuclear Energy Enabling Technologies (NEET) program sponsors research and development (R&D) and strategic infrastructure investments to develop innovative and crosscutting nuclear energy technologies. This program also makes a strong investment in modeling and simulation efforts to bring 30 years of improved computational and material science to reactor and fuel system simulation. The results will provide researchers, designers, and operators with advanced tools to better understand the behavior of nuclear energy systems; thereby improving safety, economics, and efficiency. Additionally, the program provides access to unique nuclear energy research capabilities through its nuclear science user facilities. NE Traineeships is a new subprogram under NEET that will address workforce needs in the field of radiochemistry. The capabilities developed through NEET will advance the state of nuclear technology, improving its competitiveness, and promoting continued contribution to meeting our Nation's energy and environmental challenges.

These activities create the basis for improvements in safety, performance, reliability, economics, and proliferation risk reduction; and promote creative solutions to the broad array of nuclear energy challenges. They complement those within the Reactor Concepts Research, Development and Demonstration (RD&D) and Fuel Cycle R&D programs by developing innovative solutions applicable to multiple reactor and fuel cycle concepts. The knowledge generated through these activities will allow the Office of Nuclear Energy (NE) to address key challenges affecting future nuclear energy technology deployment (e.g., capital cost, technology risks, and proliferation concerns). Further, these activities will contribute to sustaining nuclear energy as a key component of our energy portfolio and help to achieve the energy security and greenhouse gas emission reduction objectives of the US.

### Highlights of the FY 2016 Budget Request

The FY 2016 budget continues to support on-going initiatives; including the Nuclear Energy Innovation Hub in Modeling and Simulation (Hub) final five-year term and the Nuclear Energy Advanced Modeling and Simulation (NEAMS) subprogram. The NEAMS subprogram is focused on resolving high-impact problems (HIP) that can make a significant, positive change in NE applications in the near-term (2-3 years).

The request also renames the National Scientific User Facility subprogram to the Nuclear Science User Facilities (NSUF) to better align the name with the focus of the subprogram and to recognize that it is comprised of multiple facilities spread across multiple national laboratories, universities, and industry.

NE Traineeships address priority DOE science, technology, engineering, and mathematics (STEM) nuclear energy workforce needs. NE traineeships will focus on advancing critical STEM disciplines and competencies related to radiochemistry to support NE mission responsibilities.

NEET supports the Department's Clean Energy Manufacturing Initiative (CEMI), a comprehensive DOE-wide approach to increase U.S. competitiveness in clean energy manufacturing while advancing progress toward the nation's energy goals. Within the NEET program, CEMI is supported by the Advanced Methods for Manufacturing (AMM) subprogram. In FY 2016, AMM will fund approximately $1.0 million for one competitively solicited additive manufacturing project. Further, CEMI is supported by the Reactor Materials (RM) subprogram. In FY 2016, RM will fund approximately $1.0 million for one competitively solicited advanced materials manufacturing research project that will lead to results also benefitting advanced manufacturing, with a focus on extreme environment materials.

**Nuclear Energy Enabling Technologies**
**Funding ($K)**

| | FY 2014 Enacted[1] | FY 2014 Current[2] | FY 2015 Enacted | FY 2016 Request | FY 2016 vs FY 2015 |
|---|---|---|---|---|---|
| **Nuclear Energy Enabling Technologies** | | | | | |
| Crosscutting Technology Development | 13,897 | 13,452 | 14,000 | 15,343 | +1,343 |
| Nuclear Energy Advanced Modeling and Simulation (NEAMS) | 13,362 | 12,934 | 26,200 | 23,612 | -2,588 |
| Energy Innovation Hub for Modeling and Simulation | 24,293 | 23,516 | 24,300 | 24,300 | - |
| Nuclear Science User Facilities (NSUF) | 19,557 | 18,931 | 36,500 | 21,132 | -15,368 |
| Nuclear Energy Traineeships | 0 | 0 | 0 | 2,000 | +2,000 |
| **Total, Nuclear Energy Enabling Technologies** | **71,109** | **68,833** | **101,000** | **86,387** | **-14,613** |

SBIR/STTR:

- FY 2014 Transfer: SBIR $1,991; STTR $284
- FY 2015 Projected: SBIR $2,929; STTR $404
- FY 2016 Request: SBIR $2,592; STTR $388

[1] FY 2014 Enacted column reflects a rescission of $21,100 as identified within Section 317 of Public Law 113-76.
[2] Funding reflects the transfer of SBIR/STTR to the Office of Science.

| Nuclear Energy Enabling Technologies<br>Explanation of Major Changes ($K) | FY 2016 vs FY 2015 |
|---|---|
| **Crosscutting Technology Development:** The increase from $14,000,000 to $15,343,000 funds additional crosscutting R&D areas such as advanced capability development for transient testing, cybersecurity and hybrid energy systems. | **+1,343** |
| **Nuclear Energy Advanced Modeling and Simulation (NEAMS):**The decrease from $26,200,000 to $23,612,000 reflects a prioritization of funding for ToolKit validation, which will focus on solving the High-Impact Problems that can significantly improve the predictive character of the tools and make a rapid, positive impact on applications most critical to NE's near-term mission needs. | **-2,588** |
| **Energy Innovation Hub for Modeling and Simulation:** No significant changes. | **0** |
| **Nuclear Science User Facilities:** The decrease from $36,500,000 to $21,132,000 reflects completion of advanced post-irradiation examination equipment installation at the Irradiated Materials Characterization Laboratory. The resultant increase to the NSUF base funds broader researcher access to unique nuclear research capabilities through its multiple partner facilities and supports the development and publication of a nuclear infrastructure database. NSUF will continue to issue fully-funded awards in FY 2016. | **-15,368** |
| **Nuclear Energy Traineeships:** NE Traineeships is a new subprogram under NEET. The increase from $0 to $2,000,000 executes university-led, targeted training, focused on radiochemistry. | **+2,000** |
| **Total, Nuclear Energy Enabling Technologies** | **-14,613** |

## Crosscutting Technology Development

The Crosscutting Technology Development (CTD) subprogram competitively awards high-priority R&D to universities, national laboratories, and industry, leading to the development of innovative solutions to unique and crosscutting nuclear energy challenges. Additionally, NEET CTD strategically invests in competitive, nuclear energy-related infrastructure enhancement at national laboratories; ensuring researchers have access to state-of-the-art R&D capabilities. The subprogram leads the coordination with NE's other R&D programs to ensure that developed technologies and capabilities are part of an integrated system offering the potential of revolutionary improvement in safety, performance, reliability, economics, and proliferation risk reduction.

The potential benefits of the technology research activities within this program include:

- High-risk research which could overcome current technological limitations.
- Examination of new classes of materials not previously considered for nuclear applications.
- Coordinated capabilities common across NE R&D programs.
- Development of enabling technologies beyond individual programs.
- New capabilities needed by the NE R&D enterprise.

**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **Crosscutting Technology Development** | | |
| **$14,000,000** | **$15,343,000** | **+$1,343,000** |
| • Initiate competitively awarded multi-year research projects to develop innovative solutions to a range of nuclear technology needs including advanced sensors and instrumentation, reactor materials, cybersecurity, and advanced methods for manufacturing.<br>• Competitively solicit and award strategic infrastructure investments at national laboratories that will not only benefit crosscutting R&D but also identified needs of NE's other R&D programs. | • Competitively solicit and award new multi-year R&D projects in high priority crosscutting R&D areas including, advanced sensors and instrumentation, reactor materials, advanced methods for manufacturing, transient testing R&D, nuclear cybersecurity, and hybrid energy systems; as well as other innovative and crosscutting topics based on quality of proposed topics and identified need.<br>• Competitively solicit and award strategic infrastructure investments at national laboratories that will not only benefit crosscutting R&D but also identified needs of NE's other R&D programs. | • The increase in funding will allow for greater investment in additional technical areas of high priority crosscutting R&D areas. |

## Nuclear Energy Advanced Modeling and Simulation (NEAMS)

**Description**

NEAMS provides a complex set of computational simulation tools, in support of NE programs, such as the Advanced Reactor Technologies and Fuel Cycle R&D programs. NEAMS engages scientists and engineers in developing state-of-the-art, multi-scale models of material properties and advanced computational simulation tools for simulations of nuclear energy systems. NEAMS is developing a computational ToolKit which is comprised of both reactor and fuel systems analysis capabilities that can be exercised either coupled or independently, depending on the needs of the end user. Computational tools developed under the NEAMS program define the state-of-the-art in nuclear simulation and are currently being used by over 60 organizations, both domestically and abroad.

In FY 2016, work on the Toolkit will focus on creating a release version that incorporates a fully functional pressurized water reactor (PWR) fuel performance set of codes for steady state, operational transients, and accident conditions. In addition, the next-generation reactor codes will continue development for light water reactor and advanced concept reactor applications. Additional investments will be made in verification and validation for the Toolkit via high-impact problems for nuclear energy applications.

For validation purposes, NEAMS will address High-Impact Problems (HIP) that can make a significant, positive change in nuclear energy applications in the near-term (2-3 years). The HIPs will be defined and solved in partnership with other DOE programs and nuclear energy stakeholders, to ensure relevance and to certify the impact.

## Nuclear Energy Advanced Modeling and Simulation (NEAMS)

**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **Nuclear Energy Advanced Modeling and Simulation (NEAMS) $26,200,000** | **$23,612,000** | **-$2,588,000** |
| • Continue to refine atomistic and MARMOT simulations used to inform engineering scale models in the BISON fuels code.<br>• Release BISON Update for LWR Fuel Performance (Rev. 2) in transient conditions. This release of BISON will be fully functional for PWR performance under steady-state conditions, operational transients (i.e., normal power shifts), and accident conditions (reactivity insertion accidents and loss of coolant accidents). Will also provide some capability to perform boiling water reactor simulations. It will add advanced, mechanistic models for cracking and restructuring.<br>• Issue Update to BISON Validation and Assessment Report (Rev. 2). Will include BISON simulations of steady-state, ramp, and RIA scenarios compared to (selected) relevant PWR experimental pins from the FRAPCON and FUMEX-III databases.<br>• Complete design of three dimensional in-core fuels validation experiment to be conducted at the Halden Reactor.<br>• Use SHARP to complete a high-resolution, multi-physics simulation of the Unprotected Loss of Flow (ULOF) transient in EBR-II, with explicit calculation of reactivity feedback due to structural deformation of fuel pins, assembly components, and core support structures.<br>• Release version 0.9 of the integrated SHARP reactor core analysis toolkit to early users. Initiate expanded effort to validate NEAMS Toolkit components through the use of experimentation, benchmarking, and collaborations with end user partners. | • Enhance the capabilities of the Fuels Product Line; release BISON and MARMOT updates with transient testing improvements.<br>• Enhance the capabilities of the Reactor Product Line; release SHARP update with integration, computational efficiency, and usability updates based on early user experience; issue initial SHARP validation and assessment report.<br>• Improve the Integration of the ToolKit components; issue BISON-SHARP integration and assessment plan to document process of implementing first step in multi-scale pellet-to-plant simulation.<br>• Initiate expanded effort to validate NEAMS Toolkit components through the use of experimentation, benchmarking, and collaborations with end user partners, via High-Impact Problems (HIP). Complete mid-term reviews of the first HIPs.<br>• Hold two Principal Investigators Meetings to review progress and accomplishments. | • The decrease from $26,200,000 to $23,612,000 reflects a prioritization of funding for ToolKit validation, which will focus on solving those High-Impact Problems that can significantly improve the predictive character of the tools and make a rapid, positive impact on applications most critical to near-term needs of NE's mission. |

**Energy Innovation Hub for Modeling and Simulation**

The Energy Innovation Hub for Modeling and Simulation (Hub) is creating a virtual reactor model of an actual Westinghouse-designed, pressurized water reactor (PWR), owned and operated by the Tennessee Valley Authority-owned (TVA); to simulate reactor behavior. Once completed, engineers will use this virtual model to improve the safety and economics of reactor operations by simulating proposed solutions to reactor power production increases, and reactor life and license extensions. The combination of data gained from the virtual model and the physical reactor will be used to resolve technology issues that have challenged nuclear energy development. The Oak Ridge National Laboratory (ORNL) is leading a consortium (CASL – Consortium for Advanced Simulation of Light Water Reactors) of national labs, universities, and industry partners to manage Hub execution. During FY 2015, the Hub was extensively reviewed by NE, with careful review of the Hub's performance during its first phase and proposed plans for its second phase. While a final decision to renew the hub has not been made at this time, the review by NE documented solid performance by the Hub throughout its history. Subject to the an FY 2015 announcement of renewal, during FY 2016, the Hub will add new capabilities to the virtual reactor that will allow its coupled thermal-hydraulics, neutronics, fuels performance, and chemistry tools to address performance and safety issues for Pressurized Water (PWR) and Boiling Water (BWR) reactors, and Small Modular Reactors (SMRs). In addition, the Hub will expand its partnership to include other reactor technology vendors and electric utilities. Plans include conducting cost-shared deployment tests that would install virtual reactor tools on industry computers. Information obtained from these tests will provide an improved understanding of industry-defined issues that currently limit the energy output of their reactors.

## Energy Innovation Hub for Modeling and Simulation

**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **Energy Innovation Hub for Modeling and Simulation $24,300,000** | **$24,300,000** | **$0** |
| • Start final phase of the Hub.<br>• Release version 5.0 of the Virtual Environment for Reactor Analysis (VERA).<br>• Adapt the VERA toolset to be used to improve understanding of LWRs currently under construction and startup testing.<br>• Apply CASL modeling and simulation tools to support design improvements for Small Modular Reactors.<br>• Extend deployment the CASL computer test stands beyond the core consortium partners.<br>• Start implementation of the CASL deployment strategy that supports increased use of the virtual reactor tool set by nuclear technology vendors and utilities to improve the operational performance and safety of existing and new reactors. | • Expand Hub consortiums membership to include vendors of boiling water and small modular reactor technologies.<br>• Expand Hub Industry Council membership to include additional electrical utility users of the virtual reactor modeling and simulation tools.<br>• Release version 6.0 of the Virtual Environment for Reactor Analysis (VERA).<br>• Release a version of VERA to be used in educational settings.<br>• Demonstrate the use of VERA to understand performance and safety issues with nuclear fuel cladding issues that currently limit reactor power output.<br>• Demonstrate the ability of VERA to study the impact of boron containing deposits of fuel that cause power shifts and cladding corrosion.<br>• Establish working group to understand the requirements for maintaining the Hub developed modeling and simulation capabilities beyond the second phase. | • Funding held at FY 2015 level provides on-going efforts to support new capabilities for phase 2 of the Hub. |

**Nuclear Science User Facilities (NSUF)**

The request renames the National Scientific User Facility subprogram to the Nuclear Science User Facilities (NSUF) to better align with the focus of the subprogram and to recognize that it is comprised of multiple facilities spread across multiple national laboratories, universities and industry. The NSUF represents a "prototype laboratory for the future," promoting the use of unique nuclear research facilities and encouraging active university, industry, and laboratory collaboration in relevant nuclear scientific research. The NSUF, through competitive solicitations, provides a mechanism for research organizations to collaborate, conduct experiments and post-experiment analysis, and utilize high performance computing at facilities not normally accessible to these organizations. On an annual basis, researchers propose projects to be conducted at these unique facilities, with timelines ranging from a few months to several years. When projects are awarded, the NSUF program pays for experiment support and laboratory services at the user facilities. In this manner, researchers benefit from the introduction to new techniques, equipment, and personnel. The Idaho National Laboratory Advanced Test Reactor (ATR) and post-irradiation examination (PIE) facilities at the Center for Advanced Energy Studies and Materials and Fuels Complex are available as user facilities. Additionally, research reactors at Oak Ridge National Laboratory, Massachusetts Institute of Technology, North Carolina State University, the Advanced Photon Source beam line capabilities at the Illinois Institute of Technology, irradiation experiment design and fabrication capabilities at Pacific Northwest National Laboratory, hot cells and fabrication capabilities at Westinghouse, and examination facilities at the Universities of Wisconsin, Michigan, California-Berkeley, Purdue, and Nevada-Las Vegas are partnered with the NSUF, bringing additional user facilities to the research community. In FY 2016, the NSUF will seek to establish dedicated high performance computing capabilities such as Falcon at the Idaho National Laboratory. This new capability, with a focus on nuclear energy-related research, will complement the existing Advanced Scientific Computing Research User Facilities. Since its designation as a user facility in 2007, the NSUF has awarded 109 experiments to 22 universities and 4 laboratories. All new awards are fully funded, eliminating mortgages and improving consistency.

**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **Nuclear Science User Facilities (NSUF)** | | |
| **$36,500,000** | **$21,132,000** | **-$15,368,000** |
| • Eliminate mortgage associated with previously awarded multi-year irradiation and PIE projects.<br>• Award approximately one long-term project with full (forward) funding to avoid future NSUF mortgages. May be a joint award with a NEUP project.<br>• Award, execute and complete a minimum of 5 competitively-awarded "rapid turnaround" PIE experiments.<br>• Coordinate with NEUP to issue an infrastructure award to help support NE relevant work.<br>• Initiate the design and procurement of the shielding and confinement for the Focused Ion Beam.<br>• Complete the installation of advanced post-irradiation examination equipment at the Irradiated Materials Characterization Laboratory. | • Fully fund multiple irradiation/PIE projects.<br>• Award, execute, and complete a minimum of 5 competitively-awards “rapid turnaround” PIE experiments.<br>• Lead the development, execution, and award of NE’s annual infrastructure solicitation.<br>• Develop and publish initial nuclear infrastructure database.<br>• Provide high performance computing capabilities to users by adding new partner facilities. | • The decrease reflects completion of advanced post-irradiation examination equipment installation at the Irradiated Materials Characterization Laboratory. The resultant increase to the NSUF base fully funds new awards, while expanding use of partner facilities and deployment of a nuclear infrastructure database. |

**Nuclear Energy Traineeships**

The Office of Nuclear Energy has mission-specific/mission-critical workforce needs in the area of radiochemistry. Given that the current radiochemistry workforce is approaching the age for retirement and that a limited number of universities in the U.S. provide radiochemistry curriculum due to a lack of professors and infrastructure, the U.S. is faced with a growing demand for the education and training of scientists in radiochemistry. The DOE national laboratories are also losing capability due to retirement of a substantial number of their "core" groups of radiochemists and nuclear chemists. The nation will need radiochemistry expertise for decades to come in order to support its energy and security interests, and most importantly, to maintain global leadership in the next generation of safe nuclear energy technology from both a national security and an environmental perspective. Failure to take appropriate steps now to develop the 21st century radiochemistry workforce will clearly jeopardize the future of safe nuclear energy technology.

Establishing a competitively-awarded, university-led traineeship is the preferred mechanism for providing the required focused, graduate level radiochemistry training through a tailored academic graduate program that delivers unique and innovative radiochemistry curriculum with rigorous thesis or dissertation research requirement aligned with the identified critical DOE mission-driven workforce need. DOE laboratory partnerships would be encouraged.

The Traineeship in Radiochemistry will complement the existing components of the Nuclear Energy University Programs (NEUP) currently focused on university-led research and development and infrastructure enhancement in direct support of the Office of Nuclear Energy mission.

## Nuclear Energy Traineeships

**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **Nuclear Energy Traineeships** | | |
| **$0** | **$2,000,000** | **+$2,000,000** |
| • No Funding requested. | • 5 year financial assistance awards will provide training for up to 18 graduate students in radiochemistry aligned with DOE workforce needs by employing a competitive selection process that is open, transparent, and peer reviewed. Universities will be required to provide some cost share, which could take the form of providing faculty support and "other student costs". The program supports 4-5 new students per year at a planning level of $55,000 per student per year to fund stipend and tuition/fee support to a defined amount per student. Additional activities include; radiochemistry-focused workshops, seminars, internships with strategic partners, or participation in relevant external established courses or programs. An evaluation plan will be included to reflect program goals and a mechanism for tracking program outcomes. Further, the training program would also support professional development in non-research skills such as project management, oral and written communications, and developing and working within large collaboration (team science). | • NE Traineeships is a new subprogram under NEET. The increase from $0 to $2,000,000 executes university-led, targeted training, focused on radiochemistry. |

**Nuclear Energy Enabling Technologies Capital Summary ($K)**

| | Total | Prior Years | FY 2014 Enacted | FY 2014 Current | FY 2015 Enacted | FY 2016 Request | FY 2016 vs FY 2015 |
|---|---|---|---|---|---|---|---|
| Capital Operating Expenses Summary (including (Major Items of Equipment (MIE)) | | | | | | | |
| Capital Equipment > $500K (including MIE) | n/a | n/a | 0 | 1,400 | 18,000 | 0 | +16,600 |
| Plant Projects (GPP and IGPP) (<$10M) | n/a | n/a | 0 | 0 | 0 | 0 | - |
| Accelerator Improvement Projects (AIP) (<$5M) | n/a | n/a | 0 | 0 | 0 | 0 | - |
| Total, Capital Operating Expenses | n/a | n/a | 0 | 1,400 | 18,000 | 0 | +16,600 |

**Nuclear Energy Enabling Technologies**
**Performance Measures**

In accordance with the GPRA Modernization Act of 2010, the Department sets targets for, and tracks progress toward, achieving performance goals for each program.

| | FY 2014 | FY 2015 | FY 2016 |
|---|---|---|---|
| Performance Goal (Measure) | **NEET- Mod & Sim Hub - Complete 90% of annual program milestones to support the creation of a virtual reactor prototype for predictive simulation of Light Water Reactors by 2015.** | | |
| Target | 90% | 90% | 90% |
| Result | 100% | N/A | N/A |
| Endpoint Target | The milestones represent annual progress toward the creation of a Light Water Reactor model by 2015 for use by industry to improve performance at nuclear power plants. | | |

## Radiological Facilities Management

**Overview**

Radiological Facilities Management (RFM) provides support for radiological facilities not on Department of Energy (DOE) property. In FY 2016, the Department is requesting funding only for the Research Reactor Infrastructure (RRI) subprogram. RRI supports the continued operation of U.S. research reactors by providing research reactor fuel services and maintenance of fuel fabrication equipment.

**Highlights of the FY 2016 Budget Request**

In FY 2016, in support of its mission and objectives, the RRI subprogram will provide project management, technical support, quality engineering and inspection, and nuclear material support to 25 reactors located at 24 U.S. universities. Major program deliverables will be to procure new plate fuel elements and ship them to universities, and also to ship used plate and TRIGA reactor fuel elements from universities to DOE used fuel receipt facilities. In addition, work will continue on initiatives that evaluate alternatives to the current TRIGA reactor fuel sole supply source.

For the RRI subprogram, continued delays and uncertainties associated with the planned 2018 resumption of production at the TRIGA fuel fabrication facility operated in France by TRIGA International has potential to disrupt the continued operability of a subset of the 12 TRIGA research reactors serviced by the RRI subprogram. Evaluation of alternatives has commenced and will continue through 2016.

**Radiological Facilities Management**
**Funding ($K)**

| | FY 2014 Enacted[1] | FY 2014 Current | FY 2015 Enacted | FY 2016 Request | FY 2016 vs FY 2015 |
|---|---|---|---|---|---|
| **Radiological Facilities Management** | | | | | |
| Space and Defense Infrastructure | 19,968 | 19,968 | 20,000 | 0 | -20,000 |
| Research Reactor Infrastructure | 5,000 | 5,000 | 5,000 | 6,800 | +1,800 |
| **Total, Radiological Facilities Management** | **24,968** | **24,968** | **25,000** | **6,800** | **-18,200** |

[1] FY 2014 Enacted column reflects a rescission of $31,600 as identified within Section 317 of Public Law 113-76.

**Radiological Facilities Management**
**Explanation of Major Changes ($K)**

| | FY 2016 vs FY 2015 |
|---|---|
| **Space and Defense Infrastructure:** The decrease from $20,000,000 to $0 reflects completion of Nuclear Energy (NE) funded activities. NE is not requesting FY 2016 funding for infrastructure maintenance at Oak Ridge National Laboratory. Funding for this activity is requested within the Science Appropriation. | **-20,000** |
| **Research Reactor Infrastructure:** The increase from $5,000,000 to $6,800,000 reflects the accelerated repayment to the Reduced Enrichment for Research and Test Reactors (RERTR) Program for the fabrication of twelve Rhode Island Nuclear Science Center (RINSC) fuel elements. | **+1,800** |
| **Total, Radiological Facilities Management** | **-18,200** |

**Description**

Consistent with Congressional direction, this category provided funds in FY 2014 and FY 2015 to support Oak Ridge National Laboratory (ORNL) hot cells.

## Space and Defense Infrastructure

**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **Space and Defense Infrastructure $20,000,000** | **$0** | **-$20,000,000** |
| • Complete hot cell and equipment maintenance based on Congressional Direction for non-mission infrastructure. | • No funding is requested. | • Decrease reflects completion of critical hot cell equipment and infrastructure activities. |

## Radiological Facilities Management
## Research Reactor Infrastructure

**Description**

The Research Reactor Infrastructure (RRI) subprogram provides fresh reactor fuel to, and removes used fuel from, 25 operating university reactors to support the continued operation of university research reactors. This provides continued test reactor capability to universities, coupled with research, development, and educational opportunities in support of U.S. nuclear energy initiatives.

The continued operation of university research reactors plays an important role in developing future scientists and engineers in the U.S. This subprogram sustains unique capabilities for research and development and educational opportunities supporting U.S. energy initiatives. Used nuclear fuel shipments support U.S. and DOE non-proliferation and national security objectives.

## Research Reactor Infrastructure

**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **Research Reactor Infrastructure** | | |
| **$5,000,000** | **$6,800,000** | **+$1,800,000** |
| • Procure 40 and deliver 36 plate fuel elements required annually by University of Missouri (MURR) and University of Massachusetts (MIT) as determined by need and fuel availability. Complete up to 6 used fuel shipments to Savannah River Site (SRS) and the Idaho National Laboratory (INL), pending resolution of moratorium on such shipments to INL.<br>• Continue Research Reactor Infrastructure (RRI) project management, quality assurance, nuclear material accountability, and transportation cask maintenance.<br>• Continue TRIGA fuel alternatives analysis and implementation activities as warranted by the FY 2014 analysis results and status of TRIGA International outage.<br>• Initiate activities to receive Nuclear Regulatory Commission (NRC) approval of BEA Research Reactor (BRR) cask Safety Analysis Report (SAR) amendment and procure associated universal "basket" to support shipment of university fuel types that lack an approved basket. | • Procure 40 and deliver between 33 and 36 plate fuel elements required annually by MURR and MIT as determined by need and fuel availability.<br>• Complete up to 5 used fuel shipments to SRS and the INL, pending resolution of moratorium on such shipments to the INL.<br>• Continue RRI project management, quality assurance, nuclear material accountability, and transportation cask maintenance.<br>• Continue TRIGA fuel alternatives analysis and implementation activities as warranted by the FY 2014 analysis results and status of TRIGA International outage.<br>• Complete activities needed for NRC review and approval of BRR cask SAR amendment and procure associated universal "basket" to support shipment of university fuel types that lack an approved basket.<br>• Accelerated repayment for the fabrication of 12 Rhode Island Nuclear Science Center (RINSC) fuel elements. | • The increase reflects the repayment to the Reduced Enrichment for Research and Test Reactors (RERTR) Program for the fabrication of 12 RINSC fuel elements. |

**Radiological Facilities Management**
**Capital Summary ($K)**

| | Total | Prior Years | FY 2014 Enacted | FY 2014 Current | FY 2015 Enacted | FY 2016 Request | FY 2016 vs FY 2015 |
|---|---|---|---|---|---|---|---|
| **Capital Operating Expenses Summary (including (Major Items of Equipment (MIE))** | | | | | | | |
| Capital Equipment > $500K (including MIE) | n/a | 500 | 0 | 0 | 0 | 0 | - |
| **Total, Capital Operating Expenses** | n/a | 500 | 0 | 0 | 0 | 0 | +0 |

## Idaho Facilities Management

**Overview**

The mission of the Idaho Facilities Management (IFM) program is to manage the planning, acquisition, operation, maintenance, and disposition of the Office of Nuclear Energy (NE)-owned facilities and capabilities at the Idaho National Laboratory (INL). The IFM program maintains Department of Energy (DOE) mission-supporting facilities and capabilities at the INL in a safe, compliant status to support the Department's nuclear energy research, testing of naval reactor fuels and reactor core components, and a diverse range of national security technology programs that support the National Nuclear Security Administration (NNSA) and other federal agencies such as the Department of Homeland Security in the areas of critical infrastructure protection, nuclear nonproliferation, and incident response.

The IFM program enables long-term nuclear research and development (R&D) activities by providing the expertise, facilities, equipment, and nuclear materials necessary to conduct a wide array of experimental activities in a safe and compliant manner. The Advanced Test Reactor (ATR) provides unique irradiation capability to further nuclear fuel and reactor component research in support of advanced nuclear reactor design activities. The Materials and Fuels Complex (MFC) contains a comprehensive range of fuel and experiment fabrication, and pre- and post-irradiation examination capabilities used to assess material and fuel characteristics, and performance in varying reactor environments. A limited number of facilities at the Idaho Nuclear Technology and Engineering Center (INTEC) are utilized to support material consolidation and storage at the Material Security Consolidation Facility (CPP-651), fuel cycle research and development, and National and Homeland Security (N&HS) activities. The Research and Education Campus is home to a diverse range of research capabilities and facilities; supporting research in nuclear energy as well as N&HS and energy and the environment.

**Highlights of the FY 2016 Budget Request**

In FY 2016, the IFM program strategic priorities are to maximize the utility of existing facilities and capabilities through focused sustainment activities and cost-effective rehabilitation. Activities focus on safe and compliant operation of the INL's nuclear research reactor and non-reactor research facilities, while conducting corrective and cost-effective preventative maintenance activities necessary to sustain this core infrastructure. Critical capability improvements and/or replacements will be accomplished through operating activities, General Plant, and line item capital projects, if deemed necessary. In FY 2016, these activities include:

- The Department is proceeding with pre-critical decision (CD)-2 design activities for the Sample Preparation Laboratory (SPL) at the INL to satisfy core requirements of the mission need under the Advanced Post Irradiation Examination (APIE) Capabilities Project. The scaled down alternative of the APIE Capabilities Project will provide a new functionally focused laboratory with a smaller footprint at a reduced cost, which when coupled with existing facilities and recapitalization efforts, will fulfill near-term APIE capabilities needed to improve understanding of nuclear fuels and material performance.
- The Department will invest in major power distribution infrastructure refurbishments at the INL, including, but not limited to, the replacement of the Supervisory Control and Data Acquisition (SCADA) system, replacement of power-lines and transformers, and the replacement of multiple site substations that are near or have exceeded their lifecycle. These refurbishments and replacements to the INL power distribution infrastructure will improve system reliability and prevent costly corrective maintenance outages enabling long-term support of site-wide missions.
- Reestablishing a transient testing capability at the Transient Reactor Test (TREAT) Facility at the INL will enable the NE R&D programs to understand fuel performance phenomenology at the milli-second to second time scales, as well as provide a capability to screen advanced fuel concepts, including accident tolerant fuels, which allows for early identification of the limits of fuel performance. In FY 2016, inspections of the existing TREAT fuel will complete and refurbishments of major systems including the control console, transient rod drive, and shutdown rod drive will be underway.
- The Remote-Handled Low-Level Waste (RHLLW) Disposal Facility Project will provide onsite replacement of the INL's remote-handled low-level waste disposal capability. This capability is needed to support ongoing and future programs, including NE and Naval Reactors (NR) at the INL. This project is funded by NE and NR. In FY 2016, construction and facility readiness activities will continue.

**Idaho Facilities Management**
**Funding ($K)**

| | FY 2014 Enacted[1] | FY 2014 Current | FY 2015 Enacted | FY 2016 Request | FY 2016 vs FY 2015 |
|---|---|---|---|---|---|
| **Idaho Facilities Management** | | | | | |
| INL Nuclear Research Reactor Operations and Maintenance | 87,869 | 87,869 | 99,264 | 90,244 | -9,020 |
| INL Non-Reactor Nuclear Research Facility Operations and Maintenance | 69,091 | 69,091 | 76,207 | 75,584 | -623 |
| INL Engineering and Support Facility Operations and Maintenance | 10,630 | 10,630 | 11,356 | 31,459 | +20,103 |
| INL Regulatory Compliance | 10,288 | 10,288 | 13,804 | 12,539 | -1,265 |
| Advanced Post Irradiation Examination (APIE) Capabilities | 2,000 | 2,000 | 0 | 0 | - |
| Construction | 16,398 | 16,398 | 5,369 | 2,000 | -3,369 |
| **Total, Idaho Facilities Management** | **196,276** | **196,276** | **206,000** | **211,826** | **+5,826** |

[1] FY 2014 Enacted column reflects a rescission of $284,500 as identified within Section 317 of Public Law 113-76.

**Idaho Facilities Management**
**Explanation of Major Changes ($K)**

| | FY 2016 vs FY 2015 |
|---|---|
| **INL Nuclear Research Reactor Operations and Maintenance:** The decrease from $99,264,000 to $90,244,000 reflects completion of the Advanced Test Reactor (ATR) Life Extension Program, the completion of installation of the Uninterrupted Power Supply in FY 2015, planned funding for the resumption of transient testing, cost of ATR fuel, and staff required to maintain and operate ATR consistent with Departmental programmatic and safety requirements. | **-9,020** |
| **INL Non-Reactor Nuclear Research Facility Operations and Maintenance:** The decrease from $76,207,000 to $75,584,000 reflects the planned funding required for implementation of the updated Materials and Fuels Complex (MFC) Documented Safety Analyses (DSAs). | **-623** |
| **INL Engineering and Support Facility Operations and Maintenance:** The increase from $11,356,000 to $31,459,000 reflects a refurbishment and replacement of the Idaho National Laboratory (INL) site-wide power distribution infrastructure, including the replacement of the Supervisory Control and Data Acquisition (SCADA) system and the replacement of multiple site substations. Increase also addresses the procurement of replacement emergency services vehicles and equipment to address end of life-cycle issues. | **+20,103** |
| **INL Regulatory Compliance:** The decrease from $13,804,000 to $12,539,000 reflects funding necessary for other project costs funds for the RHLLW Disposal Facility Project consistent with the project schedule. | **-1,265** |
| **Advanced Post-Irradiation Examination (APIE) Capabilities:** No significant change, no funding requested in FY 2016. | **0** |
| **Construction:** The decrease from $5,369,000 to $2,000,000 reflects the initiation of Pre-CD-2 design funding for the SPL Project and the completion of construction funding requests for the RHLLW Disposal Facility Project. | **-3,369** |
| **Total, Idaho Facilities Management** | **+5,826** |

**Idaho Facilities Management**
**INL Nuclear Research Reactor Operations and Maintenance**

**Description**

This subcategory supports nuclear research reactor operations and maintenance at the Advanced Test Reactor (ATR) for the Idaho National Laboratory (INL), including the associated support infrastructure, the ATR Critical Facility (ATRC), the Transient Reactor Test (TREAT) Facility, and the Neutron Radiography Reactor (NRAD). The NRAD and TREAT facilities are both located at the Materials and Fuels Complex (MFC).

ATR is the primary research reactor at the INL. The ATR supports the majority of Nuclear Energy (NE) research and development (R&D) programs, as well as Naval Reactors (NR) Program work in support of the U.S. Navy nuclear fleet and National Nuclear Security Administration (NNSA) programs including Global Threat Reduction Initiatives to support conversion of research and test reactors to low-enriched uranium fuel. The ATR is also used by universities, laboratories, and industry, and is designated as a Nuclear Scientific User Facility. Research and development demand for neutron irradiation at ATRC and neutron radiography and small component test irradiation at NRAD has increased significantly over the past several years. All programmatic work is funded by the sponsoring federal programs. The cost to other users is determined in accordance with Department of Energy (DOE) regulations and depends upon the demands on the reactor and the nature of the user.

This subcategory also provides funding to support activities related to the resumption of a domestic transient fuel testing capability utilizing the TREAT Facility. Activities associated with the restart of the TREAT Reactor include system and component evaluations, design, and refurbishment and replacement, and safety evaluations, as well as the training for operators and support staff.

## INL Nuclear Research Reactor Operations and Maintenance

**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **INL Nuclear Research Reactor Operations and Maintenance $99,264,000** | **$90,244,000** | **-$9,020,000** |
| • Maintain and operate the Idaho National Laboratory (INL) reactors and supporting infrastructure.<br>• Maintain a two year minimum Advanced Test Reactor (ATR) fuel inventory and sufficient ATR critical spares.<br>• Complete the ATR Life Extension Program, including Nuclear Instrumentation activities.<br>• Complete installation of Uninterrupted Power Supply to support ATR operations.<br>• Continue preparatory activities for the ATR Core Internals Change-out (CIC).<br>• Conduct over 30 irradiation campaigns as scheduled while maintaining an operating efficiency greater than 80%.<br>• Continue planned ATR Safety Margin Improvement activities such as installation of automated primary cooling system leak detection.<br>• Complete Transient Reactor Test (TREAT) system assessments to support resumption of transient testing.<br>• Initiate replacement of electrical equipment at ATR that is past the end of useful life.<br>• Initiate replacement of the ATR evaporation pond liner.<br>• Initiate updates to the TREAT fire protection system. | • Maintain and operate the INL reactors and supporting infrastructure while accommodating business model impacts.<br>• Maintain a two year minimum ATR fuel inventory and sufficient ATR critical spares.<br>• Continue preparatory activities for the ATR CIC, currently planned for 2018.<br>• Conduct at least 60 irradiation campaigns as scheduled while maintaining an operating efficiency greater than 80%.<br>• Continue replacement of electrical equipment at ATR that is past the end of useful life.<br>• Complete TREAT fuel inspections and fire protection upgrades.<br>• Continue refurbishment of major TREAT systems including the control console, transient rod drive, and compensation/shutdown rod drive. | • The decrease reflects completion of the ATR Life Extension Program in FY 2015, completion of the installation of the Uninterrupted Power Supply in FY 2015, planned funding for the resumption of transient testing, cost of ATR fuel, and staff required to maintain and operate ATR consistent with Departmental programmatic and safety requirements. |

**Idaho Facilities Management**
**INL Non-Reactor Nuclear Research Facility Operations and Maintenance**

**Description**

This subcategory provides funding for operations, maintenance, and support for non-reactor nuclear and radiological research facilities primarily located at the Materials and Fuels Complex (MFC). Activities within this category support sustainment of unique nuclear and radiological capabilities that are required to support Nuclear Energy's (NE) essential research and development programs. Work scope focuses on maintaining a safe operating envelope while conducting corrective and cost-effective preventative maintenance activities necessary to sustain this core infrastructure. The non-reactor nuclear research facilities support core programmatic research capabilities including:

- Post-Irradiation Examination (PIE) and Fresh Fuel Characterization – Receipt of irradiated fuels/materials, non-destructive examination, destructive examinations and analyses, and mechanical testing of highly radioactive materials.
- Experimental Fuel Fabrication – Glovebox lines, fume hoods, and hot cell capabilities; unique fabrication capabilities; and instrumentation and testing equipment that support research and development (R&D) on multiple fuel types and hazard levels.
- Advanced Separation and Waste Forms – Aqueous separations and pretreatment technologies, and electrochemical separations and waste form development (engineering scale).

Funding is also provided for the management of NE-owned special nuclear material (SNM), including the characterization, packaging, storage, and disposition of surplus SNM. Access to, and responsible management of SNM, is fundamental to ensuring nuclear material is readily available to support mission activities.

Beginning in FY 2016, and continuing into future years, base operations for the Remote-Handled Low-Level Waste (RHLLW) Disposal Facility, as well as Other Project Costs (OPCs) for the Sample Preparation Laboratory (SPL) Project, are funded under non-reactor nuclear research facility operations.

Also beginning in FY 2016, four radiological research facilities will transition from institutional (overhead) funding to the Idaho Facilities Management program. These facilities are the Electron Microscopy Laboratory (EML), the Fuel and Applied Sciences Building (FASB), the Radiochemistry Lab (RCL), and the Experimental Fuels Facility (EFF). This transition will consolidate direct-funding of radiological and nuclear facilities into a single program, allowing for better integration and coordination of operations and investments.

## INL Non-Reactor Nuclear Research Facility Operations and Maintenance

**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **INL Non-Reactor Nuclear Research Facility Operations and Maintenance $76,207,000** | **$75,584,000** | **-$623,000** |
| • Provide trained operators and technicians, qualified criticality safety officers, and material balance custodians to operate and maintain Materials and Fuels Complex (MFC) nuclear facilities.<br>• Analyze and authorize adjustments to operating parameters and facility operations and coordinate programmatic work activities.<br>• Perform program integration to support effective execution of projects and programs within the nuclear facilities at the MFC.<br>• Perform maintenance within the MFC nuclear facilities and infrastructure consistent with the approved safety bases.<br>• Support reliable availability of critical facilities and capabilities for the growing demand of research and development (R&D) mission needs.<br>• Complete planned facility modifications identified in MFC Documented Safety Analyses (DSAs).<br>• Complete 1-3 shipments of surplus Nuclear Energy (NE)-owned special nuclear material for off-site disposition.<br>• Continue the Materials Condition Assessment (MCA) program at MFC to improve understanding of facility conditions and long-term maintenance requirements.<br>• Initiate procurements and maintenance/replacement activities associated with hot cell windows and manipulators. | • Provide trained operators and technicians, qualified criticality safety officers, and material balance custodians to operate and maintain MFC nuclear facilities.<br>• Analyze and authorize adjustments to operating parameters and facility operations and coordinate programmatic work activities.<br>• Perform program integration to support effective execution of projects and programs within the nuclear facilities at the MFC.<br>• Perform maintenance within the MFC nuclear facilities and infrastructure consistent with the approved safety bases.<br>• Continue maintenance activities associated with hot cell windows and manipulators<br>• Support reliable availability of critical facilities and capabilities for the growing demand of R&D mission needs.<br>• Continue MFC documented safety analysis implementation for Hot Fuels Examination Facility (HFEF) and the Zero Power Physics Reactor (ZPPR).<br>• Complete 1-3 shipments of surplus NE-owned special nuclear material for off-site disposition.<br>• Continue the MCA program at MFC to improve understanding of facility conditions and long-term maintenance requirements.<br>• Initiate base funding for the Remote-Handled Low-Level Waste (RHLLW) Disposal Facility to facilitate readiness activities.<br>• Initiate pre-critical decision (CD)-2 documentation, including environmental documentation and associated analyses for the Sample Preparation Laboratory (SPL) Project. | • The decrease reflects the funding required for implementation of the updated MFC Documented Safety Analyses (DSAs). |

**Idaho Facilities Management**
**INL Engineering and Support Facility Operations and Maintenance**

**Description**

This subcategory provides funds to support the effective management of the buildings, structures, and systems that support the non-nuclear facilities at the Idaho National Laboratory (INL), and to remain in compliance with Departmental orders and regulations. New in FY 2016, this subcategory will include activities to support the procurement of emergency services equipment and vehicles to provide emergency response capabilities to the INL site. Activities that support the Administration's "Freeze the Footprint" initiative to responsibly manage the disposition of aging infrastructure are funded from this subcategory.

In addition, support is provided for Federally-funded program activities and community regulatory support activities to meet obligations defined in crosscutting agreements and contracts such as: Shoshone-Bannock Tribes, Defense Contract Audit Agency, site environmental monitoring, Payment in Lieu of Taxes, and the National Oceanic and Atmospheric Administration.

Beginning in FY 2016, Idaho Facilities Management program (IFM) will initiate a major investment in the INL site-wide power distribution system. IFM will fund activities including the replacement of the Supervisory Control and Data Acquisition (SCADA) system, replacement of power lines and transformers, and the replacement of multiple site substations that are near or have exceeded their lifecycle. These refurbishments and replacements will improve system reliability and prevent costly corrective maintenance outages enabling the long-term support of site-wide mission activities.

Starting in FY 2016, facility and campus planning activities will transition from IFM funding into institutional (overhead) funding. This includes activities to support Departmental sustainability goals to achieve measurable and verifiable energy, water, and greenhouse gas reductions; responsible use, and disposal of, materials and resources; and cost-effective facilities, services, and program management.

## INL Engineering and Support Facility Operations and Maintenance

**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **INL Engineering and Support Facility Operations and Maintenance $11,356,000** | **$31,459,000** | **+$20,103,000** |
| • Manage non-nuclear facilities, real property management, sustainment, and community support activities.<br>• Conduct performance-based, real property life-cycle asset management activities.<br>• Implement recapitalization activities structured to keep existing facilities modern and relevant in an environment of changing standards and missions, consistent with Department of Energy (DOE) Order 430.1B.<br>• Continue facility and land use life-cycle planning to identify essential capital alterations and additions; improvements to land, buildings, and utility systems necessary to maintain Idaho National Laboratory (INL) general purpose infrastructure; common/domestic services infrastructure; and multi-program infrastructure.<br>• Continue implementation of a systematic real property asset building inspection program and operation and maintenance of the Department's Facility Information Management System and Condition Assessment Information System.<br>• Conduct planned disposition work for non-nuclear excess buildings.<br>• Conduct planned roof repair and replacement activities utilizing cool roof technology. | • Initiate the refurbishment and replacement of INL power distribution infrastructure including the Supervisory Control and Data Acquisition (SCADA) system and site substation replacements.<br>• Conduct planned disposition work for non-nuclear excess buildings.<br>• Conduct planned roof repair and replacement activities utilizing cool roof technology.<br>• Procure replacement emergency services vehicles and associated equipment such as firefighting apparatus. | • The increase reflects a major investment in power distribution system infrastructure at INL including the replacement of the SCADA system and site substations. The increase also addresses the procurement of emergency services vehicles and equipment. |

**Idaho Facilities Management**
**INL Regulatory Compliance**

**Description**

This subcategory supports compliance activities that support continued compliance with State and Federal environmental laws and other regulations that are under the purview of the Office of Nuclear Energy (NE) owner responsibilities. Compliance activities focus on air, soil, and water monitoring and waste disposal consistent with Federal and State permit requirements and agreements such as the Idaho National Laboratory (INL) Site Treatment Plan. Regulatory activities also include efforts that support continued compliance with the 1995 Settlement Agreement with the State of Idaho, which governs management and disposition of used nuclear fuel and transuranic wastes at the INL.

Also funded under this subcategory are project costs to support the Remote-Handled Low-Level Waste (RHLLW) Disposal Facility Project to meet long-term waste disposal needs for NE and Naval Reactors (NR), consistent with regulatory requirements.

## INL Regulatory Compliance

**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **INL Regulatory Compliance $13,804,000** | **$12,539,000** | **-$1,265,000** |
| • Continue regulatory compliance program management.<br>• Meet Idaho National Laboratory (INL) Site Treatment Plan milestones for treatment of two cubic meters of Mixed Low-Level Waste (MLLW).<br>• Scheduled transfer(s) of used nuclear fuel from wet storage in accordance with the 1995 Idaho Settlement Agreement and consistent with material requirements for the treatment of enriched uranium Experimental Breeder Reactor II (EBR-II) used nuclear fuel.<br>• Support design and construction activities for Remote-Handled Low-Level Waste (RHLLW) Disposal Facility Project, including the review and approval process for the Composite Analysis prepared in accordance with Department of Energy (DOE) O 435.1, Radioactive Waste Management.<br>• Modify Materials and Fuel Complex facilities to package waste in Waste Isolation Pilot Plant (WIPP) compliant containers to accelerate off-site shipment. | • Continue regulatory compliance program management.<br>• Meet INL Site Treatment Plan milestones for treatment of two cubic meters of MLLW.<br>• Schedule transfer(s) of used nuclear fuel from wet storage in accordance with the 1995 Idaho Settlement Agreement and consistent with material requirements for the treatment of enriched uranium EBR-II used nuclear fuel.<br>• Support design and construction activities for RHLLW Disposal Facility Project, including the review and approval process for the Composite Analysis prepared in accordance with DOE O 435.1*, Radioactive Waste Management* and initiation of project readiness activities. | • The decrease reflects the funding necessary for other project costs for the RHLLW Disposal Facility Project consistent with the project schedule. |

**Idaho Facilities Management**
**Advanced Post Irradiation Examination Capabilities**

**Description**

In FY 2016, this subcategory that captured Other Project Costs (OPCs) for the Advanced Post Irradiation Examination (APIE) Capabilities Project will no longer be utilized. Instead, OPCs for the APIE Capabilities Project's leading alternative, the Sample Preparation Laboratory (SPL), will instead be captured under the "Idaho Facilities Management INL Non-Reactor Nuclear Research Facility Operations and Maintenance" subcategory. Capital funding will continue to be captured under the subcategory titled, "Idaho Facilities Management Construction."

## Advanced Post Irradiation Examination (APIE) Capabilities

**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **Advanced Post Irradiation Examination (APIE) Capabilities $0** | **$0** | **$0** |
| • No funding is requested. | • No funding is requested. | • No significant change. |

## Idaho Facilities Management
## Construction

**Description**

Line-item capital projects are required at the Idaho National Laboratory (INL) to maintain its infrastructure and its ability to support mission goals. These projects help achieve the Department's and the Office of Nuclear Energy's (NE) strategic objectives by maintaining site services and providing critical information for future decisions. This activity is focused on two primary objectives: (1) identification, planning, and prioritization of projects required to meet NE program objectives, and (2) development and execution of these projects within approved cost and schedule baselines as such projects are deemed necessary. While the Department's acquisition management process does not guarantee that a project will be completed once the initial information gathering and preliminary design phase are complete, it does provide an important decision-making framework that, when well executed, allows only the most critically necessary, cost-effective projects to proceed to construction.

**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **Construction $5,369,000** | **$2,000,000** | **-$3,369,000** |
| *Remote-Handled Low-Level Waste Disposal Facility Project (13-D-905) ($5,369,000)*<br>• Initiate construction of new replacement disposal capability to meet Nuclear Energy (NE) and Naval Reactors (NR) long-term program needs.<br>• Complete final design and initiate construction on waste receiving facility and site infrastructure.<br>• Complete final design for Remote-Handled Low-Level Waste (RHLLW) vault system for disposal of waste containers. | *Remote-Handled Low-Level Waste Disposal Facility Project (13-D-905) ($0)*<br>• No funding is requested. | *Remote-Handled Low-Level Waste Disposal Facility Project (13-D-905) (-$5,369,000)*<br>• The decrease in funding represents the completion of construction funding requests for the RHLLW Disposal Facility Project. |
| *Sample Preparation Laboratory (16-E-200) ($0)*<br>• No funding is requested. | *Sample Preparation Laboratory (16-E-200) ($2,000,000)*<br>• Commence Preliminary Design. | *Sample Preparation Laboratory (16-E-200) (+$2,000,000)*<br>• The increase in funding is to support Pre-critical decision (CD)-2 design and analysis activities for the Sample Preparation Laboratory (SPL) Project. |

**Idaho Facilities Management**
**Capital Summary ($K)**

| | Total | Prior Years | FY 2014 Enacted | FY 2014 Current | FY 2015 Enacted | FY 2016 Request | FY 2016 vs FY 2015 |
|---|---|---|---|---|---|---|---|
| **Capital Operating Expenses Summary (including (Major Items of Equipment (MIE))** | | | | | | | |
| Plant Projects (GPP) (<$10M) | n/a | 2,954 | 80 | 80 | 0 | 0 | - |
| **Total, Capital Operating Expenses** | **n/a** | **2,954** | **80** | **80** | **0** | **0** | **+0** |
| **Plant Projects (GPP) (Total Estimated Cost (TEC) <$10M)** | | | | | | | |
| Total Plant Projects (GPP) (Total Estimated Cost (TEC) <$5M) | n/a | 2,954 | 80 | 80 | 0 | 0 | - |
| **Total, Plant Projects (GPP) (Total Estimated Cost (TEC) <$10M)** | **n/a** | **2,954** | **80** | **80** | **0** | **0** | **+0** |
| **Total, Capital Summary** | **n/a** | **2,954** | **80** | **80** | **0** | **0** | **+0** |

**Idaho Facilities Management**
**Construction Projects Summary ($K)**

| | Total | Prior Years | FY 2014 Enacted | FY 2014 Current | FY 2015 Enacted | FY 2016 Request | FY 2016 vs FY 2015 |
|---|---|---|---|---|---|---|---|
| **13-D-905, Remote-Handled Low-Level Waste Disposal Project, INL (Summary represents NE costs; Project is co-funded with NR)** | | | | | | | |
| Total Estimated Cost (TEC) | 21,767 | 0 | 16,398 | 16,398 | 5,369 | 0 | -5,369 |
| Other Project Costs (OPC)* | 18,996 | 11,584 | 415 | 415 | 2,553 | 1,504 | -1,049 |
| **Total Project Cost (TPC) Project Number 13-D-905** | **40,763** | **11,584** | **16,813** | **16,813** | **7,922** | **1,504** | **-6,418** |
| **16-E-200, Sample Preparation Laboratory, INL** | | | | | | | |
| Total Estimated Cost (TEC) | 78,000 | 0 | 0 | 0 | 0 | 2,000 | +2,000 |
| Other Project Costs (OPC)* | 17,000 | 4,431 | 2,000 | 2,000 | 0 | 1,500 | +1,500 |
| **Total Project Cost (TPC) Project Number 16-E-200** | **95,000** | **4,431** | **2,000** | **2,000** | **0** | **3,500** | **+3,500** |
| **Total All Construction Projects** | | | | | | | |
| Total Total Estimated Cost (TEC) | 99,767 | 0 | 16,398 | 16,398 | 5,369 | 2,000 | -3,369 |
| Total Other Project Costs (OPC) | 35,996 | 16,015 | 2,415 | 2,415 | 2,553 | 3,004 | +451 |
| **Total Project Cost (TPC) All Construction Projects** | **135,763** | **16,015** | **18,813** | **18,813** | **7,922** | **5,004** | **-2,918** |

*Indicates a project where the cost of the Conceptual Design Report is estimated to exceed $3M.

**Idaho Facilities Management**
**Performance Measures**

In accordance with the GPRA Modernization Act of 2010, the Department sets targets for, and tracks progress toward, achieving performance goals for each program.

| | FY 2014 | FY 2015 | FY 2016 |
|---|---|---|---|
| Performance Goal (Measure) | **Facility Availability - Idaho Facilities Management Program - Enable nuclear research and development activities by providing operational facilities and capabilities, as measured by availability percentages.** | | |
| Target | 80% | 80% | 80% |
| Result | ATR 65.9%; MFC 88.6% | N/A | N/A |
| Endpoint Target | Maintain the percentage of facilities and capabilities that are available for research and development activities at 90% or better. | | |
| Performance Goal (Measure) | **Plant and Construction: Cost and Schedule Baseline Variance - Execute line item construction projects within approved cost profiles and schedules, using cost performance index and schedule performance index (using earned value measurement systems), with the green level maintaining indexes between 0.9 and 1.10, the yellow level between 0.8 and 1.20 and the red level less than 0.8 or greater than 1.20.** | | |
| Target | 80% | 80% | 80% |
| Result | 100% (tracking only one project – NRAD. NRAD met SPI and CPI indexes, but missed June 2014 completion and is behind schedule.) | N/A | N/A |
| Endpoint Target | Maintain the total percentage of projects with green cost and schedule indexes at 90% or better. | | |

## Idaho Sitewide Safeguards and Security

**Overview**

The Idaho Sitewide Safeguards and Security (S&S) program supports the Idaho National Laboratory (INL) complex nuclear facility infrastructure and enables the Office of Nuclear Energy (NE) to conduct research and development (R&D) in support of multiple program missions. To better align the S&S funding with INL infrastructure and Research and Development R&D programs, the S&S program was transferred to the Nuclear Energy appropriation in FY 2014.

The S&S program funds NE base physical and cyber security activities for the INL, providing protection of the Department of Energy's (DOE) nuclear materials, classified and unclassified matter, government property, personnel and other vital assets from theft, diversion, sabotage, espionage, unauthorized access, compromise, and other hostile acts that may cause adverse impacts on our national security; program continuity; or the health and safety of employees, the public, or the environment.

The S&S program at the INL benefits the site infrastructure and users by providing the safeguards and security functions required at DOE sites to enable R&D utilizing nuclear materials and protected information. In addition to NE R&D activities, S&S enables a range of national security programs that support the National Nuclear Security Administration (NNSA) and other Federal agencies including the Department of Homeland Security in the areas of critical infrastructure protection, nuclear nonproliferation and incident response. Safeguards and security functions through the INL S&S program also enable the Department of the Army, the Department of the Navy and NNSA Naval Reactors mission activities.

**Highlights of the FY 2016 Budget Request**

The FY 2016 request provides direct funding for the S&S base program for NE. Base program costs determined to be allocable, i.e., beneficial to specific Department programs and Strategic Partnership Projects (SPP) , are paid by those programs and SPP via full cost recovery. The costs for program and SPP-specific security requirements beyond the S&S base program that are specifically requested or driven by the program or SPP project are directly charged to those customers as appropriate.

In FY 2016, the S&S program will continue to sustain program functionality at the level necessary to assure high confidence in the protection of INL assets and a high degree of customer service by maintaining effective staffing levels, proactive preventative and corrective maintenance programs, and a robust cyber security program. The FY 2016 request will focus on implementing infrastructure investments, capital improvements, emerging technology investments and enhanced cyber security program capabilities to adequately secure site assets.

FY 2016 funding supports increased S&S program scope in the following areas:

- Completing critical physical security infrastructure investments required to maintain an S&S program consistent with Departmental requirements and ensure adequate protection levels; such as upgrading the perimeter intrusion detection and assessment system (PIDAS) and central alarm system (CAS) at the Materials and Fuels Complex (MFC).
- Implementing enhanced external penetration capabilities and data protection resources to monitor and mitigate risks for INL Cloud services.
- Establishing an INL Industrial Control Systems cyber security program to ensure protection of critical infrastructure systems vital to operations at the INL.

Within the FY 2016 Budget Request, the Idaho Sitewide Safeguards and Security (S&S) program supports one Departmental Crosscut: Cybersecurity. The goal of the Cybersecurity crosscut is to protect the integrity of Departmental information by strengthening our cyber security posture. The Idaho Sitewide S&S program will support this crosscut by maintaining the computing infrastructure and network security configuration necessary to support classified and unclassified information and electronic operations at the Idaho National Laboratory (INL).

**FY 2016 Crosscuts ($K)**

| | Cybersecurity | Total |
|---|---|---|
| Idaho Sitewide Safeguards and Security | 14,466 | 14,466 |

**Idaho Sitewide Safeguards and Security**
**Funding ($K)**

| | FY 2014 Enacted | FY 2014 Current | FY 2015 Enacted | FY 2016 Request | FY 2016 vs FY 2015 |
|---|---|---|---|---|---|
| **Idaho Sitewide Safeguards and Security** | | | | | |
| Protective Forces | 55,475 | 55,475 | 57,547 | 65,611 | +8,064 |
| Security Systems | 8,578 | 8,578 | 14,718 | 11,632 | -3,086 |
| Security Infrastructure | 0 | 0 | 0 | 11,681 | +11,681 |
| Information Security | 3,242 | 3,242 | 3,451 | 3,721 | +270 |
| Personnel Security | 5,529 | 5,529 | 7,050 | 6,749 | -301 |
| Material Control & Accountability | 3,669 | 3,669 | 4,340 | 4,456 | +116 |
| Program Management | 5,581 | 5,581 | 5,626 | 7,845 | +2,219 |
| Cyber Security | 11,926 | 11,926 | 11,268 | 14,466 | +3,198 |
| **Total, Idaho Sitewide Safeguards and Security** | **94,000** | **94,000** | **104,000** | **126,161** | **+22,161** |

**Idaho Sitewide Safeguards and Security**
**Explanation of Major Changes ($K)**

| | FY 2016 vs FY 2015 |
|---|---|
| **Protective Forces:** The increase from $57,547,000 to $65,611,000 reflects full year costs associated with FY 2015 planned hires consistent with Departmental protection requirements and changes to the site labor wage agreement, cost model, and scope adjustments. Funding also supports protective force equipment, training, facilities, and management. | **+8,064** |
| **Security Systems:** The decrease from $14,718,000 to $11,632,000 reflects the projected reduction in the backlog of physical security systems life cycle replacement and provides funds to complete preventative/corrective maintenance and scheduled lifecycle replacements of physical security systems. Funding also supports staffing required for effective maintenance, replacement, and performance testing of physical security systems. | **-3,086** |
| **Security Infrastructure:** The increase from $0 to $11,681,000 provides funds to upgrade physical security infrastructure including the perimeter intrusion detection and assessment system (PIDAS) and central alarm system (CAS) at the Materials and Fuels Complex (MFC). | **+11,681** |
| **Information Security:** The increase from $3,451,000 to $3,721,000 provides funds to maintain information security services for key Idaho National Laboratory (INL) facilities consistent with the site operational needs. | **+270** |
| **Personnel Security:** The decrease from $7,050,000 to $6,749,000 reflects efficiencies gained through consolidation of badging offices and provides funds to maintain personnel security services for key (INL) facilities consistent with the site operational needs including Homeland Security Presidential Directive 12 (HSPD-12) badging and smart card administration requirements. | **-301** |
| **Material Control & Accountability:** The increase from $4,340,000 to $4,456,000 provides funds to maintain accounting and control of special nuclear material (SNM) at key INL facilities consistent with the site operational needs. | **+116** |
| **Program Management:** The increase from $5,626,000 to $7,845,000 supports performance assurance activities including table top exercise, simulations, self-assessments, limited scope performance tests and force-on-force exercises required to ensure adequate protection of INL assets consistent with Departmental requirements. | **+2,219** |
| **Cyber Security:** The increase from $11,268,000 to $14,466,000 supports the addition of essential cyber security specialists, lifecycle hardware/software upgrades and replacements for classified and unclassified systems, external penetration capabilities, data protection resources to monitor and mitigate risks for INL Cloud services, and establishing an INL Industrial Control Systems cyber security program. | **+3,198** |
| **Total, Idaho Sitewide Safeguards and Security** | **+22,161** |

**Idaho Sitewide Safeguards and Security**
**Protective Forces**

**Description**

Protective Force provides security police officers (SPO's) and other specialized personnel, equipment, training, and management needed during normal and security emergency conditions for adequate protection of Special Nuclear Material (SNM), classified and sensitive information, Government property, and personnel. Protective force personnel are deployed 24 hours a day, 7 days a week, across the 890 square miles of the Idaho National Laboratory (INL) site to deter, detect, delay, and respond to adversarial threats. Funding needs are based on protection strategies designed to ensure adequate protective force staffing levels, equipment, facilities, training, management, and administrative support are available to respond to any security incident outlined in the Site Security Plans.

**Protective Forces**

**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **Protective Forces $57,547,000** | **$65,611,000** | **+$8,064,000** |
| • Provides funds to maintain a protective force consistent with the Site Security Plans and approved site labor wage agreement, including associated training activities, and facilities required to maintain protective force qualifications.<br>• Provide increased Protective Force services for Idaho National Laboratory (INL) in-town assets.<br>• Maintain and provide 24/7 operation of the Warning Communication System.<br>• Conduct Basic Police Officer Training for new hires.<br>• Conduct Use of force training on active shooter and lesser threat scenarios.<br>• Complete refurbishment of Range 3.<br>• Provides funding to purchase protective force equipment such as ammunition, weapons, protective gear (tactical vests, helmets) and vehicles.<br>• Additional weapons and protective gear for new hires.<br>• Replacement weapons for those at the end of useful life. | • Provides funds to maintain a protective force consistent with the Site Security Plan, approved site labor wage agreement, and INL cost model changes, including associated training activities and facilities required to maintain protective force qualifications.<br>• Provide Protective Force services for all INL assets consistent with Site Security Plans.<br>• Maintain and provide 24/7 operation of the Warning Communication System.<br>• Conduct Basic Police Officer Training for new hires required to address attrition.<br>• Provide range operations and training including weapons qualifications.<br>• Conduct Use of force training on active shooter and lesser threat scenarios.<br>• Provides funding to purchase protective force equipment such as ammunition, weapons, protective gear (tactical vests, helmets) and vehicles.<br>• Replacement weapons, ammunition and equipment for those at the end of useful life. | • The increase reflects full year costs associated with FY 2015 planned hires consistent with Departmental protection requirements and changes to the site labor wage agreement, cost model, and scope adjustments. Funding also supports protective force equipment, training, facilities, and management. |

**Idaho Sitewide Safeguards and Security**
**Security Systems**

**Description**

Security Systems provides equipment to protect vital security interests and government property, including performance testing, intrusion detection and assessment, entry and search control, barriers, secure storage, lighting, sensors, entry/access control devices, locks, explosives detection, and tamper-safe monitoring. Security Systems provides maintenance of approximately 4,600 security alarms and 6,100 security locks at multiple Idaho National Laboratory (INL) security areas ensuring 24 hour a day, 7 days a week operation of these systems. Maintaining a reliable physical security infrastructure allows the Idaho Sitewide Safeguards and Security (S&S) program to maintain consistent/lower staffing levels and lower labor costs.

**Security Systems**

**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **Security Systems $14,718,000** | **$11,632,000** | **-$3,086,000** |
| • Provides funds to plan and conduct preventative and corrective maintenance on physical security systems at multiple Idaho National Laboratory (INL) security areas to ensure 24 hour operation of these systems including associated staffing requirements.<br>• Supports the operation of INL central alarm stations, development and modification of security alarm systems and life cycle replacement of systems including:<br>  • Access control system database servers and field panels.<br>  • Detection system equipment (motion sensors, door sensors, cameras, radars, etc.). | • Provides funds to plan and conduct preventative and corrective maintenance on physical security systems at multiple INL security areas to ensure 24 hour operation of these systems including associated staffing requirements.<br>• Supports the operation of INL central alarm stations, development and modification of security alarm systems and life cycle replacement of systems including:<br>  • Access control system database servers and field panels<br>  • Detection system equipment (motion sensors, door sensors, cameras, radars, etc.). | • The decrease reflects the projected reduction in the backlog of physical security systems life cycle replacement based on planned FY 2015 accomplishments. |

**Idaho Sitewide Safeguards and Security**
**Security Infrastructure**

**Description**

Security Infrastructure provides critical security infrastructure investments and protection enhancements necessary to ensure adequate protection of Idaho National Laboratory (INL) assets consistent with Departmental requirements. FY 2016 activities include upgrading the perimeter intrusion detection and assessment systems (PIDAS) and the central alarm system (CAS) at the Materials and Fuels Complex (MFC).

**Security Infrastructure**

**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **Security Infrastructure $0** | **$11,681,000** | **+$11,681,000** |
| • No funding requested. | • Upgrade Perimeter Intrusion Detection and Assessment System (PIDAS) at the Materials and Fuels Complex (MFC).<br>  • The PIDAS is a series of physical security systems and barriers utilized to detect, assess and delay an adversary and are required for the protection of Security Category I and II special nuclear material (SNM). The proposed upgrade will replace exterior equipment which meet or exceed manufacturer recommendations for lifecycle replacement and installation of additional intrusion detection, assessment, and access control systems.<br>• Upgrade Central Alarm System (CAS) at MFC.<br>  • The MFC CAS is utilized to manage security systems, assess alarms, and dispatch patrols. Originally designed to include the equipment and personnel required to manage only the local MFC facility, it is now operated as an Idaho National Laboratory (INL) CAS with backup responsibilities for alternate site locations. As technology has been developed and implemented to enhance the site security posture the CAS has not kept pace and requires upgrading to allow for efficient operations. | • The increase provides funds to upgrade physical security infrastructure including the PIDAS and CAS at the MFC. |

## Idaho Sitewide Safeguards and Security
## Information Security

**Description**

Information Security provides for the protection and control of classified and sensitive matter that is generated, received, transmitted, used, stored, reproduced or destroyed at the Idaho National Laboratory (INL). The Classified Matter Protection and Control Program and Operations Security Program ensure that classified and sensitive unclassified matter is appropriately managed and adequately protected and controlled to prevent access by unauthorized individuals and that those individuals that do have access are trained to handle classified matter. Information Security executes the Technical Security Countermeasures (TSCM) program and conducts TSCM surveys.

## Information Security

**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **Information Security $3,451,000** | **$3,721,000** | **+$270,000** |
| • Provides funds to implement Idaho National Laboratory (INL) information security activities to protect classified and sensitive unclassified matter, including programs for Classified Matter and Control, Technical Surveillance Countermeasures, Classification/ Declassification, and Operations Security.<br>• Supports coordination activities with INL research and development (R&D) programs to develop project-specific security requirements within the context of the overall INL information security program and to support increased classification work scope.<br>• Provides funds to support personnel necessary to enhance the Site Operations Security Program. | • Provides funds to implement INL information security activities to protect classified and sensitive unclassified matter, including programs for Classified Matter and Control, Technical Surveillance Countermeasures, Classification/ Declassification, and Operations Security.<br>• Supports coordination activities with INL R&D programs to develop project-specific security requirements within the context of the overall INL information security program and to support increased classification work scope.<br>• Provides funds to maintain Site Operations Security Program. | • The increase is due to costs associated with maintaining information security services for key INL facilities consistent with the site operational needs and anticipated growth in work scope. |

**Idaho Sitewide Safeguards and Security**
**Personnel Security**

**Description**
Personnel Security provides for access to classified and sensitive information and assignment of personnel in sensitive positions through the clearance program, adjudication, security awareness and education, U.S. citizen and foreign visitor control, Human Reliability Program, psychological/medical assessments, and administrative review costs. Personnel security also provides for federally funded activities such as the annual cost to support the database that maintains smart card credentials for Idaho National Laboratory (INL) personnel and badging requirements.

## Personnel Security

**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **Personnel Security $7,050,000** | **$6,749,000** | **-$301,000** |
| • Provides funds to conduct Idaho National Laboratory (INL) personnel security programs including security investigations to determine the suitability of INL personnel for classified work, assessing requests for U.S and foreign researchers to work in selected sensitive subject areas, and maintaining databases that hold clearance information for approximately 6,000 employees.<br>• Provides funds for federal activities such as processing, tracking, and adjudication of security investigations for federal and non-federal employees, including medical examinations and headquarters directed initiatives.<br>• Supports Homeland Security Presidential Directive 12 (HSPD-12) badging and smart card administration requirements. | • Provides funds to conduct INL personnel security programs including security investigations to determine the suitability of INL personnel for classified work, assessing requests for U.S and foreign researchers to work in selected sensitive subject areas, and maintaining databases that hold clearance information for approximately 6,000 employees.<br>• Provides funds for federal activities such as processing, tracking, and adjudication of security investigations for federal and non-federal employees, including medical examinations and headquarters directed initiatives.<br>• Supports HSPD-12 badging and smart card administration requirements. | • The decrease reflects efficiencies gained through consolidation of INL badging offices and costs associated with maintaining personnel security services consistent with the site operational needs and additional staffing required to support HSPD-12 badging and smart card administration requirements. |

## Idaho Sitewide Safeguards and Security
## Material Control & Accountability

**Description**

Material Control & Accountability (MC&A) provides the personnel, equipment, and services required to account for and control all special nuclear material (SNM) at Idaho National Laboratory (INL) from diversion. MC&A is accomplished through the administration of a robust formal inventory process for all SNM on site that allows INL security personnel to locate and track specific quantities in real time, state of the art measurement equipment, non-destructive analysis, and a robust tamper indicating device program.

## Material Control & Accountability

**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **Material Control & Accountability** | | |
| **$4,340,000** | **$4,456,000** | **+$116,000** |
| • Provides funds to maintain the site's special nuclear material (SNM) database and tracking systems, coordinate increased on-and off-site material movements, and to conduct SNM inventories. | • Provides funds to maintain the site's SNM database and tracking systems, coordinate increased on-and off-site material movements, and to conduct SNM inventories. | • The increase is due to costs associated with maintaining Material Control & Accountability (MC&A) services for key Idaho National Laboratory (INL) facilities/programs consistent with the site operational needs and increased site material consolidation and disposition activities. |

## Idaho Sitewide Safeguards and Security
## Program Management

**Description**

Program Management includes policy oversight, development, and update of site security plans; vulnerability assessments and performance testing to ensure adequate protection of special nuclear material (SNM); and investigations into incidents of security concern; and issuance of security infractions. The activities completed within Program Management allow for risk-informed decision making, support a performance-based Safeguards and Security (S&S) program, and directly test the efficacy of the Idaho National Laboratory (INL) protection methodology/posture.

## Program Management

**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **Program Management $5,626,000** | **$7,845,000** | **+$2,219,000** |
| • Provides funds to maintain and update security program documentation, vulnerability assessments and performance testing through a combination of table-top exercises, simulations and force-on-force exercises to assure program effectiveness and efficiency as required annually by Departmental policy.<br>• Provides funds to conduct risk assessments and performance testing activities required to develop implementation plans for additional security requirements. | • Provides funds to maintain and update security program documentation, vulnerability assessments and performance testing through a combination of table-top exercises, simulations and force-on-force exercises to assure program effectiveness and efficiency as required annually by Departmental policy.<br>• Provides funds to conduct vulnerability assessments and performance testing activities required to develop detailed implementation plans for additional security requirements. | • The increase is due to costs associated with performance assurance activities including table top exercises, simulations, self-assessments, limited scope performance tests and force-on-force exercises required to ensure adequate protection of Idaho National Laboratory (INL) assets consistent with Departmental requirements. |

## Idaho Sitewide Safeguards and Security
## Cyber Security

**Description**

Cyber Security maintains the computing infrastructure and network security configuration necessary to support classified and unclassified information and electronic operations at the Idaho National Laboratory (INL). The Cyber Security program uses a graduated risk approach based on data sensitivity and impact of loss/compromise to ensure that electronic or computer information systems, are protected in a manner consistent with upholding key priorities, including importance to national security, support of Department of Energy (DOE) missions and programs, vulnerability to threats, and the magnitude of harm that would result from an information system compromise. Starting in FY 2016, an Industrial Control Systems program will be established to ensure protection of critical infrastructure systems vital to operations at the INL.

## Cyber Security

**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **Cyber Security $11,268,000** | **$14,466,000** | **+$3,198,000** |
| • Provide funds to operate, test, and maintain cyber security systems for the Idaho National Laboratory (INL) consistent with the Department's measured risk management and vulnerability management strategies.<br>• Support certification and accreditation activities for classified cyber security systems.<br>• Maintain INL training programs to educate users on cyber security strategies and Contractor Assurance System operating procedures and supporting processes.<br>• Complete lifecycle hardware/software upgrades and replacements and maintain essential cyber security positions and associated training.<br>• Re-categorize two INL network enclaves data categorization from low enclaves to Federal Information Security Management Act (FISMA) moderate protection.<br>• Perform feasibility study for extending the INL cyber security program to include the industrial control systems for INL. | • Maintain an effective cyber security program consistent with the Department's measured risk management and vulnerability management strategies.<br>• Establish and maintain staffing levels, technical training, and systems tools to detect, contain, and mitigate advanced persistent threats.<br>• Complete hardware, software and lifecycle replacement of classified and unclassified cyber systems needed to maintain a viable cyber security program at an acceptable risk level.<br>• Establishes INL Industrial Control Systems cyber security program.<br>• Provide enhanced vulnerability and incident management capabilities including new data protection resources to monitor and mitigate risk for new INL cloud services and wireless security infrastructure upgrades.<br>• Complete re-authorization (certification and accreditation) of unclassified enclaves. | • The increase is due to additional work scope and personnel associated with lifecycle hardware/software upgrades and replacements for classified and unclassified systems, external penetration capabilities, data protection resources to monitor and mitigate risks for INL Cloud services, and establishing an INL Industrial Control Systems cyber security program. |

**Idaho Sitewide Safeguards and Security**
**Capital Summary ($K)**

| | Total | Prior Years | FY 2014 Enacted | FY 2014 Current | FY 2015 Enacted | FY 2016 Request | FY 2016 vs FY 2015 |
|---|---|---|---|---|---|---|---|
| **Capital Operating Expenses Summary (including (Major Items of Equipment (MIE))** | | | | | | | |
| Capital Equipment > $500K (including MIE) | n/a | 0 | 1,500 | 1,500 | 1,500 | 1,500 | - |
| Plant Projects (GPP) (<$10M) | n/a | 0 | 0 | 0 | 0 | 11,681 | +11,681 |
| **Total, Capital Operating Expenses** | **n/a** | **0** | **1,500** | **1,500** | **1,500** | **13,181** | **+11,681** |
| **Capital Equipment > $500K (including MIE)** | | | | | | | |
| Total Non-MIE Capital Equipment (>$500K) | n/a | 0 | 1,500 | 1,500 | 1,500 | 1,500 | - |
| **Total, Capital Equipment (including MIE)** | **n/a** | **0** | **1,500** | **1,500** | **1,500** | **1,500** | **+0** |
| **Plant Projects (GPP) (Total Estimated Cost (TEC) <$10M)** | | | | | | | |
| Materials and Fuels Complex (MFC) Perimeter Intrusion Detection and Assessment System (PIDAS) Upgrade | n/a | 0 | 0 | 0 | 0 | 8,281 | +8,281 |
| MFC Central Alarm System (CAS) Upgrade | n/a | 0 | 0 | 0 | 0 | 3,400 | +3,400 |
| **Total, Plant Projects (GPP) (Total Estimated Cost (TEC) <$10M)** | **n/a** | **0** | **0** | **0** | **0** | **11,681** | **+11,681** |
| **Total, Capital Summary** | **n/a** | **0** | **1,500** | **1,500** | **1,500** | **13,181** | **+11,681** |

## International Nuclear Energy Cooperation

**Overview**

International Nuclear Energy Cooperation's (INEC) mission is to serve as the Department's overall lead for all international activities related to civil nuclear energy, including analysis, development, and implementation of international civil nuclear energy policy and coordination and integration of the Office of Nuclear Energy's (NE) international nuclear technical activities. These activities support international bilateral and multilateral engagement and civil nuclear energy research and development (R&D) activities with countries having an established or planned civilian nuclear power sector. INEC may also employ workshops to engage industry and foreign governments on international civil nuclear issues such as financing, safety, or comprehensive nuclear fuel services (CFS).

INEC provides the Department the ability to meet growing demands for engagement with international partners on civil nuclear policy, RD&D, and related activities. INEC engages both bilaterally and multilaterally to support broader U.S. policy and commercial goals related to the safe and secure deployment of nuclear energy globally and allow more effective integration of NE international R&D and policy interests, including increasing proliferation resistance of new and existing technologies. INEC also leverages nuclear energy efforts in coordination with Department of Energy's (DOE) National Nuclear Security Administration, Office of Environmental Management, and Office of International Affairs; the National Security Council; Department of State; Department of Commerce; and the Nuclear Regulatory Commission to facilitate U.S. nuclear energy R&D, policy, and commercial interests internationally.

**Highlights of the FY 2016 Budget Request**

In FY 2016, INEC will negotiate new agreements and support existing international agreements working with the Department of State and other Departments on establishing new engagements with advanced and developing nuclear energy countries as necessary globally. INEC will advance multilateral collaboration with the International Atomic Energy Agency (IAEA), International Framework for Nuclear Energy Cooperation (IFNEC), Organisation for Economic Co-operation and Development/Nuclear Energy Agency (OECD/NEA) and other fora focusing on concepts such as CFS and the analytical studies to support this engagement.

## International Nuclear Energy Cooperation
## Funding ($K)

| | FY 2014 Enacted[1] | FY 2014 Current | FY 2015 Enacted | FY 2016 Request | FY 2016 vs FY 2015 |
|---|---|---|---|---|---|
| **International Nuclear Energy Cooperation** | | | | | |
| International Nuclear Energy Cooperation | 2,496 | 2,496 | 3,000 | 3,000 | - |
| **Total, International Nuclear Energy Cooperation** | **2,496** | **2,496** | **3,000** | **3,000** | **+0** |

[1] FY 2014 Enacted column reflects a rescission of $3,900 as identified within Section 317 of Public Law 113-76.

**International Nuclear Energy Cooperation**
**Explanation of Major Changes ($K)**

| | FY 2016 vs FY 2015 |
|---|---|
| **International Nuclear Energy Cooperation:** No significant change. | **0** |
| **Total, International Nuclear Energy Cooperation** | **+0** |

**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **International Nuclear Energy Cooperation $3,000,000** | **$3,000,000** | **$0** |
| • Provide country-specific policy and logistical support required to effectively implement NE's bilateral nuclear energy R&D activities with expert support from national laboratory lead country coordinators. Maintain the existing bilateral and multilateral cooperation commitments as appropriate. Enhance technical cooperation with advanced and developing nuclear energy countries globally to support both the Office of Nuclear Energy and U.S. Government strategic priorities and objectives.<br>• Provide expertise and technical assistance to the Department of Commerce in its efforts to support U.S. civil nuclear exports.<br>• Advance multilateral collaboration on CFS concepts and continue analytical studies supporting this engagement. | • Develop new collaboration opportunities with U.K., France, India, and Japan in light of R&D Agreements, implementing arrangements and Action Plan updates completed in 2014 and 2015.<br>• Continue to provide expertise and technical assistance to the Department of Commerce in its efforts to support U.S. civil nuclear exports.<br>• Continue to advance multilateral collaboration with the IAEA and OECD/NEA on key issues such as CFS concepts and continue analytical studies supporting this engagement. | • Even though there is no funding changes between FY 2015 and FY 2016, INEC will sustain existing engagement and expand bilateral and multilateral activities that were initiated in 2014 and 2015. New collaboration will be developed as determined by Office of Nuclear Energy and U.S. Government strategic priorities and objectives. |

## Program Direction

### Overview

Program Direction provides the federal staffing resources and associated costs required to support the overall direction and execution of the Office of Nuclear Energy (NE) programs. NE has staff located in multiple locations: Washington, D.C., the Idaho Operations Office, the Oak Ridge Operations Office, and the Nevada Site Office. The Idaho Operations Office funding supports their efforts to be a fully functional service center for NE, as well as other Department of Energy (DOE) offices. Activities within the site office support function include execution of headquarters (HQ) directed procurements, supplemental support for any unforeseen actions, as well as maintenance to federal buildings.

In addition to NE federal personnel, Program Direction supports the coordination of the Energy portfolio by the Office of the Under Secretary for Science and Energy. NE Program Direction also supports select federal staff from the Office of the General Counsel and Energy Information Administration responsible for administrative activities and judicial litigation associated with the termination of the Yucca Mountain Nuclear Waste Repository project, legal issues related to the standard contract, and the Department's responsibilities regarding spent fuel and high level waste, as specified by the Nuclear Waste Policy Act (NWPA).

The Support Services subprogram allows the Department to cost-effectively hire the best available industry experts to support federal staff in managing the nuclear programs and complex activities. The ability to acquire expertise quickly and on an “as needed basis” provides unlimited flexibility in team composition as the needs of NE evolve. Program Direction also includes the Other Related Expenses subprogram, which provides NE’s funding contribution to the Department’s Working Capital Fund (WCF) for common administrative services at HQ. The Department is working to achieve economies of scale through an enhanced WCF. The WCF supports specific Departmental services and activities that are shared across DOE including: enhanced cyber security architecture, employee health and testing services, and consolidated training and recruitment initiatives; all established in previous fiscal years and supported in FY 2016.

In addition to appropriated funds, NE also manages approximately $140.0 million dollars annually from other activities including: Strategic Partnerships Program and reimbursable funding from the National Aeronautics and Space Administration (NASA) and the Department of Defense (DoD).

The Program Direction request reflects NE’s continued effort to optimize support for its federal workforce, while continuing to improve efficiency and cost-effectiveness; and ensure the expert federal management and oversight of NE mission activities.

### Highlights of the FY 2016 Budget Request

The Nuclear Energy Program Direction request is equal to the FY 2015 appropriation; reflecting NE’s continuing efforts to maintain appropriate federal oversight of NE missions and supporting activities.

## Program Direction
## Funding ($K)

| | FY 2014 Enacted | FY 2014 Current | FY 2015 Enacted | FY 2016 Request | FY 2016 vs FY 2015 |
|---|---|---|---|---|---|
| **Program Direction Summary** | | | | | |
| **Washington Headquarters** | | | | | |
| Salaries and Benefits | 30,000 | 30,000 | 30,426 | 30,822 | +396 |
| Travel | 1,250 | 1,185 | 1,250 | 1,250 | 0 |
| Support Services | 3,000 | 3,652 | 2,200 | 2,200 | 0 |
| Other Related Expenses | 13,750 | 14,798 | 6,300 | 6,121 | -179 |
| **Total, Washington Headquarters** | **48,000** | **49,635** | **40,176** | **40,393** | **+217** |
| **Oak Ridge Operations Office** | | | | | |
| Salaries and Benefits | 1,100 | 1,100 | 1,111 | 1,125 | +14 |
| Travel | 25 | 0 | 25 | 25 | 0 |
| Support Services | 300 | 312 | 300 | 300 | 0 |
| Other Related Expenses | 1,000 | 1,539 | 1,650 | 1,591 | -59 |
| **Total, Oak Ridge Operations Office** | **2,425** | **2,951** | **3,086** | **3,041** | **-45** |
| **Idaho Operations Office** | | | | | |
| Salaries and Benefits | 26,000 | 25,789 | 26,250 | 26,591 | +341 |
| Travel | 575 | 625 | 575 | 575 | 0 |
| Support Services | 4,000 | 2,000 | 2,493 | 2,200 | -293 |
| Other Related Expenses | 9,000 | 9,000 | 7,420 | 7,200 | -220 |
| **Total, Idaho Operations Office** | **39,575** | **37,414** | **36,738** | **36,566** | **-172** |
| **Total Program Direction** | | | | | |
| Salaries and Benefits | 57,100 | 56,889 | 57,787 | 58,538 | +751 |
| Travel | 1,850 | 1,810 | 1,850 | 1,850 | 0 |
| Support Services | 7,300 | 5,964 | 4,993 | 4,700 | -293 |
| Other Related Expenses | 23,750 | 25,337 | 15,370 | 14,912 | -458 |
| **Total, Program Direction** | **90,000** | **90,000** | **80,000** | **80,000** | **0** |
| **Federal FTEs** | **394** | **394** | **394** | **394** | **0** |

| | FY 2014 Enacted | FY 2014 Current | FY 2015 Enacted | FY 2016 Request | FY 2016 vs FY 2015 |
|---|---|---|---|---|---|
| **Support Services** | | | | | |
| Technical Support | | | | | |
| Mission Related | 2,505 | 2,200 | 2,000 | 2,000 | 0 |
| Advisory and Assistance | 365 | 255 | 185 | 180 | -5 |
| Total, Technical Support | 2,870 | 2,455 | 2,185 | 2,180 | -5 |
| Management Support | | | | | |
| Administrative | 1,720 | 1,309 | 1,000 | 1,000 | 0 |
| IT | 2,710 | 2,200 | 1,808 | 1,520 | -288 |
| Total Management Support | 4,430 | 3,509 | 2,808 | 2,520 | -288 |
| **Total, Support Services** | **7,300** | **5,964** | **4,993** | **4,700** | **-293** |
| **Other Related Expenses** | | | | | |
| Working Capital Fund | 9,096 | 9,096 | 6,980 | 6,895 | -85 |
| Training | 550 | 525 | 500 | 500 | 0 |
| Miscellaneous | 12,604 | 14,216 | 6,390 | 6,017 | -373 |
| Rents and Utilities | 1,500 | 1,500 | 1,500 | 1,500 | 0 |
| **Total, Other Related Expenses** | **23,750** | **25,337** | **15,370** | **14,912** | **-458** |

## Program Direction

**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **Program Direction $80,000,000** | **$80,000,000** | **$0** |
| **Salaries and Benefits $57,787,000** | **$58,538,000** | **+$751,000** |
| Provides salaries and benefits for 394 federal staff. | Provides salaries and benefits for 394 federal staff. | Increase provides for a net increase of 1.3% in federal salary costs for step increases and federal pay scale increases. |
| **Travel $1,850,000** | **$1,850,000** | **$0** |
| Provides for travel of the federal staff including any necessary permanent change of duty status costs. | Provides for travel of the federal staff including any necessary permanent change of duty status costs, particularly associated with the NE staff at Department of Energy (DOE) overseas offices. | Travel remains level at approximately 70% of FY 2010 Office of Nuclear Energy expenditures. |
| **Support Services $4,993,000** | **$4,700,000** | **-$293,000** |
| Provides for technical and administrative support services for the Nuclear Energy (NE) federal staff including access to and participation with external and international nuclear energy organizations such as the Organisation for Economic Co-operation and Development/Nuclear Energy Agency. | Provides for technical and administrative support services for the NE federal staff including access to and participation with external and international nuclear energy organizations such as the Organisation for Economic Co-operation and Development/Nuclear Energy Agency. | Reduction of $5,000 for technical support services reflects ongoing efforts to reduce costs while maintaining appropriate oversight of NE missions.<br><br>Reduction of $288,000, in management support services reflects ongoing savings achieved streamlining and coordination of IT services through the DOE integrated IT services program. |
| **Other Related Expenses $15,370,000** | **$14,912,000** | **-$458,000** |
| Provides for NE's share of goods and services procured through the Department's Working Capital Fund; rents and utilities associated with the Idaho Operations Office and allocated shared of such costs for the Nevada Site Office; federal training expenses; and other miscellaneous expenses. | Provides for NE's share of goods and services procured through the Department's Working Capital Fund; rents and utilities associated with the Idaho Operations Office and allocated shared of such costs for the Nevada Site Office; federal training expenses; and other miscellaneous expenses. | Savings through the reduction of marginal value activities are partially offset by the ongoing growth in the cost of the Department's Working Capital Fund. Also included is NE's modest share of allocated charges to support the Nevada Site Office. |

## Nuclear Energy
## Facilities Maintenance and Repair

The Department's Facilities Maintenance and Repair activities are tied to its programmatic missions, goals, and objectives. The Facilities Maintenance and Repair activities funded by this budget are displayed below are intended to halt asset condition degradation.

**Costs for Direct-Funded Maintenance and Repair (including Deferred Maintenance Reduction) ($K)**

| | FY 2014 Actual Cost | FY 2014 Planned Cost | FY 2015 Planned Cost | FY 2016 Planned Cost |
|---|---|---|---|---|
| Idaho National Laboratory | 13,721 | 13,721 | 14,765 | 18,334 |
| Total, Direct-Funded Maintenance and Repair | 13,721 | 13,721 | 14,765 | 18,334 |

**Costs for Indirect-Funded Maintenance and Repair (including Deferred Maintenance Reduction) ($K)**

| | FY 2014 Actual Cost | FY 2014 Planned Cost | FY 2015 Planned Cost | FY 2016 Planned Cost |
|---|---|---|---|---|
| Idaho National Laboratory | 14,410 | 14,410 | 15,327 | 15,709 |
| Total, Indirect-Funded Maintenance and Repair | 14,410 | 14,410 | 15,327 | 15,709 |

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**Report on FY 2014 Expenditures for Maintenance and Repair**

This report responds to legislative language set forth in Conference Report (H.R. 108-10) accompanying the Consolidated Appropriations Resolution, 2003 (Public Law 108-7) (pages 886-887), which requests the Department of Energy provide an annual year-end report on maintenance expenditures to the Committees on Appropriations. This report compares the actual maintenance expenditures in FY 2014 to the amount planned for FY 2014, including Congressionally directed changes.

## Nuclear Energy
## Total Costs for Maintenance and Repair ($K)

| | FY 2014 Actual Cost | FY 2014 Planned Cost |
|---|---|---|
| Idaho National Laboratory | 28,131 | 28,131 |
| **Total, Maintenance and Repair** | **28,131** | **28,131** |

The Idaho Facilities Management program met its planned minimum target in FY 2014. There was no variance from the target.

**Nuclear Energy**
**Research and Development ($K)**

| | FY 2014 Current[1] | FY 2015 Enacted | FY 2016 Request | FY 2016 vs FY 2015 |
|---|---|---|---|---|
| Basic | 0 | 0 | 0 | - |
| Applied | 612,247 | 673,504 | 712,002 | +38,498 |
| Development | 21,834 | 23,190 | 25,570 | +2,380 |
| Subtotal, R&D | **634,081** | **696,694** | **737,572** | **+40,878** |
| Equipment | 0 | 0 | 0 | - |
| Construction | 0 | 0 | 0 | - |
| **Total, R&D** | **634,081** | **696,694** | **737,572** | **+40,878** |

[1] Funding reflects the SBIR/STTR amounts transferred to the Office of Science.

**Nuclear Energy**

**Small Business Innovative Research/Small Business Technology Transfer (SBIR/STTR) ($K)**

| | FY 2014 Transferred | FY 2015 Projected | FY 2016 Request | FY 2016 vs FY 2015 Projected |
|---|---|---|---|---|
| STEP R&D | | | | |
| SBIR | 0 | 145 | 150 | +5 |
| STTR | 0 | 20 | 23 | +3 |
| Reactor Concepts RD&D | | | | |
| SBIR | 3,159 | 3,857 | 3,244 | -613 |
| STTR | 451 | 532 | 487 | -45 |
| Fuel Cycle R&D | | | | |
| SBIR | 4,374 | 5,061 | 5,543 | +482 |
| STTR | 625 | 698 | 831 | +133 |
| Nuclear Energy Enabling Technologies | | | | |
| SBIR | 1,991 | 2,929 | 2,592 | -337 |
| STTR | 284 | 404 | 388 | -16 |
| **Total, SBIR** | **9,524** | **11,992** | **11,529** | **-463** |
| **Total, STTR** | **1,360** | **1,654** | **1,729** | **+75** |

Department Of Energy
FY 2016 Congressional Budget
Funding By Appropriation By Site
($K)

| Nuclear Energy | FY 2014 Current | FY 2015 Enacted | FY 2016 Request |
|---|---|---|---|
| **Argonne National Laboratory** | | | |
| **Fuel Cycle R & D** | | | |
| Fuel Cycle R & D | 11,677 | 11,100 | 12,300 |
| **Nuclear Energy Enabling Technologies** | | | |
| Nuclear Energy Enabling Technologies | 4,449 | 5,000 | 4,500 |
| **Reactors Concepts RD&D** | | | |
| Reactors Concepts RD&D | 11,603 | 16,000 | 11,695 |
| **International Nuclear Energy Cooperation** | | | |
| International Nuclear Energy Cooperation | 630 | 725 | 1,031 |
| **Total, Argonne National Laboratory** | **28,359** | **32,825** | **29,526** |
| **Brookhaven National Laboratory** | | | |
| **Fuel Cycle R & D** | | | |
| Fuel Cycle R & D | 2,300 | 2,100 | 1,500 |
| **Reactors Concepts RD&D** | | | |
| Reactors Concepts RD&D | 210 | 220 | 150 |
| **Total, Brookhaven National Laboratory** | **2,510** | **2,320** | **1,650** |
| **Idaho National Laboratory** | | | |
| **Fuel Cycle R & D** | | | |
| Fuel Cycle R & D | 41,344 | 41,600 | 37,500 |
| **Radiological Facilities Management** | | | |
| Radiological Facilities Management | 4,500 | 4,500 | 6,300 |
| **Idaho Facilities Management** | | | |
| Idaho Facilities Management | 189,852 | 199,040 | 203,957 |
| **Idaho Sitewide Safeguards and Security** | | | |
| Idaho Sitewide Safeguards and Security | 91,900 | 101,381 | 123,538 |
| **Nuclear Energy Enabling Technologies** | | | |
| Nuclear Energy Enabling Technologies | 25,928 | 45,885 | 30,093 |
| **Reactors Concepts RD&D** | | | |
| Reactors Concepts RD&D | 47,687 | 50,980 | 43,974 |
| **International Nuclear Energy Cooperation** | | | |
| International Nuclear Energy Cooperation | 899 | 1,155 | 1,050 |
| **Total, Idaho National Laboratory** | **402,110** | **444,541** | **446,412** |

Department Of Energy

FY 2016 Congressional Budget

Funding By Appropriation By Site

($K)

| Nuclear Energy | FY 2014 Current | FY 2015 Enacted | FY 2016 Request |
|---|---|---|---|
| **Idaho Operations Office** | | | |
| **University Research Program** | | | |
| University Research | 5,000 | 5,000 | 0 |
| **Fuel Cycle R & D** | | | |
| Fuel Cycle R & D | 51,339 | 59,000 | 77,560 |
| **Radiological Facilities Management** | | | |
| Radiological Facilities Management | 500 | 500 | 500 |
| **Idaho Facilities Management** | | | |
| Idaho Facilities Management | 5,100 | 5,200 | 6,569 |
| **Idaho Sitewide Safeguards and Security** | | | |
| Idaho Sitewide Safeguards and Security | 2,100 | 2,100 | 2,123 |
| **Program Direction-NE** | | | |
| Program Direction-NE | 37,414 | 36,738 | 36,566 |
| **Nuclear Energy Enabling Technologies** | | | |
| Nuclear Energy Enabling Technologies | 5,348 | 6,422 | 6,631 |
| **Reactors Concepts RD&D** | | | |
| Reactors Concepts RD&D | 31,336 | 36,742 | 21,490 |
| **International Nuclear Energy Cooperation** | | | |
| International Nuclear Energy Cooperation | 37 | 35 | 135 |
| **SMR Licensing Technical Support** | | | |
| SMR Licensing Technical Support | 109,508 | 53,600 | 62,000 |
| **Supercritical Transformational Electric Power Generatio** | | | |
| Supercritical Transformational Electric Power Generation | 0 | 4,500 | 4,500 |
| **Total, Idaho Operations Office** | **247,682** | **209,837** | **218,074** |
| **Kansas City Site Office** | | | |
| **Idaho Facilities Management** | | | |
| Idaho Facilities Management | 60 | 260 | 250 |
| **Total, Kansas City Site Office** | **60** | **260** | **250** |
| **Lawrence Berkeley National Laboratory** | | | |
| **Fuel Cycle R & D** | | | |
| Fuel Cycle R & D | 2,865 | 2,300 | 2,700 |
| **Nuclear Energy Enabling Technologies** | | | |
| Nuclear Energy Enabling Technologies | 50 | 100 | 100 |
| **Total, Lawrence Berkeley National Laboratory** | **2,915** | **2,400** | **2,800** |

Department Of Energy
FY 2016 Congressional Budget
Funding By Appropriation By Site
($K)

| Nuclear Energy | FY 2014 Current | FY 2015 Enacted | FY 2016 Request |
|---|---|---|---|
| **Lawrence Livermore National Laboratory** | | | |
| **Fuel Cycle R & D** | | | |
| Fuel Cycle R & D | 1,195 | 1,000 | 1,000 |
| **Nuclear Energy Enabling Technologies** | | | |
| Nuclear Energy Enabling Technologies | 200 | 1,000 | 800 |
| **Reactors Concepts RD&D** | | | |
| Reactors Concepts RD&D | 59 | 100 | 100 |
| **Total, Lawrence Livermore National Laboratory** | **1,454** | **2,100** | **1,900** |
| **Los Alamos National Laboratory** | | | |
| **Fuel Cycle R & D** | | | |
| Fuel Cycle R & D | 13,605 | 13,600 | 13,200 |
| **Nuclear Energy Enabling Technologies** | | | |
| Nuclear Energy Enabling Technologies | 875 | 1,940 | 1,372 |
| **Reactors Concepts RD&D** | | | |
| Reactors Concepts RD&D | 100 | 0 | 0 |
| **International Nuclear Energy Cooperation** | | | |
| International Nuclear Energy Cooperation | 0 | 50 | 0 |
| **Total, Los Alamos National Laboratory** | **14,580** | **15,590** | **14,572** |
| **Nevada Field Office** | | | |
| **Idaho Facilities Management** | | | |
| Idaho Facilities Management | 272 | 0 | 0 |
| **Total, Nevada Field Office** | **272** | **0** | **0** |
| **Oak Ridge National Laboratory** | | | |
| **Fuel Cycle R & D** | | | |
| Fuel Cycle R & D | 24,532 | 24,100 | 26,100 |
| **Radiological Facilities Management** | | | |
| Radiological Facilities Management | 19,968 | 19,898 | 0 |
| **Nuclear Energy Enabling Technologies** | | | |
| Nuclear Energy Enabling Technologies | 27,425 | 27,178 | 26,511 |
| **Reactors Concepts RD&D** | | | |
| Reactors Concepts RD&D | 14,545 | 19,824 | 23,550 |
| **International Nuclear Energy Cooperation** | | | |
| International Nuclear Energy Cooperation | 380 | 410 | 315 |
| **Total, Oak Ridge National Laboratory** | **86,850** | **91,410** | **76,476** |
| **Oak Ridge Office** | | | |
| **Fuel Cycle R & D** | | | |
| Fuel Cycle R & D | 550 | 600 | 600 |
| **Program Direction-NE** | | | |
| Program Direction-NE | 2,951 | 3,086 | 3,041 |
| **Total, Oak Ridge Office** | **3,501** | **3,686** | **3,641** |

Department Of Energy
FY 2016 Congressional Budget
Funding By Appropriation By Site
($K)

| Nuclear Energy | FY 2014 Current | FY 2015 Enacted | FY 2016 Request |
|---|---|---|---|
| **Pacific Northwest National Laboratory** | | | |
| **Fuel Cycle R & D** | | | |
| Fuel Cycle R & D | 10,825 | 10,400 | 11,100 |
| **Nuclear Energy Enabling Technologies** | | | |
| Nuclear Energy Enabling Technologies | 2,070 | 0 | 0 |
| **Reactors Concepts RD&D** | | | |
| Reactors Concepts RD&D | 1,150 | 1,150 | 1,150 |
| **International Nuclear Energy Cooperation** | | | |
| International Nuclear Energy Cooperation | 100 | 100 | 60 |
| **Total, Pacific Northwest National Laboratory** | **14,145** | **11,650** | **12,310** |
| **Sandia National Laboratories** | | | |
| **Fuel Cycle R & D** | | | |
| Fuel Cycle R & D | 11,800 | 11,900 | 15,800 |
| **Nuclear Energy Enabling Technologies** | | | |
| Nuclear Energy Enabling Technologies | 200 | 300 | 200 |
| **Reactors Concepts RD&D** | | | |
| Reactors Concepts RD&D | 2,505 | 2,530 | 2,300 |
| **International Nuclear Energy Cooperation** | | | |
| International Nuclear Energy Cooperation | 0 | 190 | 0 |
| **SMR Licensing Technical Support** | | | |
| SMR Licensing Technical Support | 400 | 400 | 0 |
| **Total, Sandia National Laboratories** | **14,905** | **15,320** | **18,300** |
| **Savannah River National Laboratory** | | | |
| **Fuel Cycle R & D** | | | |
| Fuel Cycle R & D | 75 | 0 | 0 |
| **Total, Savannah River National Laboratory** | **75** | **0** | **0** |
| **Savannah River Operations Office** | | | |
| **Fuel Cycle R & D** | | | |
| Fuel Cycle R & D | 4,365 | 4,400 | 5,500 |
| **Total, Savannah River Operations Office** | **4,365** | **4,400** | **5,500** |

Department Of Energy
FY 2016 Congressional Budget
Funding By Appropriation By Site
($K)

| Nuclear Energy | FY 2014 Current | FY 2015 Enacted | FY 2016 Request |
|---|---|---|---|
| **Washington Headquarters** | | | |
| **University Research Program** | | | |
| University Research | 500 | 0 | 0 |
| **Fuel Cycle R & D** | | | |
| Fuel Cycle R & D | 4,735 | 14,900 | 12,900 |
| **Radiological Facilities Management** | | | |
| Radiological Facilities Management | 0 | 102 | 0 |
| **Idaho Facilities Management** | | | |
| Idaho Facilities Management | 992 | 1,500 | 1,050 |
| **Idaho Sitewide Safeguards and Security** | | | |
| Idaho Sitewide Safeguards and Security | 0 | 519 | 500 |
| **Transfer from State Department** | | | |
| Transfer from State Department | 128 | 0 | 0 |
| **Program Direction-NE** | | | |
| Program Direction-NE | 49,635 | 40,176 | 40,393 |
| **Nuclear Energy Enabling Technologies** | | | |
| Nuclear Energy Enabling Technologies | 2,288 | 13,175 | 16,180 |
| **Reactors Concepts RD&D** | | | |
| Reactors Concepts RD&D | 17 | 5,454 | 3,731 |
| **International Nuclear Energy Cooperation** | | | |
| International Nuclear Energy Cooperation | 450 | 335 | 409 |
| **SMR Licensing Technical Support** | | | |
| SMR Licensing Technical Support | 92 | 500 | 500 |
| **Supercritical Transformational Electric Power Generatio** | | | |
| Supercritical Transformational Electric Power Generation | 0 | 500 | 500 |
| **Total, Washington Headquarters** | **58,837** | **77,161** | **76,163** |
| **Total, Nuclear Energy** | **882,620** | **913,500** | **907,574** |

# Fossil Energy Research and Development

# Fossil Energy Research and Development

**Fossil Energy Research and Development**

**Table of Contents**

**Fossil Energy Research and Development**
**Proposed Appropriation Language**

For Department of Energy expenses necessary in carrying out fossil energy research and development activities, under the authority of the Department of Energy Organization Act (Public Law 95–91), including the acquisition of interest, including defeasible and equitable interests in any real property or any facility or for plant or facility acquisition or expansion, and for conducting inquiries, technological investigations and research concerning the extraction, processing, use, and disposal of mineral substances without objectionable social and environmental costs (30 U.S.C. 3, 1602, and 1603), [$571,000,000]*$560,000,000*, to remain available until expended: *Provided*, That [119,000,000]*$114,202,000* shall be available until September 30, [2016]*2017*, for Program Direction.

**Explanation of Changes**

No changes.

**Public Law Authorizations**

Coal:

- Public Law 95-91.

CCS and Power Systems:

- Public Law 95-91.

Natural Gas Technologies:

- Public Law 91-91, "Department of Energy Organization Act", 1977
- Public Law 109-58, "Energy Policy Act of 2005".

Unconventional Fossil Energy Technologies:

- Public Law 95-91, "Department of Energy Organization Act", 1977
- Public Law 109-58, "Energy Policy Act of 2005".

Plan and Capital Equipment

- Public Law 95-91, "Department of Energy Organization Act", 1977
- Public Law 108-153, "21st Century Nanotechnology Research and Development Act 2003"
- Public Law 109-58, "Energy Policy Act of 2005".
- Public Law 110-69, "America COMPETES Act of 2007"
- Public Law 110-140, "Energy Independence and Security Act 2007"
- Public Law 111-358, "America COMPETES Act of 2010"

Environmental Restoration

- Public Law 95-91, "Department of Energy Organization Act", 1977
- Public Law 108-153, "21st Century Nanotechnology Research and Development Act 2003"
- Public Law 109-58, "Energy Policy Act of 2005".
- Public Law 110-69, "America COMPETES Act of 2007"
- Public Law 111-358, "America COMPETES Act of 2010"

Special Recruitment Programs

- Public Law 95-91, "Department of Energy Organization Act", 1977
- Public Law 108-153, "21st Century Nanotechnology Research and Development Act 2003"
- Public Law 109-58, "Energy Policy Act of 2005".
- Public Law 110-69, "America COMPETES Act of 2007"
- Public Law 111-358, "America COMPETES Act of 2010"

## Fossil Energy Research and Development

**($K)**

| FY 2014 Enacted | FY 2014 Current | FY 2015 Enacted | FY 2016 Request |
|---|---|---|---|
| 561,931 | 550,630 | 560,587 | 560,000 |

**Overview**

The Office of Fossil Energy (FE) advances technologies related to the reliable, efficient, affordable, and environmentally sound development of fossil fuels which are essential to our Nation's security and economic prosperity. FE supports the President's all of the above energy strategy through leadership in Federal research, development, and demonstration efforts on advanced carbon capture and storage (CCS) technologies to facilitate achievement of the President's climate goals. FE also develops technology and informational -based solutions for the prudent and sustainable development of domestic unconventional resources. These Fossil Energy Research and Development (FER&D) programs create public benefits by 1) performing and managing research that reduces market barriers to the environmentally sound use of fossil fuels, 2) partnering with industry and others to advance fossil energy technologies toward commercialization, and 3) supporting the development of information and policy options that benefit the public.

**Highlights and Major Changes in the FY 2016 Budget Request**

In FY 2016, Fossil Energy Research and Development will continue to focus on carbon capture and storage and activities that increase the efficiency and availability of systems integrated with CCS.

CCS Demonstrations

In FY 2016, no new funding is requested. Initial efforts to address the technical challenges inherent to capture from a gas-fired power facility, such as a lower concentration of $CO_2$ and higher oxygen content, will begin in FY 2016 through the Carbon Capture program in preparation for a future demonstration facility. The program is committed to delivering a demonstration project that captures and stores >75 percent of the carbon emissions from a natural gas power system of at least 50 MWe capacity by 2020 using what has been determined to be the best available carbon capture technology available for demonstration at the time.

Carbon Capture/Storage

In FY 2016, Carbon Capture maintains priority on post-combustion and pre- combustion capture for fossil fuel-fired plants. The $28.6 million increase for Carbon Capture funds a new emphasis on optimizing carbon capture on natural gas systems and the transition and scale-up of multiple, advanced $CO_2$ capture technologies, including support for up to 2 large-scale pilot projects (10+ MWe) to reduce costs and validate performance and operation for both coal and natural gas-fired power plants. The $8.8 million increase for Carbon Storage funds storage infrastructure projects to validate and increase certainty of carbon storage, including Regional Carbon Sequestration Partnerships (RCSPs), and fit-for-purpose injection tests. Funding for Advanced Storage R&D develops technologies and tools to better quantify and assess risk and uncertainty of storage and improved monitoring tools and technologies. Sub-Disciplinary R&D increases funding for Energy Data Exchange (EDX) and the National Risk Assessment Partnership (NRAP) to expand capabilities and tool sets to enhance efforts on data management and surety of storage.

Advanced Energy Systems (AES)

In FY 2016, the funding request enables the program to carry out the AES mission to increase the availability and efficiency of fossil energy systems integrated with $CO_2$ capture, while maintaining the highest environmental standards at the lowest cost. Funding for Advanced Combustion Systems is decreased while continuing to focus on the development of advanced combustion technologies, such as pressurized oxy-combustion and chemical looping processes, which have the potential to achieve a capture cost of $40/tonne. Materials development for advanced turbines and advanced gasification technology developments focused on air separation, gas clean up and fuel feed systems also continue. Work on Solid Oxide Fuel Cells in FY 2016 maintains the Program's long-term focus on coal or natural gas fueled central station generation.

Cross-Cutting Research

In FY 2016, Cross Cutting Research supports R&D in modeling and simulation, materials, Energy-Water Nexus, sensors and controls, and university research. These activities serve as the scientific foundation for research development and deployment (RD&D) of technologies at various stages of development within Carbon Capture, Carbon Storage, and Advanced Energy Systems. Plant Optimization Technology funds advanced ultra supercritical materials R&D, water management research and development, sensors and controls, and cross-cutting materials R&D. FY 2016 funding will enable continuation of activities in Coal Utilization Science and Focus Area for Computational Energy Science, both of which support data handling and optimization to improve the design and operation of advanced power systems with carbon capture and sequestration. The program provides first principle and physics-based modeling of phenomenon for complex energy conversion and carbon capture processes.

Supercritical Carbon Dioxide Technology

The Supercritical Carbon Dioxide Technology (sCO2) subprogram within the CCS and Power Systems was created by FY 2015 appropriations. It supports the Department's crosscut, Supercritical Carbon Dioxide Technology (sCO2), which is focused on technology development for supercritical carbon dioxide-based power conversion cycles. These cycles can be applied to most heat sources, including fossil, nuclear, solar and geothermal applications, while offering significant improvements in efficiency, cost, footprint and water use. FER&D's ultimate goal is a directly-fired supercritical $CO_2$ fuel cycle which could also significantly reduce the costs of carbon capture and storage. The major thrusts of the crosscut are a coordinated R&D effort in high temperature technology development/component validation, and the Supercritical Transformational Electric Power Generation (STEP) initiative to design, construct and operate a 10-MW pilot test bed.

Natural Gas Technologies

The Natural Gas program will focus on continued implementation of priority collaborative research and development, together with the Environmental Protection Agency and the Department of the Interior, to ensure that shale stimulation and development is conducted in a manner that is environmentally sound and protective of human health and safety. In FY 2016, the Environmentally Prudent Development subprogram will continue implementation of the research strategy in such areas as water quality and availability including the treatment and use of co-produced water from oil and gas wells, air quality, induced seismicity, and mitigating the impacts of development. The funding requested for Emissions Mitigation from Infrastructure (+$15,000) will initiate a midstream natural gas infrastructure research and development program focused on detecting and reducing methane emissions to address the Climate Action Plan Strategy to Reduce Methane Emissions. The funding for Emissions Quantification from Natural Gas Infrastructure (+$10,000) will support new efforts focused on better quantifying methane emissions from the natural gas value chain for inclusion in the national Greenhouse Gas Inventory.

**Crosscutting Initiatives**

The Department is organized into three Under Secretariats—Science and Energy, Nuclear Security, and Management and Performance—which recognize the complex interrelationship among DOE Program Offices. The FY 2016 Budget continues crosscutting programs which coordinate across the Department and seek to tap DOE's full capability to effectively and efficiently address the U.S.'s energy, environmental, and national security challenges. These crosscutting initiatives will be discussed further within the programs in which the crosscuts are funded. The FY 2016 Request for FE contains the following crosscuts:

**Supercritical CO2:** The supercritical carbon dioxide (sCO2) based power generation effort is a technology-focused crosscutting initiative that will facilitate industry's transition to realize power cycles based on sCO2 as the working fluid. Building on industry outreach and focused R&D efforts in FY 2015, the major thrusts of the crosscut in FY 2016 are a coordinated R&D effort in high temperature technology development/component validation, and the Supercritical Transformational Electric Power Generation (STEP) initiative to design, construct and operate a 10-MW pilot test bed. Demonstrating and developing this power cycle has the potential to revolutionize electric power generation for fossil, concentrating solar, geothermal, nuclear and waste heat recovery applications in a way that is cleaner and more efficient, and which reduces cost.

**Subsurface Engineering:** Over 80 percent of our total energy supply comes from the subsurface, and this importance is magnified by the ability to also use the subsurface to store and sequester fluids and waste products. The subsurface crosscut, SubTER, will address identified challenges in the subsurface through highly focused and coordinated research in Wellbore Integrity, Stress State and Induced Seismicity, Permeability Manipulation, and New Subsurface Signals to ensure

enhanced energy security, material impact on climate change via CO2 sequestration, and significantly mitigated environmental impacts from energy-related activities and operations.

**Energy-Water Nexus:** The Energy-Water Nexus crosscut is an integrated set of cross-program collaborations designed to accelerate the Nation's transition to more resilient energy and coupled Energy-Water systems. The crosscut supports: (1) an advanced, integrated data, modeling, and analysis platform to improve understanding and inform decision-making for a broad range of users and at multiple scales; (2) investments in targeted technology research opportunities within the system of Energy-Water flows that offer the greatest potential for positive impact; and (3) policy analysis and stakeholder engagement designed to build from and strengthen the two preceding areas while motivating more rapid community involvement and response.

**Cybersecurity:** DOE is engaged in three categories of cyber-related activities: protecting the DOE enterprise from a range of cyber threats that can adversely impact mission capabilities; bolstering the U.S. Government's capabilities to address cyber threats; and, improving cybersecurity in the electric power subsector and the oil and natural gas subsector. The cybersecurity crosscut supports central coordination of the strategic and operational aspects of cybersecurity and facilitates cooperative efforts such as the Joint Cybersecurity Coordination Center for incident response and the implementation of Department-wide Identity Credential and Access Management.

**FY 2016 Crosscuts ($K)**

| | Supercritical $CO_2$ | Subsurface Engineering | Energy-Water Nexus | Cyber-security | Total |
|---|---|---|---|---|---|
| Coal | 34,800 | 110,518 | 6,000 | 0 | **151,318** |
| Natural Gas Technologies | 0 | 10,000 | 6,000 | 0 | **16,000** |
| Program Direction | 0 | 0 | 0 | 1,750 | **1,750** |
| **Total, Crosscuts** | **34,800** | **120,518** | **12,000** | **1,750** | **169,068** |

## Fossil Energy Research and Development
## Funding by Congressional Control
## ($K)

| | FY 2014 Enacted | FY 2014 Current[1] | FY 2015 Enacted | FY 2016 Request | FY 2016 vs FY 2015 |
|---|---|---|---|---|---|
| **Coal** | | | | | |
| **CCS Demonstrations** | | | | | |
| Natural Gas Carbon Capture and Storage | 0 | 0 | 0 | 0 | 0 |
| **Total, CCS Demonstrations** | **0** | **0** | **0** | **0** | **0** |
| **CCS and Power Systems** | | | | | |
| Carbon Capture | 92,000 | 89,231 | 88,000 | 116,631 | +28,631 |
| Carbon Storage | 108,766 | 105,493 | 100,000 | 108,768 | +8,768 |
| Advanced energy systems | 99,500 | 96,505 | 103,000 | 39,385 | -63,615 |
| Cross-cutting research | 41,925 | 40,732 | 49,000 | 51,242 | +2,242 |
| Supercritical Carbon Dioxide Technology | 0 | 0 | 10,000 | 19,300 | +9,300 |
| NETL Coal Research and Development | 50,011 | 50,011 | 50,000 | 34,031 | -15,969 |
| **Total, CCS and Power Systems** | **392,202** | **381,972** | **400,000** | **369,357** | **-30,643** |
| **Total, Coal** | **392,202** | **381,972** | **400,000** | **369,357** | **-30,643** |
| **Natural Gas Technologies** | **20,600** | **19,980** | **25,121** | **44,000** | **+18,879** |
| **Unconventional Fossil Energy Technologies** | **15,000** | **14,549** | **4,500** | **0** | **-4,500** |
| **Program Direction** | **120,000** | **120,000** | **119,000** | **114,202** | **-4,798** |
| **Plant & Capital Equipment** | **16,032** | **16,032** | **15,782** | **18,044** | **+2,262** |
| **Fossil Energy Environmental Restoration** | **5,897** | **5,897** | **5,897** | **8,197** | **+2,300** |
| **Supercomputer** | **0** | **0** | **0** | **5,500** | **+5,500** |
| **Special Recruitment Programs** | **700** | **700** | **700** | **700** | **0** |
| **Subtotal, Fossil Energy Research & Development** | **570,431** | **559,130** | **571,000** | **560,000** | **-11,000** |

[1] Funding reflects FY 2014 SBIR/STTR funds which were transferred from FER&D to Science.

| | FY 2014 Enacted | FY 2014 Current[1] | FY 2015 Enacted | FY 2016 Request | FY 2016 vs FY 2015 |
|---|---|---|---|---|---|
| Use of Prior Year Balances | -8,500 | -8,500 | 0 | 0 | 0 |
| Rescission of Prior Year Balances | 0 | 0 | -10,413 | 0 | 10,413 |
| **Total, Adjustments** | **-8,500** | **-8,500** | **-10,413** | **0** | **10,413** |
| **Total, Fossil Energy Research & Development** | **561,931** | **550,630** | **560,587** | **560,000** | **-587** |
| **Federal FTEs[2]** | **655** | **655** | **651** | **641** | **-10** |

SBIR/STTR:

- FY 2014 Transferred: SBIR $9,890; STTR: $1,411
- FY 2015 Projected: SBIR $10,284; STTR: $1,418
- FY 2016 Request: SBIR $10,646; STTR: $1,597

[2] Includes Federal FTEs in the following Programs: NETL Coal Research and Development and Program Direction.

**Overview**

The Carbon Capture and Storage (CCS) and Power Systems R&D program supports secure, affordable, and environmentally acceptable near-zero emissions fossil energy technologies through research, development, and demonstration (RD&D) to improve the performance of advanced CCS technologies. CCS separates $CO_2$ emissions from stationary sources such as power plants and industrial facilities, and permanently stores the $CO_2$ in the subsurface. Commercial availability of CCS technologies will provide an option to use fossil fuel resources to provide energy and meet the President's climate goals.

The Coal program is making significant progress in driving down the capital costs and improving the efficiency of advanced power generation systems with CCS technologies. The program is currently testing several technologies for carbon capture, gasification, and fuels cells up to the small slipstream scale and is preparing to scale these systems to large-pilot scale projects. Large-pilot scale projects would validate many of the components needed to meet the goal of capturing $CO_2$ from both coal and natural gas power systems at $40/tonne and having technologies ready for demonstration by 2020. The Carbon Storage program leads the world in validating that the injection of $CO_2$ in deep geologic reservoirs is safe and permanent through the Regional Carbon Sequestration Partnerships (RCSPs). Projects under the RCSPs have completed or continue to inject and monitor $CO_2$ at six storage sites across North America. The Coal program is also pursuing the development of advanced power generation systems such as the supercritical $CO_2$ power cycle, and advancements in sensors, turbine components, and harsh environment materials.

It is important to demonstrate that electric generation technology with CCS can be integrated at commercial scale while maintaining reliable, predictable and safe plant operations. Therefore, the FE research, development, and deployment (RD&D) portfolio includes several major integrated CCS projects encompassing different technological approaches and applications of CCS.

**Highlights of the FY 2016 Budget Request**

Funding comparisons are relative to FY2015 enacted spending ($K).

Carbon Capture

In FY 2016, the request increases funding (+$28,631) for post-combustion capture from coal and natural gas-fired systems. This increase funds a new emphasis on optimizing carbon capture on natural gas systems and allows continued scale-up of advanced technologies by providing support for at least two large-scale pilot tests (10 MWe+) that will focus on addressing the key issues of lowering the capital cost of carbon capture systems and reducing the energy penalty for both coal and natural gas-fired power systems. These efforts will support the program's commitment to deliver a demonstration project that captures and stores >75 percent of the carbon emissions from a natural gas power system of at least 50 MWe capacity by 2020 using what has been determined to be the best available carbon capture technology available for demonstration at the time. Additionally, funding continues to support R&D of promising second generation technologies at the bench and small slipstream scale and transformational technologies such as those previously developed by ARPA-E and the Energy Frontier Research Centers (EFRCs).

Carbon Storage

Storage Infrastructure (Formerly Regional Carbon Sequestration Partnerships) (-$2,916) includes funding for the Regional Carbon Sequestration Partnerships, small-scale characterization and field projects, and fit-for-purpose testing. Starting in FY 2016, Advanced Storage R&D (+$3,884) will include the Monitoring, Verification, Accounting, and Assessment activities to improve integration between the technologies developed in these two lines. Sub-disciplinary Storage R&D (formerly Focus Area for Carbon Sequestration Science) (+$19,800) increases funds to enhance efforts related to the Energy Data Exchange (EDX) and National Risk Assessment Partnership (NRAP) which will improve data infrastructure and management and expansion of technical risk assessment and quantification methodologies in support of Carbon Storage Program Goals. Funding for the Carbon Storage subprogram is a crucial part of DOE's subsurface crosscut technical team, SubTER, which will address identified challenges in the subsurface across DOE R&D programs through highly focused and coordinated research in: Wellbore Integrity, Stress State and Induced Seismicity, Permeability Manipulation, and New Subsurface Signals to ensure enhanced energy security, material impact on climate change via $CO_2$ storage, and dramatically mitigated environmental impacts from energy-related activities and operations.

Advanced Energy Systems (AES)

In FY 2016, the funding request enables the program to continue to develop advanced combustion technologies, such as pressurized oxy-combustion and chemical looping processes, which have the potential to achieve a capture cost of $40/tonne. Funding will also support continued advancement of gasification technology, advanced turbines, and solid oxide fuel cells. The AES mission is to increase the availability and efficiency of fossil energy systems integrated with $CO_2$ capture while maintaining the highest environmental standards at the lowest costs.

Cross-Cutting Research

The funding will allow for continued R&D efforts in the Sensors and Controls, Materials, Coal Utilization computer modeling, Energy Analyses, University Training and Research, and International Activities subprograms. The increase in funding requested for FY 2016 prioritizes R&D focused on technology development of advanced materials and component testing of high temperature materials for supercritical carbon dioxide (sCO2) environments in support of DOE's supercritical $CO_2$ crosscut.

Supercritical Carbon Dioxide Technology ($sCO_2$)

The increase enables Fossil Energy, in coordination with DOE's Supercritical Carbon Dioxide crosscut team, to issue competitive funding opportunity announcements cost shared with industry for the 10 MW Supercritical Transformational Electric Power (STEP) pilot scale facility in FY 2016. It also reflects the movement of funds for materials development and systems analysis for the indirectly fired ($CO_2$) based power cycle from the Advanced Turbines subprogram to this $SCO_2$ subprogram.

NETL Coal Research & Development

The requested level of funding (-$15,969) does not include funding for Rare Earth Minerals. Also, there are minor reductions in salaries and benefits, travel, and other services due a reduction in FTEs and contractor support.

**FY 2016 Crosscuts ($K)**

| | Subsurface Engineering | Supercritical $CO_2$ | Energy-Water Nexus | Total |
|---|---|---|---|---|
| Carbon Storage | 105,768 | 0 | 0 | 105,768 |
| Crosscutting Research | 4,750 | 15,500 | 6,000 | 26,250 |
| Supercritical $CO_2$ | 0 | 19,300 | 0 | 19,300 |
| **Total, Coal** | **110,518** | **34,800** | **6,000** | **151,318** |

Within the FY 2016 Budget Request, the Coal program supports three Departmental Crosscuts: Subsurface Engineering, Supercritical Carbon Dioxide in Electric Power Generation ($sCO_2$), and Energy-Water Nexus.

The subsurface crosscut, SubTER, will address identified challenges in the subsurface through highly focused and coordinated research in Wellbore Integrity, Stress State and Induced Seismicity, Permeability Manipulation, and New Subsurface Signals to ensure enhanced energy security, material impact on climate change via $CO_2$ sequestration, and dramatically mitigated environmental impacts from energy-related activities and operations.

The supercritical carbon dioxide (sCO2) based power generation effort is a technology-focused crosscutting initiative that will facilitate industry's transition to realize power cycles based on sCO2 as the working fluid. Building on industry outreach and focused R&D efforts in FY 2015, the major thrusts of the crosscut in FY 2016 are a coordinated R&D effort in high temperature technology development/component validation, and the Supercritical Transformational Electric Power Generation (STEP) initiative to design, construct and operate a 10 MW pilot test bed. Demonstrating and developing this power cycle has the potential to revolutionize electric power generation for fossil, concentrating solar, geothermal, nuclear and waste heat recovery applications in a way that is cleaner and more efficient, and which reduces cost.

The goal of the Energy-Water Nexus crosscut is to develop an integrated set of investments and cross-program collaborations that: 1) support a National data, modeling, and analysis platform to improve understanding and inform

decision-making for a broad range of users and at multiple scales; 2) strategically target crosscutting technology opportunities within the system of water and energy flows that offer the greatest opportunity for positive impact; and 3) are informed, supported, and strengthened by focused policy analysis and stakeholder engagement. These investments position DOE to contribute strongly to the Nation's transition to more resilient energy and coupled energy-water systems.

**Coal**
**Funding ($K)**

| | FY 2014 Enacted | FY 2014 Current[1] | FY 2015 Enacted | FY 2016 Request | FY 2016 vs FY 2015 |
|---|---|---|---|---|---|
| **Coal** | | | | | |
| **CCS Demonstrations** | | | | | |
| Natural Gas Carbon Capture and Storage | 0 | 0 | 0 | 0 | 0 |
| **Total, CCS Demonstrations** | **0** | **0** | **0** | **0** | **0** |
| **CCS and Power Systems** | | | | | |
| **Carbon Capture** | | | | | |
| Post-Combustion Capture Systems | 80,000 | 77,592 | 76,000 | 104,631 | +28,631 |
| Pre-Combustion Capture Systems | 12,000 | 11,639 | 12,000 | 12,000 | 0 |
| **Total, Carbon Capture** | **92,000** | **89,231** | **88,000** | **116,631** | **+28,631** |
| **Carbon Storage** | | | | | |
| Storage Infrastructure (formerly Regional Carbon Sequestration Partnerships) | 71,866 | 69,703 | 66,000 | 63,084 | -2,916 |
| Advanced Storage R&D (formerly Geologic Storage) | 16,300 | 15,810 | 13,500 | 17,384 | +3,884 |
| Monitoring, Verification, Accounting, and Assessment[2] | 10,000 | 9,699 | 10,000 | 0 | -10,000 |
| Carbon Use and Reuse | 800 | 776 | 2,000 | 0 | -2,000 |
| Sub-disciplinary Storage R&D (formerly Focus Area for Carbon Sequestration Science) | 9,800 | 9,505 | 8,500 | 28,300 | +19,800 |
| **Total, Carbon Storage** | **108,766** | **105,493** | **100,000** | **108,768** | **+8,768** |
| **Advanced Energy Systems** | | | | | |
| Advanced Combustion Systems | 18,500 | 17,943 | 28,000 | 10,385 | -17,615 |
| Gasification Systems | 36,000 | 34,916 | 25,000 | 11,000 | -14,000 |
| Advanced Turbines | 15,000 | 14,549 | 15,000 | 9,000 | -6,000 |
| Coal and Coal Biomass to Liquids | 5,000 | 4,849 | 5,000 | 0 | -5,000 |
| Grid R&D | 0 | 0 | 0 | 0 | 0 |
| Solid Oxide Fuel Cells | 25,000 | 24,248 | 30,000 | 9,000 | -21,000 |
| **Total, Advanced Energy Systems** | **99,500** | **96,505** | **103,000** | **39,385** | **-63,615** |

[1] Funding reflects the transfer of SBIR/STTR to the Office of Science.
[2] In FY2016, Monitoring, Verification, Accounting, and Assessment is moved into the Advanced Storage R&D (formerly Geologic Storage Technologies).

| | FY 2014 Enacted | FY 2014 Current[1] | FY 2015 Enacted | FY 2016 Request | FY 2016 vs FY 2015 |
|---|---|---|---|---|---|
| **Cross-cutting Research** | | | | | |
| **Plant Optimization Technologies** | | | | | |
| Sensors and Controls | 6,525 | 6,328 | 4,500 | 4,542 | +42 |
| Cross-cutting Materials R&D | 500 | 485 | 2,000 | 1,500 | -500 |
| Advanced Ultra Supercritical Materials R&D | 5,000 | 4,849 | 5,000 | 15,500 | +10,500 |
| Water Management R&D | 5,000 | 4,849 | 7,000 | 6,000 | -1,000 |
| **Total Plant Optimization Technologies** | **17,025** | **16,511** | **18,500** | **27,542** | **+9,042** |
| **Coal Utilization Science** | | | | | |
| Computational System Dynamics | 9,500 | 9,214 | 12,000 | 7,000 | -5,000 |
| Focus Area for Computational Energy Science | 9,500 | 9,214 | 12,000 | 11,750 | -250 |
| **Total Coal Utilization Science** | **19,000** | **18,428** | **24,000** | **18,750** | **-5,250** |
| **Energy Analyses** | | | | | |
| Environmental Activities | 450 | 450 | 750 | 450 | -300 |
| Technical and Economic Analyses | 500 | 500 | 750 | 400 | -350 |
| **Subtotal Energy Analyses** | **950** | **950** | **1,500** | **850** | **-650** |
| **University Training and Research** | | | | | |
| University Coal Research | 2,500 | 2,425 | 3,000 | 2,000 | -1,000 |
| HBCU's, Education, and Training | 1,100 | 1,067 | 900 | 1,000 | +100 |
| **Total University Training and Research** | **3,600** | **3,600** | **3,900** | **3,000** | **-900** |
| **International Activities** | | | | | |
| Coal Technology Export | 650 | 650 | 500 | 500 | 0 |
| International Program Support | 700 | 700 | 600 | 600 | 0 |
| **Subtotal International Activities** | **1,350** | **1,350** | **1,100** | **1,100** | **0** |
| **Total, Cross-cutting Research** | **41,925** | **40,732** | **49,000** | **51,242** | **+2,242** |
| **Supercritical Carbon Dioxide Technology ($sCO_2$)** | **0** | **0** | **10,000** | **19,300** | **+9,300** |
| **NETL Coal Research and Development** | **50,011** | **50,011** | **50,000** | **34,031** | **-15,969** |
| **Total, CCS and Power Systems** | **392,202** | **381,972** | **400,000** | **369,357** | **-30,643** |
| **Total, Coal** | **392,202** | **381,972** | **400,000** | **369,357** | **-30,643** |

SBIR/STTR:

- FY 2014 Transferred: SBIR: $8,950; STTR: $1,278
- FY 2015 Projected: SBIR $9,476: STTR: $1,307
- FY 2016 Request: SBIR $9,405: STTR: $1,412

| | FY 2016 vs FY 2015 |
|---|---|
| **CCS Demonstrations** Natural Gas CCS no new funding is requested. | **0** |
| **CCS and Power Systems** | |
| **Carbon Capture**: In FY 2016, the request increases funding (+$28,631) for post-combustion capture from fossil fuel-fired systems. This increase funds a new emphasis on optimizing carbon capture on natural gas systems and allows continued scale-up of advanced technologies by providing support for at least 2 large-scale pilot tests (10 MWe+) that will focus on addressing the key issues of lowering the capital cost of carbon capture systems and reducing the energy penalty for both coal and natural gas-fired power systems. Additionally, funding continues to support R&D of promising 2nd generation technologies at the bench and small slipstream scale and transformational technologies such as those previously developed by ARPA-E and the Energy Frontier Research Centers (EFRCs). | **+28,631** |
| **Carbon Storage**: Storage Infrastructure (Formerly Regional Carbon Sequestration Partnerships) (-$2,916) includes sufficient funding for the Regional Carbon Sequestration Partnerships, small-scale characterization and field projects, and fit-for-purpose testing. Advanced Storage R&D (+$3,884) maintains funding for high priority targeted R&D needs such as wellbore integrity and natural system leakage detection, induced seismicity, and fluid and pressure migration technologies and now includes the Monitoring, Verification, Accounting, and Assessment line. Sub-disciplinary Storage R&D (formerly Focus Area for Carbon Sequestration Science) (+$19,800) increases funds to enhance efforts related to the Energy Data Exchange (EDX) and National Risk Assessment Partnership (NRAP) which will improve data infrastructure and management and expansion of technical risk assessment and quantification methodologies in support of Carbon Storage Program Goals and other DOE geoscience applications. | **+8,768** |
| **Advanced Energy Systems:** In FY 2016, the Advanced Combustion Systems (-$17,615) prioritizes activities focused on the development of advanced combustion technologies and enables addition of one pilot test for a Phase II project in Oxy fired pressurized fluidized bed combustor (PFBC) or chemical looping combustion (CLC). Under Gasification Systems (-$14,000), small scale R&D will continue; however, only 1-2 projects of the most successful technologies will transition to bench-scale testing. Advanced Turbines (-$6,000) will slightly reduce projected combustion and materials development activities aimed at conventional gas turbines, however, efforts to develop transformational turbine technology will accelerate under the new, supercritical carbon dioxide ($CO_2$) subprogram, discussed below. Solid Oxide Fuel Cells -$21,000) will narrow the focus to materials research essential to commercial viability. | **-63,615** |

| | FY 2016 vs FY 2015 |
|---|---|
| **Cross-cutting Research and Development**: Plant Optimization Technology (+$9,042) funds advanced ultra supercritical materials R&D, water management research and development, sensors and controls, and cross-cutting materials R&D. *Advanced Ultra Supercritical Materials R&D (+$10,500)* funds development of materials necessary for a high temperature supercritical $CO_2$ fuel cycle and supports the Supercritical $CO_2$ crosscut. *Water Management R&D (-$1,000)* allows for R&D to develop technologies and processes for treating water produce through injection of $CO_2$ in deep saline aquifers. Coal Utilization Science (-$5,250) maintains support for the development of tools to optimize data handling and exploit information technology in the design of advanced energy systems fitted with carbon capture and also continues to support the National Risk Assessment Partnership (NRAP), a multi-laboratory initiative. | **+2,242** |
| **Supercritical Carbon Dioxide Technology**: The increase (+$9,300) enables Fossil Energy, in coordination with DOE's Supercritical Carbon Dioxide crosscut team, to issue competitive funding opportunity announcements cost shared with industry for the 10 MW Supercritical Transformational Electric Power (STEP) pilot scale facility in FY 2016. It also reflects the movement of funds for materials development and systems analysis for the indirectly fired ($CO_2$) based power cycle from the Advanced Turbines subprogram to this $SCO_2$ subprogram. | **+9,300** |
| **NETL Coal Research and Development:** The reduction in requested funding (-$15,969) is two-fold. The FY 2015 Enacted amount included $15,000 to continue activities to economically recover rare earth elements from coal and coal byproduct streams, such as fly ash, coal refuse, and aqueous effluents. This area is not included in the FY 2016 request. Also, there are minor reductions in salaries and benefits, travel, and other services due a reduction in FTEs and contractor support. | **-15,969** |
| **Total, Coal** | **-30,643** |

**CCS Demonstrations**
**Natural Gas Carbon Capture and Storage**

**Description**

The Natural Gas Carbon Capture and Storage (CCS) activity is focused on the demonstration of technologies capable of capturing $CO_2$ for a gas fired power plant either by post combustion capture technologies or by adopting oxycombustion technologies. This work will accelerate the adoption of CCS technologies for these power systems. The program is committed to delivering a demonstration project that captures and stores >75 percent of the carbon emissions from a natural gas power system of at least 50 MWe capacity by 2020 using what has been determined to be the best available carbon capture technology available for demonstration at the time.

Natural Gas Carbon Capture

No funds are requested under this sub-activity in FY 2016. Initial efforts to address the technical challenges inherent to capture from a gas-fired power facility, such as a lower concentration of $CO_2$ and higher oxygen content, will begin in FY 2016 through the Carbon Capture program in preparation for a future demonstration facility. These FY 2016 activities related to natural gas CCS are under the post combustion capture subprogram, and aim to support this future demonstration attempting to achieve similar economic goals to the second generation goals for the carbon capture program.

**Description**

The Carbon Capture activity is focused on the development of post-combustion and pre-combustion $CO_2$ capture and compression technologies for new and existing fossil fuel-fired power plants and industrial sources utilizing coal and natural gas. Post-combustion $CO_2$ capture technology R&D is focused on capturing $CO_2$ from flue gas after the fuel has been consumed/combusted. Pre-combustion $CO_2$ capture is applicable to systems that capture and separate the $CO_2$ from mixed gas streams prior to combustion or utilization of the gas.

Post-Combustion

The Post-Combustion subactivity focuses specifically on developments related to second generation and transformational technologies that can achieve $CO_2$ capture at $40/tonne $CO_2$ capture cost or less, respectively, for new and existing fossil fuel-fired power plants. Second generation technologies are those that are not currently in commercial application at any scale or level of integration, but have the potential to improve the efficiency or reliability of carbon capture processes. Significant improvements in both cost and efficiency of $CO_2$ separation and compression will be required to achieve this goal. Transformational capture systems are considered to be a set of disruptive technologies which can significantly reduce the cost of capture, adapt to the operational demands of advanced power systems, and adjust to the increasing need for fossil fuel power plants to be load following electricity generators.

Critical R&D milestones have been achieved by laboratory- through pilot-scale testing of a broad spectrum of $CO_2$ capture approaches including advanced solvents, sorbents, and membranes since 2008; initiation of multiple, small-scale (0.5-1 MWe) slipstream tests of the most promising of these $CO_2$ capture technologies that began in 2010; and the initiation of one pilot scale (10+ MWe) project in 2015, preparing this technology for commercial demonstration. FY 2016 activities continue to support R&D on second generation technologies at the bench and pilot scale and R&D on transformational technologies at the laboratory scale.

Activities in FY 2016 will also optimize technologies for capture from natural gas fired power plants in preparation for a future demonstration project that captures and stores >75 percent of the carbon emissions from a natural gas power system of at least 50 MWe capacity by 2020. As part of this effort, a Request for Information (RFI) and a series of meetings will be held to gather input from stakeholders concerning technologies ready for demonstration in the near-term. The R&D effort to optimize technologies will address specific technical challenges for carbon capture from natural gas power systems, such as a lower concentration of $CO_2$ and higher oxygen content. The goals for this effort are aligned with the second generation goals for the carbon capture program. Funding in FY 2016 will support the initiation of at least one additional large-scale pilot test (10+ MWe) of advanced post-combustion capture technology and components that can be applied to both coal and natural gas power plants.

Pre-Combustion

The Pre-Combustion subactivity focuses on the development of transformational technologies for pre-combustion capture that achieve $CO_2$ capture significantly less than $40/tonne removed $CO_2$ capture cost. Significant improvements are required to reduce parasitic energy load and cost of CCS. In addition, many technologies that will be available in the near-term have not been scaled up or applied to fossil fuel-powered generation systems. FY 2016 funding continues to support laboratory, bench, and small slipstream-scale tests of transformational technologies, such as advanced solvents, sorbents, and membranes, including process intensification efforts which incorporate two or more technology concepts.

**Description**

The overall goal of the Carbon Storage Program is to develop and validate technologies for the safe and permanent geologic storage of captured $CO_2$. Development and validation of these technologies is critical to ensure industry and regulatory agencies have the capability to assess, monitor, and mitigate storage risks for $CO_2$ and ensure the viability of carbon storage as an effective technology solution that can be implemented on a large-scale to mitigate carbon emissions. Applied R&D and field projects are being conducted in five primary storage types (saline formations, oil and natural gas reservoirs, unmineable coal seams, basalts, and organic shales) in geologic reservoirs across eleven different geologic storage depositional classes. Technologies developed and validated through the Carbon Storage Program will improve storage efficiency, reduce the overall cost, decrease subsurface uncertainties, and identify ways to mitigate potential risks of implementing CCS.

DOE's Subsurface Technology and Engineering R&D (SubTER) crosscut Technical Team, aims to address identified grand challenges in the subsurface through highly focused and coordinated research in Wellbore Integrity, Stress State and Induced Seismicity, Permeability Manipulation, and New Subsurface Signals to ensure enhanced energy security, material impact on climate change via $CO_2$ storage, and dramatically mitigated environmental impacts from energy-related activities and operations. The Carbon Storage Program significantly contributes to the Department's cross-functional SubTER Technical Team activities related to subsurface technologies. Therefore, much of the work being conducted by the Office of Fossil Energy under the Carbon Storage Program is being coordinated with other DOE offices through the SubTER Technical Team to maximize the value of this research across DOE offices.

Storage Infrastructure (formerly Regional Carbon Sequestration Partnerships)[1]

The Storage Infrastructure sub-activity focuses on development and validation of technologies, infrastructure, and knowledge-sharing through the Regional Carbon Sequestration Partnerships (RCSPs) and other small- and large-scale field projects. The field projects conduct regional and site-specific characterization and validation; simulation and risk assessment; and application of monitoring, verification, accounting, and assessment technologies for various storage reservoirs. They aim to improve our understanding of $CO_2$ injection, fluid flow and pressure migration, and geomechanical and geochemical impacts from $CO_2$ injection, and develop a "commercial toolbox" for cost-effective monitoring in all storage types. In FY 2016, field activities will address specific technical research questions and regional barriers to CCS deployment. This may include projects that investigate active reservoir management as a method to better control or "steer" the $CO_2$ plume and pressure fronts within a reservoir. Additionally, in FY 2016 the RCSPs will continue implementation of the large-scale injection projects which are critical to ensuring system integration of various field technologies and processes for deployment of safe and permanent storage and monitoring.

Field projects conducted under this technology area are implemented in three phases: (i) Regional and Site Characterization; (ii) Site Development and Injection Operations; and (iii) Post-Injection Monitoring Operations. Regional characterization activities are focused on identifying regional opportunities for CCS, $CO_2$ sources, and priority opportunities for field sites. Site characterization evaluation builds on previous characterization with greater detail to ensure a field project site is qualified with suitable geologic characteristics for safe injection and post-injection operations. Both small- and large-scale field projects can integrate $CO_2$ capture, transportation, injection, and storage such that it can be achieved safely and permanently. The field projects also provide an opportunity for project developers and regulatory agencies to address regulatory and public outreach and education issues associated with carbon storage. Resource assessment is also a critical component of this effort. Understanding of storage types and estimated storage potential aids in the development of carbon mitigation plans and provides the foundation for first-mover projects. All of this information is made available to the public through the DOE's National Carbon Sequestration Database and Geographic Information System (NATCARB) geographic information system, Best Practices Manuals, and updates to the Carbon Storage Atlas.

[1] In FY 2015 the Regional Carbon Sequestration Partnership (RCSPs) sub-activity was renamed Storage Infrastructure to better represent the characterization and field activities that occur in the RCSPs and other small and large-scale field projects in a variety of geologic reservoirs.

Additionally, FY 2016 funding will also address a subset of carbon storage research questions specific to offshore CCS. These offshore site characterization activities will be coordinated with the Bureau of Ocean and Energy Management (BOEM), which has responsibility for regulatory development for offshore storage. Onshore CCS R&D remains the primary focus of this subprogram.

Advanced Storage R&D (Formerly Geologic Storage Technologies)

In FY 2016, the Geologic Storage Technologies sub-activity is being re-named to Advanced Storage R&D and now also includes the former Monitoring, Verification, Accounting, and Assessment (MVAA) sub-activity. This consolidation improves the integration of the technologies developed in these previously separated sub-activities to better serve the needs of the Carbon Storage Program in addressing its goals. The Advanced Storage R&D sub-activity is focused on 1) developing and validating storage and simulation and risk assessment technologies, and 2) developing robust technologies to monitor the transport and fate of injected $CO_2$. These advanced technologies have the potential to safely, permanently, and cost effectively store $CO_2$ in geologic reservoirs for onshore and offshore project settings. This area involves developing technologies to: ensure well integrity; provide $CO_2$ resistant construction materials and novel well completions; detect, mitigate, and identify potential $CO_2$ leakage pathways; assess and manage fluid flow, pressure and water at field and basin-scale; and assess and minimize negative geochemical and geomechanical processes (e.g., induced seismicity and stress state of the subsurface) at field and basin-scale. The simulation and risk assessment models integrate storage technologies with field operations for $CO_2$ flow and trapping mechanisms, geochemical changes, and geomechanical impacts within the geologic formations reducing potential risks and providing the foundation for future MVAA plans.

MVAA technologies developed and validated will increase confidence to stakeholders (e.g. operators, regulators and public) that monitoring technologies can accurately and effectively monitor the transport and fate of $CO_2$. Robust MVAA technologies are necessary to address safety and environmental concerns; verify $CO_2$ migration to meet regulatory requirements; and account for greenhouse gas (GHG) emissions mitigation. Technologies being developed and validated in field projects improve our ability to monitor $CO_2$ at atmospheric, near-surface (including offshore water column) and subsurface levels for integration into an intelligent monitoring system. Research focuses on developing technologies such as advanced optical detection, remote sensing, and spatial averaging over large field areas; real-time monitoring; advanced geophysical techniques; and integrated autonomous intelligent monitoring systems. These technological advances improve our ability to ensure storage permanence and optimize storage capacity.

Technologies developed in the above areas at laboratory- and bench-scale, and conducted through field validation tests in FY 2016 through the Advanced Storage R&D sub-activity, will improve assessment and mitigation of potential storage risk, maintain the integrity of storage operations, allow active management of storage operations, and optimize storage capacity.

Monitoring, Verification, Accounting and Assessment

In FY 2016, Monitoring, Verification, Accounting, and Assessment is moved into the Advanced Storage R&D (formerly Geologic Storage Technologies) subprogram budget line to better improve the integration between the technologies developed in these two budget lines.

Carbon Use and Reuse

The Carbon Use and Reuse subactivity focuses on technologies, other than enhanced hydrocarbon recovery, that have the potential to reduce $CO_2$ emissions by developing beneficial uses for $CO_2$. These beneficial uses include the conversion of $CO_2$ to chemicals, plastics, building materials, curing for cement, and studies on integration of carbon utilization technologies into power plants, such as algae. To focus on addressing the key challenges associated with geologic storage, no funding is requested for this area of research in FY 2016.

Sub-disciplinary Storage R&D (formerly Focus Area for Carbon Sequestration Science)

In FY 2016, the Focus Area for Carbon Sequestration Science is being renamed Subdisciplinary Storage R&D because the activities, while supporting in nature, are more directly focused on applied R&D activities within the overall Carbon Storage Program. The Sub-disciplinary Storage Research sub-activity supports the Carbon Storage Program through targeted research needs identified to support program activities and technology validation in field projects. FY 2016 activities in this area focus on:

(1) Reservoir and seal performance
(2) Geologic storage site optimization and operations
(3) Reservoir capacity and storage efficiencies
(4) Reservoir modeling and monitoring technologies
(5) Resource assessment and geospatial data management
(6) $CO_2$ use, re-use and conversion

This includes activities such as the Energy Data Exchange (EDX), which coordinates historical and current data and information from a wide variety of sources to facilitate access to reliable information in support of science-based decision-making. The Sub-disciplinary Storage R&D sub-activity, also includes expansion of National Risk Assessment Partnership (NRAP) efforts on addressing uncertainty around risk related to geomechanics, geochemistry, and other storage and subsurface-related efforts.

**CCS and Power Systems**
**Advanced Energy Systems**

**Description**

The Advanced Energy Systems (AES) mission is to increase the availability and efficiency of fossil energy systems integrated with $CO_2$ capture, while maintaining the highest environmental standards at the lowest cost. The program elements focus on gasification, oxy-combustion, advanced turbines, and other energy systems. While the primary focus is on coal-based power systems, improvements to these technologies will result in spillover benefits that can reduce the cost of converting other carbon-based fuels, such as natural gas, biomass, or petcoke into power and other useful products in an environmentally-acceptable manner.

Advanced Combustion Systems

This sub-activity focuses on development of advanced combustion technologies, such as pressurized oxy-combustion and chemical looping processes, to achieve $40/tonne $CO_2$ capture cost. These technologies will allow power plants to produce flue gas that is rich in $CO_2$ because the power generation process involves combustion in a high-$O_2$ concentration environment. An added co-benefit is the dramatic reduction in the emission of conventional pollutants. These advanced technologies are applicable to new and existing power plants. Combustion systems will be improved by lowering the cost of oxygen supplied to the system and by increasing the overall system efficiency. The program targets both of these improvements in FY 2016 by sponsoring cost-shared research for three key technologies: (1) Oxy-Combustion, (2) Chemical Looping Combustion, and (3) Advanced Concepts.

Gasification Systems

This sub-activity continues the progress made in FY 2015 and focuses on technology developments to reduce the cost of coal gasification (through lowering technology capital costs, and increasing plant efficiency and availability) to enable more economical conversion of fossil fuels into electricity and marketable by-products with greatly reduced greenhouse gas emissions. Research activities in FY 2016 aim to develop lower-cost technologies to separate oxygen from air; improve high-pressure solid feed systems to enable use of low-rank coals in high-pressure gasifiers, facilitate co-feeding of coal with biomass or waste; encourage more efficient high-pressure operation of dry feed gasifiers; and, further develop hydrogen production technologies to lower the capital requirements and increase the efficiency of IGCC and polygeneration applications. In addition, this sub-activity supports fundamental work to better understand and improve refractory life, the creation of models to better understand the kinetics and particulate behavior of fuel inside a gasifier, and develops solutions to mitigate the plugging and fouling of syngas coolers.

A major cost element in gasification plants is converting raw syngas into a pure and specific gas used to create the plant's output of electricity and other byproducts. High hydrogen, low methane syngas is versatile and can be used for power production with $CO_2$ capture, fuels or chemicals production, and for many polygeneration applications. The technologies being developed by the program improve the efficiency of moderate to high temperature processes and clean syngas of contaminants.

Advanced Turbines

In FY 2016, the Hydrogen Turbines sub-activity will be renamed Advanced Turbines to clarify that the scope of the program addresses advanced turbine research and development, as it has done previously. The name change better reflects the depth and breadth of the turbines R&D. This sub-activity focuses on the development of turbine component technologies capable of withstanding the high temperatures and aggressive environments that are predicted for high-hydrogen content syngas combustion. In addition, there will be focused R&D on developing advanced technology for the integral electricity-generating component for clean energy plants fueled with coal by providing advanced turbines, and advanced steam turbines. In FY 2016, turbine R&D related to directly-fired supercritical carbon dioxide ($SCO_2$) based power cycles will continue in this subprogram but materials development and systems analysis for the indirectly fired ($CO_2$) based power cycle will be moved to the new $SCO_2$ subprogram.

Continuation of the existing FY 2015 activities supports development of key turbine system components capable of achieving a 4-5 percentage point efficiency increase relative to existing combined cycle turbines. Specifically, research

focuses on rig testing of materials and components to be used in commercial scale machines, including combustor components, rotating parts, and cooling systems. These technologies will reduce inter-stage leakage via improved sealing designs, optimize airfoil heat flux with reduced cooling flows, improve material architectures for higher temperature operation, and result in superior airfoils for more efficient expansion with higher throughput.

Coal and Coal-Biomass to Liquids

No funding is requested for this activity.

Solid Oxide Fuel Cells

This sub-activity focuses on research and development to enable generation of efficient, cost-effective electricity from coal and natural gas with near-zero atmospheric emissions of $CO_2$ and air pollutants as well as minimal waster use in central power generation applications that can be integrated with carbon capture and storage. FY 2016 activities will focus on advanced materials development. The Fossil Energy Fuel Cells Program is in the process of developing highly efficient, ultra-low emission, fuel flexible solid oxide fuel cell (SOFC) technology that can exploit domestic fossil fuel resources, maintain sound environmental stewardship, and contribute to a secure, clean energy future. The inherent characteristics of SOFCs allow for a common module design that can be deployed for use with either coal-derived synthesis gas or natural gas. The Program's long-term focus is on coal or natural gas fueled central station generation, with Transformational SOFC technology ready to be deployed at the commercial scale in the 2030-2040 timeframe.

**Description**

The Cross-cutting Research activity fosters the development of innovative systems for improving availability, efficiency, and environmental performance of advanced energy systems with carbon capture and storage. The Program serves as a bridge between basic and applied research by targeting concepts that offer the potential for transformational breakthroughs and step change benefits in the way energy systems are designed, constructed, and operated. This Cross-cutting research portfolio encompasses: 1) Sensors and Controls, 2) Advanced Ultra-Supercritical and Cross-cutting Materials, 3) Computational Sciences and Modeling, 4) Water Management, and 5) Efforts that support University-based energy research including science and engineering education at minority colleges and universities.

Plant Optimization Technologies

*Sensors, Controls and Other Novel Concepts*

The Sensors & Control element focuses on the development of real time measurements critical to the operation and optimization of advanced power systems. Development of sensors focuses on measurements (including temperature, pressure, and gas composition) that need to be made in high temperature, high pressure, and/or corrosive environments of a power system or underground injection system. This sensor development also includes technologies that are low cost, embeddable, or easily deployable for condition monitoring and system operation. In FY 2016, this program will continue the R&D on transformational research in process control and optimization centers on self-organizing information networks and distributed intelligence for decision making and the ability to optimize a highly integrated plant in real time. This area also explores other novel concepts such as direct power extraction concepts and the application of additive manufacturing towards constructing complex components (e.g. turbine blades) with embedded sensing capability.

*Cross-cutting Material R&D*

Cross-cutting Materials R&D encompasses the spectrum of fundamental materials design through qualification of functional materials that support the next generation of advanced power generation. In FY 2016, new computational techniques will continue to be developed to design materials that are needed for advanced combustion and gasification systems. This computational work decreases the time and cost to develop the new materials and is projected to lead to classes of improved high performance materials.

*Advanced Ultra-supercritical Materials R&D*

In FY 2016, this area will conduct R&D focused on technology development of advanced materials and component testing of high temperature materials for directly-heated supercritical carbon dioxide ($sCO_2$) environments. This work is being coordinated with other offices through the DOE $sCO_2$ Tech Team to maximize the value of this research across DOE programs. The development of high temperature materials for supercritical carbon dioxide applications may also have spillover benefits for advanced ultra-supercritical steam applications.

*Water Management R&D*

The Water Management Research and Development activities support sustainability and improved water efficiency focusing on treatment and use of non-traditional water. In FY 2016, focused R&D will include developing technologies and processes for treating water produced by injection of carbon dioxide in deep saline aquifers. This may include exploratory research and concept development of clathrate hydrate and other desalination process for production of potable water from carbon capture and storage (CCS). Focused R&D on innovative filtration technologies including membrane-based, evaporative, chemical, electrochemical and biological systems will also be developed for the purpose of producing potable water through CCS. In FY 2016, the R&D efforts under Water Management within the Office of Fossil Energy will be coordinated with other offices throughout DOE in support of DOE's Water Energy Tech Team (WETT) crosscut in order to maximize the value of this research across DOE programs. Separately, R&D will focus on exploiting the opportunity for water-limited cooling provided by the supercritical carbon dioxide fuel cycle.

Coal Utilization Science

*Computational Systems Dynamics*

The Computational Systems Dynamics element develops immersive, interactive visualization technology as well as data communication optimization methods to improve the design and operation of advanced power systems with carbon capture and storage (CCS). This element builds computer-aided design tools for the Advanced Energy Systems activity so that novel concepts can be explored and analysis can be conducted on pre-commercial systems. Furthermore, these tools will be used to optimize data handling and exploit information technology in the design of advanced energy systems with carbon capture. This element also supports a multi-laboratory initiative under the National Risk Assessment Partnership (NRAP). NRAP harnesses the breadth of capabilities across the DOE national lab system to develop defensible, science-based quantitative methodologies for determining risk profiles at carbon dioxide ($CO_2$) storage sites. In FY 2016, these collaborative efforts will accelerate CCS development and support the goal to enable commercial deployment of second-generation CCS technologies by 2020.

*Computational Energy Science*

The Computational Energy Science element introduces first principle and physics based modeling of phenomenon for complex energy conversion and carbon capture processes. The element further supports tools and techniques to transform these computationally intensive models into reduced order and fast user enabled models for the purposes of study, development, and validation. In FY 2016, activities will include multi-scale, multi-physics simulation capabilities that couple fluid flow, heat and mass transfer, and complex chemical reactions for optimizing the design and operation of heat engines, combustors, gasifiers, chemical reactors, and other unit processes in advanced power generation systems. MFIX (Multiphase Flow with Interphase eXchanges) is a computer code developed at the National Energy Technology Laboratory (NETL) and used for describing the hydrodynamics, heat transfer, and chemical reactions in fluid-solids systems. The code is used for testing and developing multiphase flow constitutive equations. The Carbon Capture Simulation Initiative (CCSI) focuses on capture technologies, risk assessment, and integrated multi-scale physics-based simulations designed to support the applied research conducted in the carbon capture activity. These activities are intended to accelerate carbon capture and storage development and to enable commercial deployment of second-generation carbon capture and storage technologies by 2020.

Energy Analyses

*Environmental Activities*

These analyses include potential environmental impacts (e.g., on water quality, air emissions, solid waste disposal, climate change) of fossil fuel use and large-scale deployment of different generations of CCS. Of particular interest in FY 2016 are the life-cycle environmental emissions for existing and advanced fossil fuel technologies.

*Technical and Economic Analyses*

The Technical and Economic Analyses element supports program strategic planning by identifying major challenges, technologies, and advanced concepts that have the potential to improve the efficiency, cost, and/or environmental performance of fossil energy systems. In FY 2016, these analyses will include technical and economic studies such as benefit cost analysis and CCS deployment projections.

University Training and Research

*University Coal Research*

The University Coal Research (UCR) program provides grants to colleges and universities to support research consistent with the goals of Fossil Energy and the Cross-cutting Research Program. Key FY 2016 research areas that will be supported include, but are not limited to, advanced power generation with carbon capture capability; computationally based initiatives; advanced high performance materials; novel sensing and control concepts; and advanced power cycle concepts. This element provides a two-fold benefit: conducting directed energy research for the Department, and at the same time providing support for expanding the research capabilities and education of the next generation of scientists and engineers.

*HBCU's Education and Training*

The Historical Black Colleges and Universities (HBCU) and Other Minority Institutions (OMI) education and training program awards research grants to qualifying Universities and Institutions. The program targets research capability and education programs related to advanced energy systems with carbon capture and storage capability. This is an area consistent with the goals of Fossil Energy and the Cross-cutting Research Program. Key FY 2016 research areas include advanced power generation with carbon capture capability; computationally based initiatives; advanced high performance materials; novel sensing and control concepts; and advanced power cycle concepts. Grants awarded under this program are intended to maintain and upgrade the educational, training and research capabilities of HBCUs/OMIs in the fields of science and technology, with project results being used to further DOE's commitment to Fossil Energy research.

International Activities

*Coal Technology Export*

The Coal Technology Export element works with international organizations to facilitate export of U.S. climate technology and energy services to the developing world. The element will continue to engage multilateral organizations in FY 2016 including the International Energy Agency (IEA), United Nations, World Energy Council (WEC), and the Carbon Sequestration Leadership Forum (CSLF) while managing bilateral agreements with key countries such as China and India.

*International Program Support*

The International Program Support element supports FE's commitment to the International Energy Agency Clean Coal Center (IEACCC) to enhance the competitiveness and adoption of U.S. Clean Coal Technologies in targeted countries that will help protect the local and global environment. In FY 2016, it will also preserve and enhance active relationships with national and international organizations by focusing on expanding cleaner energy technology power systems activities globally.

## CCS and Power Systems
## NETL Coal Research and Development

**Description**

The on-going portion of this budget line supports the NETL staff directly associated with conducting in-house research activities for the Coal Research and Development programs. The in-house research and development activities are conducted by a staff of scientists, engineers, technicians and administrative personnel. NETL in-house research supports program specific activities in Carbon Capture, Carbon Storage, Advanced Energy Systems, and Cross-cutting Research. Funding also provides for travel, training, contractor support, and supplies/equipment to support the in-house R&D efforts.

**CCS and Power Systems**
**NETL Coal Research and Development**
**Funding ($K)**

| | FY 2014 Enacted | FY 2014 Current | FY 2015 Enacted | FY 2016 Request | FY 2016 vs FY 2015 |
|---|---|---|---|---|---|
| **NETL Coal Research and Development** | | | | | |
| Salaries and Benefits | 26,700 | 26,700 | 26,880 | 26,165 | -715 |
| Travel | 1,000 | 1,000 | 1,000 | 880 | -120 |
| Other Services | 7,311 | 7,311 | 7,120 | 6,986 | -134 |
| Recovery of Rare Earth Elements | 15,000 | 15,000 | 15,000 | 0 | -15,000 |
| **Total, NETL Coal Research and Development** | **50,011** | **50,011** | **50,000** | **34,031** | **-15,969** |
| **Federal FTEs** | **192** | **192** | **189** | **184** | **-5** |

**NETL Coal Research and Development**
**Explanation of Major Changes ($K)**

| | FY 2016 vs FY 2015 |
|---|---|
| **NETL Coal Research and Development:** The FY 2016 request does not include the $15M for Rare Earth Minerals which was provided in enacted appropriations in FY 2015. Also, there is a minor reduction in salaries and benefits, travel, and other services due to a small reduction in FTEs and contractor support. | **-15,969** |
| **Total, NETL Coal Research and Development** | **-15,969** |

## CCS and Power Systems
## Supercritical Carbon Dioxide Technology

**Description**

The Supercritical Carbon Dioxide Technology (sCO2) subprogram was created within CCS and Power Systems by FY 2015 Enacted appropriations. This subprogram is also supported by activities in the Advanced Ultra Supercritical Materials R&D budget line under Crosscutting Research, Plant Optimization Technologies. Fossil Energy's efforts on supercritical $CO_2$ support the Department's crosscutting Supercritical Carbon Dioxide Technology ($sCO_2$) Tech Team, which is focused on technology development for supercritical carbon dioxide-based power conversion cycles. These cycles can be applied to most heat sources, including fossil, nuclear, solar and geothermal applications, while offering significant improvements in efficiency, cost, footprint and water use. The major thrusts of the crosscut are a coordinated R&D effort in high temperature technology development/component validation, and the Supercritical Transformational Electric Power Generation (STEP) initiative to design, construct and operate a 10 MW $sCO_2$ test system.

FY 2015 Enacted appropriations provided funding for R&D on supercritical $CO_2$ technologies and transferred the locus of STEP from Nuclear Energy (NE) to Fossil Energy (FE). In FY 2015, selections will be made in both FE and NE for materials and component development research required to deliver major components to the STEP test system, and for feasibility analyses and further materials and component R&D required for the system. Data generated will include cost and schedule information pertaining to requirements for the development of the STEP test system. These will be done to meet the schedule and integration requirements for the STEP test system implementation plan. Building off R&D in FY 2015, FE will take the lead developing the 10 MW STEP facility through the issuance in FY 2016 of competitive funding opportunity announcements that are cost shared with industry. The 10 MWe scale STEP pilot scale facility will enable the crosscut team to evaluate power cycle and component performance over a range of operating conditions. Demonstrating favorable performance at this scale is the next step required to address technical issues, reduce risk, and mature this promising technology. Where appropriate, the 10 MW facility will be used to address and resolve technology specific issues relevant to the different heat source applications.

The $sCO_2$ power cycle will have significant benefits to fossil-fueled heat sources for topping and bottoming power conversion cycles including waste heat recovery. Fossil Energy's ultimate goal is a directly-fired supercritical $CO_2$ fuel cycle which could also provide significant benefits for Carbon Capture and Storage (CCS) by reducing the costs and parasitic load of carbon capture and $CO_2$ compression.

The 10 MWe STEP facility will have the flexibility to test in a variety of configurations that will be required by the $sCO_2$ power cycle. Since this will be the first integrated test of a system operating at this size and under these conditions, it is prudent to start up and perform the first tests in the indirect-fired configuration. This configuration eliminates the additional challenges related to a natural gas/ $sCO_2$ turbine e.g. water vapor/ $sCO_2$ mix in the working fluid, $sCO_2$ bleed system, higher temperature components, Oxygen/ $sCO_2$ combustion, and others. However, once the indirect-fire cycle has successfully operated and been tested through the necessary suite of transient and steady state conditions, FE will begin the transition to testing key elements of the direct-fired $sCO_2$ power cycle. These include adding water vapor to the working fluid, which will simulate a direct fired turbine and add corrosion issues, increasing the temperature range of the equipment, and on-site corrosion analyses capabilities. The direct-fire $sCO_2$ turbine, which is being funded under the FE turbines program and is not currently a part of STEP, could be available for integration into the STEP facility in the 2020 timeframe.

**CCS Demonstrations**
**Natural Gas Carbon Capture and Storage**

**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **Natural Gas Carbon Capture and Storage $0** | **$0** | **$0** |
| **Natural Gas Carbon Capture and Storage** | | |
| No funding was appropriated in FY 2015. | No funding is requested in FY 2016. | No Change. |

**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **Carbon Capture $88,000,000** | **$116,631,000** | **+$28,631,000** |
| **Post-Combustion Capture System $76,000,000** | **$104,631,000** | **+$28,631,000** |
| • Continue field testing of up to five bench-scale slipstream projects.<br>• Plan to complete design and begin construction of small pilot-scale slipstream projects selected in FY 2014.<br>• Solicit and award at least one large pilot-scale project for post-combustion capture. | • Funding will be used to support two large scale pilot projects, one awarded in FY 2015 and at least one additional project selected from a solicitation in FY 2016, for post combustion capture that are applicable to both coal and natural gas power systems. These activities will validate the performance and operations of a second generation technologies on coal and natural gas power systems in order to gather data and knowledge necessary for future full scale demonstration.<br>• A FY 2016 solicitation will seek to award novel transformational technologies for carbon capture at the laboratory and bench scales for coal and natural gas.<br>• The program will issue a Request for Information (RFI) and host a series of meetings to gather input from stakeholders on the most cost-effective natural gas capture technologies ready for demonstration by 2020.<br>• Funding will be used for previously selected bench and small pilot scale projects which are focused on developing advanced second generation post-combustion capture technologies and adapt specific technologies for natural gas power systems.<br>• Funding will be used to support projects selected in FY 2014 for post-combustion capture systems which are field testing technologies from the bench to small slipstream pilot-scale. | The increase in funding supports a new emphasis on reducing the costs and technical challenges of natural gas carbon capture as well as continued scale-up of second generation technologies through large-scale pilot projects and laboratory and bench-scale testing of transformational technologies for fossil-fuel-fired plants. This will allow the award of at least one additional large scale pilot project for a second generation capture technology that will test carbon capture technologies for both coal and natural gas power systems. The scale and number of projects is dependent on the scope of the proposed projects, type of technologies submitted, and level of industrial commitment. Funding will also support issuance of a Request for Information (RFI) and several stakeholder meetings to gather input on the most cost-effective natural gas capture technologies ready for demonstration by 2020. Finally, funding will allow the selection of transformational technologies at the laboratory and bench scale which are needed in FY 2016 to meet future CCS goals. |
| **Pre-Combustion Capture Systems $12,000,000** | **$12,000,000** | **$0** |
| • Continue to support laboratory and bench scale projects selected in FY 2014 which are focused on developing advanced pre-combustion capture technologies.<br>• Solicit and award small pilot-scale projects for advanced pre-combustion capture technologies. | • A solicitation in FY 2016 will support a small-scale pilot project for advanced pre-combustion capture technologies.<br>• Continue advanced laboratory scale and small slipstream R&D for pre-combustion capture technologies.<br>• Funding will be used to support the projects selected in FY 2014 for pre-combustion capture systems which are field testing technologies from the bench to small slipstream pilot-scale. | No change from FY 2015 level. |

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| | • Funding will be used to support previously selected laboratory and bench scale projects which are focused on developing advanced pre-combustion capture technologies. | |

**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **Carbon Storage $100,000,000** | **$108,768,000** | **+8,768,000** |
| **Storage Infrastructure (formerly Regional Carbon Sequestration Partnerships)[1] $66,000,000** | **$63,084,000** | **-$2,916,000** |
| • FY 2015 plans are to continue implementation of eight large-scale field projects that will cumulatively inject 6 million metric tons of $CO_2$ since 2009 to evaluate methodologies and validate technologies at the large-scale to demonstrating safe and permanent storage. In FY 2015, one additional large-scale project plans to initiate injection.<br>• Continue support of the three existing small-scale field tests to evaluate methodologies and technologies to ensure safe permanent storage of $CO_2$.<br>• Issue solicitation and select up to three offshore storage regional characterization projects resulting in future site characterization projects.<br>• Issue solicitation and select up to three small-scale or fit-for-purpose field projects or one large-scale field project to address key technical research issues (storage capacity, injectivity, and containment) associated with carbon storage.<br>• Projects selected in FY 2014 to evaluate Associated $CO_2$ storage in enhanced oil recovery (EOR) fields/operations or improved EOR technologies to increase storage efficiency will continue under existing FY 2014 funding. Additional projects will be selected utilizing FY 2015 appropriated funding.<br>• | • FY 2016 plans are to continue implementation of eight large-scale field projects that will cumulatively inject 7 million metric tons of $CO_2$ since 2009 to evaluate methodologies and validate technologies (system integration) at a large-scale demonstrating safe and permanent storage. In FY 2016, three projects will have transitioned into post-injection monitoring to understand $CO_2$ long-term storage.<br>• Continue to support the existing small-scale field tests to evaluate methodologies and technologies to ensure safe permanent storage of $CO_2$.<br>• Continue offshore storage site characterization research projects from the FY 2015 solicitation.<br>• Continue support and/or selection of small-or large-scale and fit-for-purpose field projects.<br>• Projects selected in FY 2014 and FY 2015 to evaluate associated $CO_2$ storage in enhanced oil recovery (EOR) fields/operations or improved EOR technologies to increase storage efficiency will continue under existing FY 2014 and FY 2015 funding. | Funding request is sufficient to maintain Storage Infrastructure activities that are focused on addressing the long-term fate, transport, and storage of $CO_2$ and field test and validation of technologies in a variety of reservoirs. |

[1] In FY 2015 the Regional Carbon Sequestration Partnership (RCSPs) sub-activity will be renamed Storage Infrastructure to better represent the characterization and field activities that occur in the RCSPs and other small and large-scale field projects in a variety of geologic reservoirs in onshore and offshore settings.

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **Advanced Storage R&D (formerly Geologic Storage Technologies) $13,500,000** | **$17,384,000** | **+$3,884,000** |
| • Continue applied R&D projects focused on development and validation of tools and technologies that assess and mitigate storage risk, which includes projects selected from the FY 2014 solicitation to evaluate geomechanical effects (e.g., induced seismicity), seal behavior, and fluid/pressure fronts in fractured reservoir.<br>• Issue solicitation for applied and lab-scale R&D projects developing advanced onshore and/or offshore MVA tools and technologies to optimize usage of subsurface more efficiently during injection and monitoring of $CO_2$ storage; and advance tools and methods for wellbore integrity. | • In FY 2016, Geologic Storage Technologies is being renamed to Advanced Storage R&D and now also incorporates the Monitoring, Verification, Accounting, and Assessment subprogram budget line. This consolidation improves the integration of the technologies developed in these previously separated budget lines. This will improve the development of future MVAA plans by linking advanced geologic storage modeling and simulation activities with development of advanced MVAA technologies.<br>• Continue existing projects on wellbore integrity and stress state of subsurface in support of DOE's cross-functional SubTER Technical Team.<br>• Continue to develop MVAA tools and technologies to increase efficiency of injecting and monitoring $CO_2$ in subsurface.<br>• Select new projects on geologic storage or MVAA technologies that will obtain new subsurface signals from geologic formations to provide a clearer picture of subsurface to improve characterization and tracking of $CO_2$ in the subsurface. | Existing and additional funding supports new and existing projects that support Carbon Storage Program efforts and the Department's cross-functional SubTER technical team on developing laboratory-and bench-scale technologies for identifying and obtaining new subsurface signals, ensuring wellbore integrity, and increasing understanding of the stress state and induced seismicity. Funding increase also reflects that the Monitoring, Verification, Accounting, and Assessment subprogram will be incorporated into the Advanced Storage R&D subprogram in FY 2016. |
| **Monitoring, Verification, Accounting and Assessment $10,000,000** | **$0** | **-$10,000,000** |
| • Continue funding existing applied and lab-scale R&D projects developing advanced tools and technologies to improve resolution and better track plume migration and optimize storage efficiency cost effectively.<br>• Prepare for field validation phase of tools and technologies for accurate, high-resolution measurement of $CO_2$ saturations, plumes and pressure fronts; and identification of potential or actual leakage pathways. | • In FY 2016, Monitoring, Verification, Accounting, and Assessment is moved into the Advanced Storage R&D (formerly Geologic Storage Technologies) subprogram budget line to better improve the integration between the technologies developed in these two budget lines. | Funding is now incorporated into the Advanced Storage R&D (formerly Geologic Storage Technologies) subprogram budget line. |

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **Carbon Use and Reuse $2,000,000** | **$0** | **$-2,000,000** |
| • Complete existing applied R&D projects and selected new projects utilizing FY 2015 appropriated funding. | • Complete existing applied R&D projects and continue projects selected with FY 2015 appropriated funding. | No new projects. Existing projects are funded with prior year obligations. |
| **Sub-disciplinary Storage R&D (formerly Focus Area for Carbon Sequestration Science) $8,500,000** | **$28,300,000** | **+$19,800,000** |
| • Continue funding existing projects addressing targeted research needs: 1) Reservoir and seal performance; 2) Geologic storage site optimization and operations; 3) Reservoir capacity and storage efficiencies; 4) Reservoir modeling and monitoring technologies; 5) Resource assessment and geospatial data management; and 6) $CO_2$ use, re-use and conversion. | • In FY 2016, Focus Area for Carbon Sequestration Science was renamed Sub-disciplinary Storage R&D because the activities, while supporting in nature, are more directly focused on applied R&D activities within the overall Carbon Storage Program.<br>• Continue funding existing projects addressing targeted research needs such as: 1) Reservoir and seal performance; 2) Geologic storage site optimization and operations; 3) Reservoir capacity and storage efficiencies; 4) Reservoir modeling and monitoring technologies; and 5) Resource assessment and geospatial data management; and 6) $CO_2$ use, re-use and conversion.<br>• Funds efforts for the Energy Data Exchange (EDX) and National Risk Assessment Partnerships (NRAP). Work accomplished under EDX and NRAP supports the Carbon Storage Program's goals of addressing data management, technology transfer, and uncertainty associated with risks on stress state and induced seismicity. | Increase funds enhances efforts related to EDX on data management such as geo-spatial data management, and NRAP (e.g., Integrated Assessment Model, Risk-based Monitoring and Mitigation Protocols for Long-Term Carbon Storage, Area of Review, and Post-Injection Site Care) to address uncertainty associated with risks on stress state and induced seismicity that are supportive of Carbon Storage Program goals. |

**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **Advanced Energy Systems $103,000,000** | **$39,385,000** | **-$63,615,000** |
| **Advanced Combustion Systems $28,000,000** | **$10,385,000** | **-$17,615,000** |
| • In FY 2015, the program plans to initiate design and construction of pilot-scale projects focused on pressurized oxy-combustion and chemical looping combustion systems. The number of projects is dependent upon the results achieved in FY 2014. | • In FY 2016 the program will continue the development of "transformational" technologies for demonstration-scale testing in the next 10 years using high performance materials developed through cross-cutting research allowing high temperature operations.<br>• Requested funding enables the program to continue the development, through design and construction, of pressurized oxy-combustion and chemical looping combustion pilot-scale systems. | The reduction in funding reflects a rescoping of pilot testing to one Phase II project. Requested funding is sufficient for planned development of pressurized oxy-combustion and chemical looping combustion pilot-scale systems. |
| **Gasification Systems $25,000,000** | **$11,000,000** | **-$14,000,000** |
| • FY 2015 activities include: continuation of data generation from gasification systems at pilot-scale and syngas component testing: production testing of advanced oxygen system modules for use in large industrial application (500+ TPD); and the expansion of DOE-developed multiphase flow codes to include predictive means to optimize plant reliability. | • Funding will allow continued testing of advanced oxygen production technology, multiphase reacting flow model development applicable to commercial gasification systems, and refractory development activities. | Small-scale R&D will continue; funds transition of 1-2 projects with the most successful technologies to bench-scale testing. |

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **Advanced Turbines $15,000,000** | **$9,000,000** | **-$6,000,000** |
| • FY 2015 activities include: final component testing to demonstrate efficiency goals of Phase II of Siemens Hydrogen Turbine Project; testing of components in the new Aero-Thermal Rig development under the NETL ORD; and solicitation and selection of projects focused on high temperature, high pressure combustion and materials development. | FY 2016 funding will be used for the development of component technologies for high pressure ratio and high temperature turbine technologies. This includes:<br>• Identification and development of innovative turbomachinery components for both advanced combustion turbines in combined cycle applications.<br>• Continued research through the University Turbines System Research (UTSR) program for high temperature, high pressure combustion and materials development.<br>• Continued turbine R&D related to directly-fired supercritical carbon dioxide ($CO_2$) based power cycles.<br>• Phase II down-selection process of a suite of projects for the development and testing at the laboratory/bench scale. | The decrease in funding reflects the movement of materials development and systems analysis for the indirectly fired ($CO_2$) based power cycle to the new $SCO_2$ subprogram as well as the Phase II down-selection of only the most successful projects for development and testing at the laboratory/bench scale. |
| **Coal and Coal Biomass to Liquids $5,000,000** | **$0** | **-$5,000,000** |
| The Coal and Coal/Biomass to Liquids program focuses on technologies to foster the commercial adaption of coal and coal biomass gasification and the production of affordable liquid fuels and hydrogen with excellent environmental performance. | Complete existing projects funded with prior year obligations | No funding requested. |
| **Solid Oxide Fuel Cells $30,000,000** | **$9,000,000** | **-$21,000,000** |
| • FY 2015 activities will restart the SOFC Program to focus on durable SOFC materials development. | • Requested funding will accelerate the commercialization of SOFC technology while retaining the program's long term focus on efficient, cost-effective SOFC electricity that minimizes water consumption in central power generation applications and produces a pure, CO2 exhaust stream to reduce the costs of carbon capture and storage. | Reduction in funding reflects a rescoping of some R&D to focus more narrowly on the most promising next generation SOFC technologies. |

**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **Cross-cutting Research $49,000,000** | **$51,242,000** | **+$2,242,000** |
| **Plant Optimization Technologies $18,500,000** | **$27,542,000** | **+$9,042,000** |
| *Sensors and Controls and Other Novel Concepts $4,500,000*<br>• Continue field testing of sensors and bench scale testing of advanced control methodologies.<br>• Initiate research on advanced control technologies capable of self-organizing sensor networks for improved performance of complex power systems. | *Sensors and Controls and Other Novel Concepts $4,542,000*<br>• Developing sensor technologies critical to the operation and optimization of advanced power systems.<br>• Develops control systems for advanced power systems such as oxycombustion and chemical looping. | *Sensors and Controls and Other Novel Concepts (+$42,000)*<br>• Increase funds investigation of advanced manufacturing processes and enables the ability of embedding sensors in components. |
| *Cross-cutting Materials R&D $2,000,000*<br>• Apply structural materials manufacturing processes and joining techniques for high temperature alloys to components for advanced power generation systems.<br>• Develop materials capable of withstanding rapid ramping of thermoelectric power plant start-ups. | *Cross-cutting Materials R&D $1,500,000*<br>• Supports modeling and acceleration of new classes of alloys required for advanced power systems. | *Cross-cutting Materials R&D (-$500,000)*<br>• Funding will continue to support materials manufacturing and development of new classes of alloys but will prioritize only the most promising alloys for continued R&D. |
| *Advanced Ultra-Supercritical $5,000,000*<br>• Verify materials capable of operating under advanced steam cycle conditions (760°C/5000 psi), and gas turbine performance to 1465°C. Assess increased plant efficiency and availability<br>• Verify high temperature (>800 °C) alloy performance under advanced ultra-supercritical conditions and other potential extreme environments for ASME Code performance. | *Advanced Ultra-Supercritical $15,500,000*<br>• Refocuses materials development on high-temperature component parts needed for a directly fired-supercritical carbon dioxide fuel cycle. While the focus of this sub-program will shift in FY 2016, materials development for a supercritical $CO_2$ fuel cycle will have spillover benefits for high temperature steam cycles. Funding for R&D focused on seizing the opportunity of water-limited cooling provided by a directly-heated supercritical $CO_2$ fuel cycle will be used to support the STEP pilot for which a solicitation is to be issued in FY 2016. | *Advanced Ultra-Supercritical (+$10,500,000)*<br>• The increasing in FY 2016 funding will support material and components for a directly-fired supercritical $CO_2$ fuel cycle. This R&D effort will benefit materials development for tubing, piping, valves and turbine components for Oxycombustion and Chemical Looping. |

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| *Water Management R&D $7,000,000*<br>• Integrate research activities on water management improvements in thermoelectric systems with a Department-wide research and development effort focused on identifying and mitigating challenges in water use and reuse. | *Water Management R&D $6,000,000*<br>• Research focuses on treatment of non-traditional water produced through carbon capture and storage. | *Water Management R&D (-$1,000,000)*<br>• Slight reduction in funding re-prioritizes this subprogram around treatment of non-traditional water produced through carbon capture and storage. |
| **Coal Utilization Science $24,000,000** | **$18,750,000** | **-$5,250,000** |
| *Computational System Dynamics $12,000,000*<br>• NRAP will initiate development of a basin component model (long-term behavior, ROM).<br>• NRAP will initiate development of a wellbore component model (geomechanics, chemistry, valid/calibration, ROM).<br>*Focus Area for Computational Energy Science $12,000,000*<br>• CCSI will develop models for solving technical challenges in 2nd generation solid sorbent, solvent and oxy-combustion technologies.<br>• CCSI will develop toolset software infrastructure required for simulating 2nd generation technologies. | *Computational System Dynamics $7,000,000*<br>• Maintains funding for NRAP modeling projects, for the models validated. Funding will progress and finalize key products such as tools for risk-profile determination and post-injection site care technical decision support.<br>*Computational Energy Science $11,750,000*<br>• Supports the development of interactive visualization technology and data communication optimization methods to improve the design and operation of advanced power systems with carbon capture and sequestration.<br>• Provides first principal and physics based modeling of phenomenon for complex energy conversion and carbon capture processes.<br>• Maintains funding for CCSI modeling projects, for the models validated.<br>• Implements the next generation of enabling computational formats for domain specific solution sets. | *Computational System Dynamics (-$5,000,000)*<br>• No new projects will be initiated in FY 2016.<br>*Computational Energy Science (-$250,000)*<br>• Slight decrease in funding maintains high level modeling capabilities at Fossil Energy and the National Energy Technology Laboratory (NETL). |
| **Energy Analyses $1,500,000** | **$850,000** | **-$650,000** |
| • Carry out analyses of options and barriers for incorporating CCS on gas-fueled power plants. | • Carry out analyses of options and barriers for incorporating CCS on gas-fueled power plants. | • Program will be re-scoped to prioritize the analyses expected to provide the greatest insights for future technology development. |

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **University Training and Research $3,900,000** | **$3,000,000** | **-$900,000** |
| • Select and award up to 9-12 university-based projects focused on oxy-combustion, sensors and controls, or monitoring, verification, and accounting technologies. | • Supports 8-10 grants to HBCU and UCR universities to help incubate transformational and next generation concepts while training the next generation of scientists and engineers. | • (+$100) No impact on the HBCU Program.<br>• (-$1,000) Decreases the numbers of UCR FY 2016 award by 2. |
| **International Activities $1,100,000** | **$1,100,000** | **$0** |
| • Organize the 2015 CLSF Ministerial conference featuring a significant increase in international policy initiatives. | • Organize the 2016 CLSF Ministerial conference featuring a significant increase in international policy initiatives. | • No changes. |

**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **NETL Coal Research and Development $50,000,000** | **$34,031,000** | **-$15,969,000** |
| • This funding directly support the NETL staff associated with conducting in-house research activities for the Coal R&D programs. Funding also provides for travel, training, contractor support, and supplies/equipment to support the in-house R&D efforts. Funding also includes $15 million for the Rare Earth Minerals project. | • This funding directly supports the NETL staff associated with conducting in-house research activities for the Coal R&D programs. Funding also provides for travel, training, contractor support, and supplies/equipment to support the in-house R&D efforts. | • The reduction is two fold. The FY 2015 Enacted included $15 million to economically recover rare earth elements from coal and coal byproduct streams such as fly ash, coal refuse, and aqueous effluent. This area is not included in the FY 2016 request. Also, there are minor reductions in salaries and benefits, travel, and other services due a small reduction in FTEs and contractor support. |

**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **Supercritical Carbon Dioxide Technology ($sCO_2$)** | | |
| **$10,000,000** | **$19,300,000** | **+$9,300,000** |
| • FY 2015 Enacted appropriations transferred the locus of the Supercritical Transformational Electric Power Generation (STEP) initiative to design, construct and operate a 10-MW $sCO_2$ test system from Nuclear Energy to Fossil Energy. In FY 2015, selections will be made for materials and component development research required to deliver major components to the STEP test system, and for feasibility analyses and further materials and component R&D required for a host site for the system. Data generated will include cost and schedule information pertaining to requirements for the development of the STEP test system. | • This subprogram, created by FY 2015 Enacted appropriations, will focus on issuance in FY 2016 of competitive funding opportunity announcements cost shared with industry for the 10 MW Supercritical Transformational Electric Power (STEP) pilot scale facility. This facility will enable the DOE crosscut team to evaluate power cycle and component performance over a range of operating conditions. Demonstrating favorable performance at this scale is the next step required to address technical issues, reduce risk, and mature this promising technology. Where appropriate, the 10 MW facility will be used to address and resolve technology specific issues relevant to the different heat source applications. | The increase primarily funds issuance of funding opportunity announcements for STEP and also reflects the movement of funds for materials development and systems analysis for the indirectly fired ($CO_2$) based power cycle from the Advanced Turbines subprogram to the $SCO_2$ subprogram. |

**CCS and Power Systems**
**Performance Measures**

In accordance with the GPRA Modernization Act of 2010, the Department sets targets for, and tracks progress toward, achieving performance goals for each program. For more information, refer to the Department's FY 2014 Annual Performance Report.

| | FY 2014 | FY 2015 | FY 2016 |
|---|---|---|---|
| Performance Goal (Measure) | **CCS Demonstrations - Initiate construction of CCS demonstration projects. Once constructed, initiate operation.** | | |
| Target | 1 CCS project initiated | 1 CCS project initiated | 3 CCS projects in operation[1] |
| Result | 1 CCS project initiated | Not applicable | Not applicable |
| Endpoint Target | Operations initiated at a minimum of five commercial scale CCS demonstrations by 2019 including the Clean Coal Power Initiative (CCPI), FutureGen 2.0, and the Industrial CCS Demonstration projects (funded by both annual appropriations and the American Recovery and Reinvestment Act). At least two of the five demonstrations to initiate operations by 2019 will be CCPI projects.[2] | | |
| Performance Goal (Measure) | **Carbon Capture and Advanced Energy Systems - Achieving the target signifies that the Carbon Capture & Advanced Energy Systems program is continuing to make progress in meeting its goal of developing cost-effective, reliable carbon capture technologies for pre-combustion, post-combustion, and oxy-combustion capture applications.** | | |
| Target | \$53 per tonne $CO_2$ Captured | \$51 per tonne $CO_2$ Captured | \$49 per tonne $CO_2$ Captured |
| Result | \$52.93 per tonne $CO_2$ Captured | Not applicable | Not applicable |
| Endpoint Target | By 2020, Advanced Energy Systems with a $CO_2$ capture cost of no more than \$40 per tonne. | | |
| Performance Goal (Measure) | **Carbon Storage - Inject $CO_2$ in large-volume field test sites to demonstrate the formations' capacity to permanently, economically, and safely store carbon dioxide.** | | |
| Target | 5 MMTs injected (since 2009) | 6 MMTs injected (since 2009) | 7 MMTs injected (since 2009) |
| Result | 7.6 MMTs injected since 2009 | Not applicable | Not applicable |
| Endpoint Target | Inject 9.0 million metric tons of $CO_2$ in large-volume field test sites representing different storage classes, since January 2009, to demonstrate and monitor for the formations' capacity to permanently, economically, and safely store carbon dioxide. A long-term goal is to ensure the cost effective ability to ensure 99 percent storage permanence of $CO_2$ while minimizing the environmental footprint of carbon storage activities. | | |

[1] Beginning in FY2016 transition to measuring projects placed into operation to conform to Endpoint Target.
[2] The endpoint target was previously 5 to 10 demonstrations up and running by 2016.

## Natural Gas Technologies

**Overview**

The mission of the Natural Gas program is to support DOE missions in energy, environment, and national security. The Natural Gas Technologies program is comprised of these subprograms: Environmentally Prudent Development, Emissions Reductions from Midstream Natural Gas Infrastructure, Emission Quantification from Natural Gas Infrastructure, and Gas Hydrates. Environmentally Prudent Development supports a multiagency research effort with the Department of the Interior (DOI) and the Environmental Protection Agency (EPA) to address high-priority challenges to safe and prudent development of unconventional oil and gas resources. Emissions Reductions from Midstream Natural Gas Infrastructure will develop technologies and communicate results to stakeholders to mitigate methane emissions from natural gas transmission, distribution, and storage facilities. Emission Quantification from Natural Gas Infrastructure will conduct research to better quantify methane emissions across the natural gas value chain.

**Highlights of the FY 2016 Budget Request**

The Natural Gas program will focus on continued implementation of priority collaborative research and development, together with EPA and DOI, to ensure that shale gas development is conducted in a manner that is environmentally sound and protective of human health and safety. In FY 2016, the Environmentally Prudent Development subprogram will continue implementation of the collaborative research strategy in such areas as water quality and availability including the treatment and use of co-produced water from oil and gas wells, air quality, induced seismicity, and mitigating the impacts of development (e.g. wellbore integrity, reducing surface and subsurface footprint, and reduced water use).

The Natural Gas program will initiate a midstream natural gas infrastructure subprogram focused on reducing methane emissions. In FY 2016, research will focus on reducing methane leaks and enhancing operational efficiencies of pipelines, storage facilities, and compressor stations, and on communicating results to stakeholders to mitigate methane emissions from natural gas transmission, distribution, and storage facilities.

The Natural Gas program will also implement a new Emissions Quantification from Natural Gas Infrastructure research subprogram focused on better quantifying methane emissions from the natural gas value chain. The program will work with the Environmental Protection Agency to ensure that data produced is compatible with the national Greenhouse Gas Inventory. Efforts will focus on understanding regional variation and reducing uncertainty in emissions estimates.

The Natural Gas program, through public sector-led efforts, has been evaluating the occurrence, nature, and behavior of naturally occurring gas hydrates and the resulting resource, hazard, and environmental implications. In FY 2016, the program will continue ongoing activities already funded with prior year appropriations.

**FY 2016 Crosscuts ($K)**

| | Subsurface Engineering | Water Energy | Total |
|---|---|---|---|
| Environmentally Prudent Development | 10,000 | 6,000 | 16,000 |

Within the FY 2016 Budget Request, the Natural Gas Technologies program supports two DOE Crosscuts: Subsurface Engineering and Water-Energy. The Subsurface Engineering crosscut will address identified challenges in the subsurface through highly focused and coordinated research in Wellbore Integrity, Stress State and Induced Seismicity, Permeability Manipulation, and New Subsurface Signals to ensure enhanced energy security, material impact on climate change via $CO_2$ sequestration, and dramatically mitigated environmental impacts from energy-related activities and operations. The Natural Gas program will support the Subsurface crosscut through its collaborative research and development activities under the Environmentally Prudent Development budget line.

The goal of the Water-Energy crosscut is to develop an integrated set of investments and cross-program collaborations that: 1) support a National data, modeling, and analysis platform to improve understanding and inform decision-making for a broad range of users and at multiple scales; 2) strategically target crosscutting technology opportunities within the system of water and energy flows that offer the greatest opportunity for positive impact; and 3) are informed, supported, and

strengthened by focused policy analysis and stakeholder engagement. These investments position DOE to contribute strongly to the Nation's transition to more resilient energy and coupled energy-water systems. The Natural Gas program will contribute to the Water-Energy crosscut by developing technologies and management practices for reducing the volume of freshwater demand, produced water that requires disposal, and recycling flowback water as alternatives to the use of 100 percent freshwater for oil and gas extraction.

**Natural Gas Technologies**
**Funding ($K)**

| | FY 2014 Enacted | FY 2014 Current[1] | FY 2015 Enacted | FY 2016 Request | FY 2016 vs FY 2015 |
|---|---|---|---|---|---|
| **Natural Gas Technologies** | | | | | |
| Environmentally Prudent Development | 12,600 | 12,221 | 10,121 | 19,000 | +8,879 |
| Emissions Mitigation from Midstream Infrastructure | 0 | 0 | 0 | 15,000 | +15,000 |
| Emissions Quantification from Natural Gas Infrastructure | 0 | 0 | 0 | 10,000 | +10,000 |
| Gas Hydrates | 8,000 | 7,759 | 15,000 | 0 | -15,000 |
| **Total, Program Natural Gas** | **20,600** | **19,980** | **25,121** | **44,000** | **+18,879** |

SBIR/STTR:

- FY 2014 Transferred: SBIR $543: STTR: $77
- FY 2015 Projected: SBIR $685: STTR: $94
- FY 2016 Request: SBIR $1,241: STTR: $185

[1] Funding reflects the transfer of SBIR/STTR to the Office of Science.

**Natural Gas Technologies**
**Explanation of Major Changes ($K)**

| | FY 2016 vs FY 2015 |
|---|---|
| **Environmentally Prudent Development:** The increase in funding will support additional work proposed under two Departmental Crosscuts. Under WETT, FE proposes an assessment/development technology option for treatment and use of co-produced water from oil and gas wells. Under SubTER, FE proposes an expanded effort on wellbore integrity and reduction of the subsurface footprint associated with unconventional oil and gas production. | **+8,879** |
| **Emissions Mitigation from Midstream Infrastructure:** The increase in funding is necessary to initiate a midstream natural gas infrastructure program focused on reducing methane emissions from natural gas systems in support of the Climate Action Plan Strategy to Reduce Methane Emissions. This new program will develop and demonstrate more cost-effective technologies to detect and reduce losses from natural gas transmission and distribution systems. It will include efforts to reduce leakages and develop next generation compressors. | **+15,000** |
| **Emissions Quantification from Natural Gas Infrastructure:** The increase in funding will support research focused on better quantifying methane emissions from the natural gas value chain for updating the national Greenhouse Gas Inventory. | **+10,000** |
| **Gas Hydrates:** No additional funding requested. | **-15,000** |
| **Total, Natural Gas** | **+18,879** |

**Description**

Environmentally Prudent Development

The Environmentally Prudent Development subprogram will focus on the continued implementation of priority collaborative research and development, together with the EPA and DOI, to address high-priority challenges to safe and prudent development of unconventional resources. This collaborative research and development is consistent with recommendations from the White House's "Blueprint for a Secure Future" and the Secretary of Energy Advisory Board's recommendations.

The Program will ensure that the Federal government's understanding of risks associated with oil and gas operations and unconventional gas keeps pace with advancements in production technology. This will be accomplished through scientific assessment of the risks, potential impacts, and adequacy of current prevention and mitigation technologies. By conducting research, in the public interest, to mitigate risks of hydraulic fracturing and other shale stimulation and production techniques, DOE can bring a greater sense of confidence to the public and assist state authorities in crafting regulations that effectively mitigate risks.

Guided by the multiagency Strategy for Research and Development released in July of 2014[2], the Natural Gas program will focus on the following priority research areas: water quality, water availability, air quality, induced seismicity, and mitigating the impacts of development. The program will fund targeted subsurface characterization focused on mitigating the surface and subsurface footprint and impact of production. Within the request, the program supports two Departmental Crosscuts: Subsurface Engineering and Water-Energy.

Emissions Mitigation from Midstream Infrastructure

Natural gas transmission and storage and distribution emissions represented 13 percent of total US anthropogenic methane emissions and approximately 57 percent of Natural Gas System related methane emissions in 2012[3]. The Department is committed to developing advanced, cost-effective technologies to improve operational efficiency and mitigate methane emissions from natural gas transmission, distribution, and storage facilities.

The focus of the subprogram will be to improve emissions detection and mitigation technologies, communicate results to and partner with stakeholders to ensure that new technologies can be implemented, and measure the effectiveness on emission reductions. The program contributes to DOE's portfolio of low-carbon energy options by developing advanced technologies that seek to reduce methane emissions from natural gas systems in support of the Climate Action Plan Strategy to Reduce Methane Emissions.

Emissions Quantification from Natural Gas Infrastructure

The Emissions Quantification from Natural Gas Infrastructure research subprogram will focus on better quantifying methane emissions from the natural gas value chain. The program will work with the Environmental Protection Agency to ensure that data produced is compatible with the national Greenhouse Gas Inventory. Efforts will focus on understanding regional variation and reducing uncertainty in emissions estimates.

Gas Hydrates

In FY 2016 the program will continue ongoing activities already funded with prior year appropriations.

[2] Federal Multiagency Collaboration on Unconventional Oil and Gas Research – Strategy for Research and Development. http://unconventional.energy.gov/pdf/Multiagency_UOG_Research_Strateg.pdf

[3] 2014 US EPA Greenhouse Gas Inventory.

**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **Natural Gas Technologies $25,121,000** | **$44,000,000** | **+$18,879,000** |
| **Environmentally Prudent Development $10,121,000** | **$19,000,000** | **+$8,879,000** |
| • Focus on continued implementation of the collaborative research strategy in such areas as water quality, water availability, air quality, induced seismicity, and mitigating the impacts of development (e.g. wellbore integrity, reduce surface and subsurface environmental footprint, and water use).<br>• A total of 18 research projects are active during FY 2015. | • Focus on continued implementation of the collaborative research strategy in areas such as water quality, water availability, air quality, induced seismicity, and mitigating the impacts of development (e.g. wellbore integrity, reduce surface and subsurface footprint, and water use).<br>• Assess and develop technology options for treatment and use of co-produced water from oil and gas wells. | The increase will fund research on subsurface characterization and mitigation and R&D efforts to reduce and reuse water from oil and natural gas production. |
| **Emissions Mitigation from Midstream Natural Gas $0** | **$15,000,000** | **+$15,000,000** |
| • Not applicable | • Solicit and select projects that develop advanced, cost-effective technologies to detect and mitigate methane emissions from natural gas transmission, distribution, and storage facilities.<br>• Communicate results on methane emissions mitigation to stakeholders. | The increase will fund the initiation of the midstream natural gas infrastructure program focused on reducing methane emissions and developing next generation compressors. |
| **Emissions Quantification from Natural Gas Infrastructure $0** | **$10,000,000** | **+$10,000,000** |
| • Not applicable | • Research projects focused on better quantifying methane emissions from natural gas value chain. | The increase will fund the new emissions quantification from natural gas infrastructure program focused on better quantifying methane emissions from natural gas value chain. |
| **Gas Hydrates $15,000,000** | **$0** | **-$15,000,000** |
| • Evaluate progress of the 7 University-lead resource characterization, modeling, and the response of methane hydrate systems to natural environmental change research projects that were initiated from the FY 2013 FOA.<br>• A total of 21 research projects were funded through the FY 2012 and FY 2013 FOAs. We anticipate roughly 11 of those projects will be | • 1 research project was funded through the FY 2014 FOA and will continue in FY 2016 with prior year appropriations. 10 of the 21 projects fully funded through the FY 2012 and FY 2013 FOAs will also continue. No additional funding requested. | No additional funding requested. |

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| completed by the end of FY 2015.<br>• Solicit and select projects to conduct lab- and field-based research focused on increasing public understanding of methane dynamics in gas-hydrate bearing areas. Anticipated peer reviewed journal publication of final compilation of scientific findings from the Ignik Sikumi Arctic test conducted in FY 2012. | | |

## Unconventional Fossil Energy Technologies from Petroleum – Oil Technologies

**Overview**

The mission of the Unconventional Fossil Energy Technologies from Petroleum – Oil Technologies is to provide information and technologies that will assure sustainable, reliable, affordable, and environmentally sound supplies of domestic unconventional fossil energy resources.

Consistent with past Budget Requests, in FY 2016 no funding is requested for the Unconventional Fossil Energy Technologies program. Although no funding was requested in FY 2015, $4.5 million was Congressionally directed for oil and natural gas research in unconventional, offshore, and small producers. In FY 2016, Fossil Energy's efforts to address high priority challenges to safe and prudent development of unconventional resources will continue under Environmentally Prudent Development under the Natural Gas Technologies budget line.

**Highlights of the FY 2016 Budget Request**

No activity is requested for FY 2016.

**Unconventional Fossil Energy Technologies**
**Funding ($K)**

| | FY 2014 Enacted[1] | FY 2014 Current | FY 2015 Enacted | FY 2016 Request | FY 2016 vs FY 2015 |
|---|---|---|---|---|---|
| Unconventional Fossil Energy Technologies | 15,000 | 14,549 | 4,500 | 0 | -4,500 |

**Unconventional Fossil Energy Technologies**

**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **Unconventional Fossil Energy Technologies** | | |
| **$4,500,000** | **$0** | **-$4,500,000** |
| **Unconventional Fossil Energy Technologies** | | |
| **$4,500,000** | **$0** | **-$4,500,000** |
| • The mission of the Unconventional Fossil Energy Technologies Program is to provide information and technologies that will assure sustainable, reliable, affordable, and environmentally sound supplies of domestic unconventional fossil energy resources. | • In FY 2016 no funding is requested for the Unconventional Fossil Energy Technologies program. Fossil Energy's efforts to address high priority challenges to safe and prudent development of unconventional resources will continue under Environmentally Prudent Development under the Natural Gas Technologies budget line. | • In FY 2016 no funding is requested for the Unconventional Fossil Energy Technologies program. |

[1] Funding reflects the transfer of SBIR/STTR to the Office of Science.

## Program Direction

### Overview

Program Direction provides for the Headquarters and field Federal workforce and contractor support responsible for the overall direction and administrative support of the Fossil Energy Research and Development (FER&D) program. The Federal staff provides program and project management and guidance, contract administration, and budget formulation and execution duties, etc. FER&D's primary mission is to support technological innovation that enables clean, affordable energy from fossil resources while enhancing economic, environmental, and energy security. The mission of the program is to create technology and technology-based policy options for the public benefit.

The Headquarters staff is responsible for providing overall guidance, direction, and support for the program offices. The National Energy Technology Laboratory (NETL) staff performs the day-to-day project management functions of the FER&D programs. NETL is also responsible for developing project budgets, implementing procurement plans, and other programs and site support activities necessary to achieve their program objectives. NETL has sites in Morgantown, WV; Pittsburgh, PA; Sugar Land, TX; Albany, OR; and Anchorage, AK. These sites include 117 buildings and 14 major research facilities on more than 240 acres.

Import/Export Authorization is managed in the Division of Natural Gas Regulatory Activities within the Office of Oil & Natural Gas. The program has responsibility for regulating natural gas and liquefied natural gas (LNG) imports and exports under the Natural Gas Act of 1938, section 3, using both Federal staff and contractor support.

### Highlights of the FY 2016 Budget Request

There are no significant changes in scope of work or activities from FY 2015.

**FY 2016 Crosscuts ($K)**

| | Cybersecurity | Total |
|---|---|---|
| Program Direction | 1,750 | 1,750 |

Within the FY 2016 Budget Request, the Program Direction line supports one Departmental Crosscut: Cybersecurity. For FER&D, this includes operation and enhancement of the FER&D cybersecurity policy and program as it relates to the enterprise computing environment at Headquarters and field locations. Key activities include cybersecurity policy implementation, governance and oversight activities, incident detection and response through continuous monitoring and diagnostics, and meeting Departmental requirements for the Identity Control and Access Management initiative. Within the FY 2016 Budget Request for Program Direction, $1.8 million will be used to support these crosscutting cyber activities.

## Program Direction
## Funding ($K)

| | FY 2014 Enacted | FY 2014 Current | FY 2015 Enacted | FY 2016 Request | FY 2016 vs FY 2015 |
|---|---|---|---|---|---|
| **Program Direction Summary** | | | | | |
| **Washington Headquarters** | | | | | |
| Salaries and Benefits | 16,371 | 16,371 | 16,371 | 16,259 | -112 |
| Travel | 900 | 900 | 900 | 900 | 0 |
| Support Services | 85 | 85 | 85 | 66 | -19 |
| Other Related Expenses | 12,322 | 12,322 | 12,322 | 11,071 | -1,251 |
| **Total, Washington Headquarters** | **29,678** | **29,678** | **29,678** | **28,296** | **-1,382** |
| **National Energy Technology Laboratory** | | | | | |
| Salaries and Benefits | 44,750 | 44,750 | 45,250 | 45,250 | 0 |
| Travel | 1,600 | 1,600 | 1,600 | 1,450 | -150 |
| Support Services | 22,629 | 22,629 | 21,879 | 20,025 | -1,854 |
| Other Related Expenses | 19,260 | 19,260 | 18,510 | 17,168 | -1,342 |
| **Total, National Energy Technology Laboratory** | **88,239** | **88,239** | **87,239** | **83,893** | **-3,346** |
| **Import/Export Authorization** | | | | | |
| Salaries and Benefits | 1,437 | 1,437 | 1,437 | 1,367 | -70 |
| Travel | 22 | 22 | 22 | 20 | -2 |
| Support Services | 0 | 0 | 0 | 0 | 0 |
| Other Related Expenses | 624 | 624 | 624 | 626 | +2 |
| **Total, Import/Export Authorization** | **2,083** | **2,083** | **2,083** | **2,013** | **-70** |
| **Total Program Direction** | | | | | |
| Salaries and Benefits | 62,558 | 62,558 | 63,058 | 62,876 | -182 |
| Travel | 2,522 | 2,522 | 2,522 | 2,370 | -152 |
| Support Services | 22,714 | 22,714 | 21,964 | 20,091 | -1,873 |
| Other Related Expenses | 32,206 | 32,206 | 31,456 | 28,865 | -2,591 |
| **Total, Program Direction** | **120,000** | **120,000** | **119,000** | **114,202** | **-4,798** |
| **Federal FTEs**[1] | **463** | **463** | **462** | **457** | **-5** |

[1] Additional FTEs are funded within the NETL Coal R&D program.

| | FY 2014 Enacted | FY 2014 Current | FY 2015 Enacted | FY 2016 Request | FY 2016 vs FY 2015 |
|---|---|---|---|---|---|
| **Support Services** | | | | | |
| Technical Support | | | | | |
| Headquarters | 85 | 85 | 66 | 66 | 0 |
| NETL | 4,890 | 4,890 | 4,679 | 4,279 | -400 |
| Total, Technical Support | 4,975 | 4,975 | 4,745 | 4,345 | -400 |
| | | | | | |
| Management Support | | | | | |
| Headquarters | 0 | 0 | 0 | 0 | 0 |
| NETL | 17,739 | 17,739 | 17,219 | 15,746 | -1473 |
| Total Management Support | 17,739 | 17,739 | 17,219 | 15,746 | -1473 |
| **Total, Support Services** | **22,714** | **22,714** | **21,964** | **20,091** | **-1873** |
| | | | | | |
| **Other Related Expenses** | | | | | |
| Headquarters | 12,322 | 12,322 | 12,322 | 11,071 | -1,251 |
| NETL | 19,260 | 19,260 | 18,510 | 17,168 | -1,342 |
| Import / Export Authorization | 624 | 624 | 624 | 626 | +2 |
| **Total, Other Related Expenses** | **32,206** | **32,206** | **31,456** | **28,865** | **-2,591** |

## Program Direction

**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **Total Program Direction $119,000,000** | **$114,202,000** | **-$4,798,000** |
| **Salaries and Benefits $63,058,000** | **$62,876,000** | **-$182,000** |
| The funding supports Federal staff who will continue monitoring (oversight and audit) activities to ensure appropriate and cost-effective information protection measures are applied to the information and information technology assets. | The funding supports Federal staff who will continue monitoring (oversight and audit) activities to ensure appropriate and cost-effective information protection measures are applied to the information and information technology assets. | The funding change is due to projected attrition rate increasing slightly. |
| The funding supports Federal staff at the National Energy Technology Laboratory. The staff provides management of the Lab; project management/implementation for the FER&D programs; legal support; public affairs; administrative services such as finance, | The funding supports Federal staff at the National Energy Technology Laboratory. The staff provides management of the Lab; project management/implementation for the FER&D programs; legal support; public affairs; administrative services such as finance, procurement, human resources; and operational services such as information technology | No change |

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| procurement, human resources; and operational services such as information technology management, ESS&H program execution, site management and maintenance. | management, ESS&H program execution, site management and maintenance. | |
| **Travel $2,522,000** | **$2,370,000** | **-$152,000** |
| Travel includes funding for trips for project monitoring/site visits, management meetings, training, etc. Instituted travel reduction to comply with the OMB directive for reduced travel from FY 2010 levels. | Travel includes funding for trips for project monitoring/site visits, management meetings, training, etc. Instituted travel reduction to comply with the OMB directive for reduced travel from FY 2010 levels. | Minor reduction in NETL and Import/Export Authorization travel funding due to less projected travel. |
| **Support Services $21,964,000** | **$20,091,000** | **-$1,873,000** |
| Support Service at Headquarters includes technical support, IT support, site operations support, administrative support, and grounds and maintenance support. | Support Service at Headquarters includes; technical support, IT support, site operations support, administrative support, and grounds and maintenance support. | The decrease in Support Services is due to a decrease in administrative contracts requirements. |
| Support Services at NETL include project management support, technical support, IT support, site operations support, administrative support, and grounds and maintenance support. | Support services at NETL include project management support, technical support, IT support, site operations support, administrative support, grounds and maintenance support. | Reduction is support services due to reduced scope and restructuring of contracts. |
| **Other Related Expenses $31,456,000** | **$28,865,000** | **-$2,591,000** |
| The activities supported by this line item include E-Government initiatives, Working Capital fund, computer systems and support and contractual services for HQ. | The activities supported by this line item include E-Government initiatives, Working Capital fund, computer systems and support and contractual services for HQ. | The funding change is due to a slight decrease in the amount of technical, management, and computer systems support services needed. |
| The activities supported by this line item include Lab operational expenses such as; rents, communications, utilities, services, training, supplies, equipment, maintenance, etc. | The activities supported by this line item include Lab operational expenses such as; rents, communications, utilities, services, training, supplies, equipment, maintenance, etc. | Slight reduction in other related expenses due lower rental costs and fewer equipment purchases. |

## Plant and Capital Equipment

**Overview**

This funding request supports the upkeep of a lab footprint valued at $600 million in three geographic locations, with more than 240 acres of land, including 117 buildings with over 1,000,000 square feet of space, supporting in excess of 1,400 federal and contractor employees. As indicated in the National Energy Technology Laboratory (NETL) Ten Year Site Plan, priorities for funding are established to ensure compliance with life safety standards, to maintain critical lab infrastructure, to further implementation of the lab consolidation plan for NETL's Albany site, to comply with High Performance Sustainable Building goals including Labs 21 compliance and to maintain critical Information Technology infrastructure.

**Highlights of the FY 2016 Budget Request**

The FY 2016 General Plant Projects (GPP) funding will be prioritized consistent with NETL's Ten Year Site Plan to achieve the following:

- Critical safety projects to address ArcFlash deficiencies and to replace failing infrastructure for fire protection and potable water lines will continue.
- Projects to provide up-to-date building management systems at the NETL Morgantown site will be implemented.
- Implementation of NETL's Consolidation Plan for its Albany site will continue on schedule.
- Projects to achieve compliance with sustainability goals mandated in Public Law 110-140, The Energy Independence and Security Act of 2007, and Executive Orders 13423 and 13514 will be implemented on schedule.
- Projects targeted to address deferred maintenance at NETL facilities will be implemented.
- Improvement of critical laboratory core capability will continue.
- Needed improvements to NETL's Information Technology infrastructure will be implemented.

**Plant and Capital Equipment**
**Funding ($K)**

| | FY 2014 Enacted | FY 2014 Current | FY 2015 Enacted | FY 2016 Request | FY 2016 vs FY 2015 |
|---|---|---|---|---|---|
| General Plant Projects | 16,032 | 16,032 | 15,782 | 18,044 | +2,262 |
| **Total, Plant and Capital Equipment** | **16,032** | **16,032** | **15,782** | **18,044** | **+2,262** |

**Plant and Capital Equipment**
**Explanation of Major Changes ($K)**

| | FY 2016 vs FY 2015 |
|---|---|
| **General Plant Projects:** An increase of $2,262K from the FY 2015 Enacted funding level is requested to address deferred maintenance at each of NETL's sites, as well as provide funding for the installation of new alarm detection and notification systems which will lower operating costs and improve protection of employees and plant equipment. | **+2,262** |
| **Total, Plant and Capital Equipment** | **+2,262** |

**Plant and Capital Equipment**

**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **Plant and Capital Equipment $15,782,000** | **$18,044,000** | **+$2,262,000** |
| • General Plant Projects (GPP) funding at NETL will be used to consolidate operations and address significant life safety deficiencies at its Albany, Oregon site' to correct critical infrastructure issues at multiple sites, and, to move toward compliance with DOE sustainability goals as specified in the Energy Policy Act of 2005, the Energy Independence and Security Act of 2007, and Executive Orders 13423 and 13514. | • General Plant Projects (GPP) funding at NETL will be used to support the upkeep of the lab footprint as indicated in NETL's Ten Year Site Plan. Priorities for funding are established to ensure compliance with life safety standards, to maintain critical lab infrastructure, to further implementation of the lab consolidation plan for NETL's Albany site, to comply with High Performance Sustainable Building goals including Labs 21 compliance, and to maintain critical IT infrastructure. | • Additional funding will be used to address deferred maintenance issues, as well as replace an aging alarm detection and notification system with newer technology. |

## Plant and Capital Equipment
## Capital Summary ($K)

| | Total | Prior Years | FY 2014 Enacted | FY 2014 Current | FY 2015 Enacted | FY 2016 Request | FY 2016 vs FY 2015 |
|---|---|---|---|---|---|---|---|
| **Capital Operating Expenses Summary (including (Major Items of Equipment (MIE))** | | | | | | | |
| Plant Projects (GPP and IGPP) (<$10M) | n/a | n/a | 16,032 | 16,032 | 15,782 | 18,044 | +2,262 |
| **Total, Capital Operating Expenses** | **n/a** | **n/a** | **16,032** | **16,032** | **15,782** | **18,044** | **+2,262** |
| **Plant Projects (GPP and IGPP) (Total Estimated Cost (TEC) <$10M)** | | | | | | | |
| Total Plant Projects (GPP/IGPP) (Total Estimated Cost (TEC) <$5M) | n/a | n/a | 16,032 | 16,032 | 15,782 | 18,044 | +2,262 |
| **Total, Plant Projects (GPP/IGPP) (Total Estimated Cost (TEC) <$10M)** | **n/a** | **n/a** | **16,032** | **16,032** | **15,782** | **18,044** | **+2,262** |
| **Total, Capital Summary** | **n/a** | **n/a** | **16,032** | **16,032** | **15,782** | **18,044** | **+2,262** |

## Fossil Energy Environmental Restoration

**Overview**

Fossil Energy (FE) Environmental Restoration activities ensure protection of workers, the public, the environment, facilities and operations in performing the FE mission of the National Energy Technology Laboratory (NETL) at the Morgantown, West Virginia; Pittsburgh, Pennsylvania; Sugarland, Texas; Fairbanks, Alaska; and Albany, Oregon sites.

This program supports actions and projects to correct Environment, Safety, Security, and Health (ESS&H) deficiencies associated with the various programs and infrastructure across all NETL sites. Actions and projects performed under this program are not considered to be classified as capital asset projects as defined by DOE Order 413.3B. The program also supports actions and projects to realize DOE's pollution prevention and energy management goals. Importantly, this program supports NETL's Resource Conservation and Recovery Act (RCRA) and Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) obligations at all NETL sites and implementation of Departmental security requirements.

**Highlights of the FY 2016 Budget Request**

In FY 2016, the funding for the CERCLA subprogram will be used to continue active operation and maintenance of the groundwater remediation system at Rock Springs Sites 4, 6, 7, 9, and 12 as well as continue a 10-year surface revegetation at the Hoe Creek Site, all located in Wyoming.

In FY 2016, the RCRA subprogram will continue RCRA-related on-site regulatory, corrective, preventive, and maintenance activities, such as asbestos and lead abatement, waste minimization, hazardous waste and materials management, and pollution prevention activities. Also included in FY 2016 funding is the NETL Albany site RCRA clean-up which includes: abating lead and asbestos exposures; resolving chemical storage issues; monitoring soil and ground water; maintaining ventilation and air pollution systems; improving air emission management, materials handling, facility equipment disposal, and waste disposal activities; regulatory ground water monitoring activities in conjunction with the Oregon Department of Environmental Quality (ODEQ) involving investigation; and risk assessment activities for the specific trichloroethylene (TCE) ground water contamination issue.

The Other ESS&H subprograms will continue to implement and improve baseline regulatory compliance, integrated safety management, and ISO 14001/OHSAS 18001 certified management programs including emergency management, occupational medicine and health, industrial hygiene, industrial safety, environmental management, ergonomics, ESS&H training, security programs, and fire protection. This will include: actions in support of addressing ESS&H deficiencies associated with facilities and infrastructure; actions in support of achieving DOE's pollution prevention and energy management goals; and improving emergency response capabilities and alarm infrastructures. It will also implement actions in support of personnel security, operational security, export/import controls, and the foreign national visitor and assignment programs.

**Fossil Energy Environmental Restoration**
**Funding ($K)**

| | FY 2014 Current[1] | FY 2014 Enacted | FY 2015 Enacted | FY 2016 Request | FY 2016 vs FY 2015 |
|---|---|---|---|---|---|
| **Fossil Energy Environmental Restoration** | | | | | |
| CERCLA[1] Remedial Actions | 200 | 200 | 200 | 525 | +325 |
| RCRA[2] Remedial Actions | 1,697 | 1,697 | 1,697 | 1,697 | 0 |
| Other ESS&H[3] Actions | 4,000 | 4,000 | 4,000 | 5,975 | +1,975 |
| **Total, Fossil Energy Environmental Restoration** | **5,897** | **5,897** | **5,897** | **8,197** | **+2,300** |

[1] CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act (of 1980)
[2] RCRA = Resource Conservation and Recovery Act (of 1976)
[3] ESS&H = Environment, Safety, Security, and Health

**Fossil Energy Environmental Restoration**
**Explanation of Major Changes ($K)**

| | FY 2016 vs FY 2015 |
|---|---|
| **CERCLA Remedial Actions:** Continuing activities include groundwater remediation at Rock Springs and a 10-year revegetation effort at Hoe Creek. Increase in funding is directly related to manpower support requirements for variable work involving air sparging activities at the Rock Springs sites. | **+325** |
| **RCRA Remedial Actions:** Asbestos and lead abatement activities continue to diminish; however, air pollution prevention and hazardous materials management to increase. A significant driver of costs in this activity remains the investigation and development of remediation options and other compliance activities as required by the State of Oregon related to the groundwater contamination at the Albany site. | **0** |
| **Other ES&H Actions:** Concentrate on core ESS&H activities while maintaining regulatory work with CERCLA and RCRA. Upgrades to existing ESS&H infrastructure such as fire/gas alarms systems, emergency response equipment and facilities, and security systems are needed. Also needed are replacements for existing corrective action and chemical management software systems. | **+1,975** |
| **Total, Fossil Energy Environmental Restoration** | **+2,300** |

**Fossil Energy Environmental Restoration**

**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **Fossil Energy Environmental Restoration** | | |
| **$5,897,000** | **$8,197,000** | **+$2,300,000** |
| **CERCLA Remedial Actions $200,000** | **$525,000** | **+325,000** |
| • Continue active operation and maintenance of the air sparge remediation system at Rock Springs Sites 4, 6, 7, 9, and 12 as well as a 10-year surface revegetation at the Hoe Creek Site | • Continue active operation and maintenance of the air sparge remediation system at Rock Springs Sites 4, 6, 7, 9, and 12 as well as a 10-year surface revegetation at the Hoe Creek Site | Additional funding will be used for manpower requirements for variable work involving air sparging activities at the Rock Springs sites. |
| **RCRA Remedial Actions $1,697,000** | **$1.697,000** | **$0** |
| • Continue RCRA-related on-site regulatory, corrective, preventive, and maintenance activities, such as asbestos and lead abatement, waste minimization, and pollution prevention activities along with the NETL Albany groundwater investigation and compliance activities. | • Continue RCRA-related on-site regulatory, corrective, preventive, and maintenance activities, such as asbestos and lead abatement, waste minimization, and pollution prevention activities along with the NETL Albany groundwater investigation and compliance activities. | No change. |

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **Other ES&H Actions $4,000,000** | **$5,975,000** | **+1,975,000** |
| • Continue to implement and improve baseline regulatory compliance, integrated safety management, and ISO 14001 programs. Also continue implementation of actions in support of personnel security, operational security, export/import controls, and the foreign national visitor and assignment programs. Upgrade existing infrastructure systems such as fire/gas alarm systems, emergency response equipment and facilities, and software support systems. | • Continue to implement and improve baseline regulatory compliance, integrated safety management, and ISO 14001 programs. Also continue implementation of actions in support of personnel security, operational security, export/import controls, and the foreign national visitor and assignment programs. Upgrade existing infrastructure systems such as fire/gas alarm systems, emergency response equipment and facilities, and software support systems. | Additional funding will be used to replace existing corrective action and chemical management software systems which have been in use for a number of years and which are no longer economical to maintain. These systems also no longer meet increased performance requirements for the important ESS&H programs they support. |

## Supercomputer

**Overview**

The National Energy Technology Laboratory (NETL) is home to the NETL Supercomputer – one of the world's largest high-performance computers – along with an advanced visualization center serving the Fossil Energy's research and development needs.

A unique and collaborative tool tailored for science and engineering calculations in support of Fossil Energy (FE) research, the Supercomputer advances FE and NETL missions by creating complex model simulations for advanced energy technology development. These types of simulations help overcome technical development barriers quickly, reliably, and cost-effectively. The Supercomputer design balances computational requirements, efficiency, usability, and collaboration techniques to deliver a premier system to the Lab and its partners.

**Highlights of the FY 2016 Budget Request**

The NETL Supercomputer, commissioned in 2012, is currently scheduled to begin an update/refresh process in FY 2016. Given the rapid advances in computing technology, Supercomputers typically have an expected life cycle of approximately three years after which standard warranties run out, replacement parts are not readily available, and maintenance costs rapidly escalate. The funding requested in FY 2016 will cover the cost of the first stage of the refresh process. Thanks to advances in technology, the computational power of the next generation equipment will be much greater. It is anticipated that the refresh will upgrade the processing speed to 5 PFLOPS, a 10-fold increase.

**Supercomputer**
**Funding ($K)**

| | FY 2014 Current | FY 2014 Enacted | FY 2015 Enacted | FY 2016 Request | FY 2016 vs FY 2015 |
|---|---|---|---|---|---|
| Supercomputer | 0 | 0 | 0 | 5,500 | +5,500 |
| **Total, Supercomputer** | **0** | **0** | **0** | **5,500** | **+5,500** |

**Supercomputer**
**Explanation of Major Changes ($K)**

| | FY 2016 vs FY 2015 |
|---|---|
| **Supercomputer**: The request for funding for the Supercomputer is a new budget line for FY 2016. This funding will provide for an update/refresh of a subset of the processing units in the high performance computer. | **+5,500** |
| **Total, Supercomputer** | **+5,500** |

**Supercomputer**

**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **Supercomputer $0** | **$5,500,000** | **+$5,500,000** |
| The NETL Supercomputer was commissioned in FY 2012. As a result, the first refresh is not scheduled until FY2016 | Funding will provide for an update/refresh of a subset of the processing units in the high performance computer. This refresh will upgrade the processing speed to 5 PFLOPS, a 10-fold increase. | Funding for a new program in FY 2016. |

## Special Recruitment Programs

**Overview**

The Office of Fossil Energy (FE) developed the Mickey Leland Energy Fellowship (MLEF) Program to support an increase in the number of females and under-represented minorities entering the scientific and engineering career fields within the U.S. workforce. The MLEF Program is a ten-week summer educational program that offers undergraduate, graduate, and Ph.D. students majoring in science, technology, engineering, and mathematic disciplines the opportunity to learn about the programs, policies, and research and development initiatives within the Office of Fossil Energy and the challenges in providing clean, affordable energy for future generations.

**Highlights of the FY 2016 Budget Request**

In FY 2016, a diverse group of undergraduate, graduate, and Ph.D. students in science, technology, engineering, and mathematic majors will be recruited and selected to participate in the MLEF program. All participants in the MLEF will complete a hands-on research project under the mentorship of a Fossil Energy scientist, researcher, or program official.

**Special Recruitment Programs**
**Funding ($K)**

| | FY 2014 Enacted | FY 2014 Current | FY 2015 Enacted | FY 2016 Request | FY 2016 vs FY 2015 |
|---|---|---|---|---|---|
| Special Recruitment Programs | 700 | 700 | 700 | 700 | 0 |
| **Total, Special Recruitment Programs** | **700** | **700** | **700** | **700** | **0** |

**Special Recruitment Programs**
**Explanation of Major Changes ($K)**

| | FY 2016 vs FY 2015 |
|---|---|
| **Special Recruitment Programs:** There are no changes in funding; the program will continue ongoing efforts. | **0** |
| **Total, Special Recruitment Programs** | **0** |

**Special Recruitment Programs**

**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **Special Recruitment Programs $700,000** | **$700,000** | **+$0** |
| • A diverse group of undergraduate, graduate, and Ph.D. students in science, technology, engineering and mathematic majors will be recruited and selected to participate in the MLEF program. | • A diverse group of undergraduate, graduate, and Ph.D. students in science, technology, engineering and mathematic majors will be recruited and selected to participate in the MLEF program. | No change. |

## Fossil Energy Research and Development
## Facilities Maintenance and Repair

The Department's Facilities Maintenance and Repair activities are tied to its programmatic missions, goals, and objectives. Facilities Maintenance and Repair activities funded by this budget are displayed below.

**Costs for Direct-Funded Maintenance and Repair (including Deferred Maintenance Reduction) ($K)**

| | FY 2014 Actual Cost | FY 2014 Planned Cost | FY 2015 Planned Cost | FY 2016 Planned Cost |
|---|---|---|---|---|
| National Energy Technology Laboratory | 15,140 | 13,145 | 13,539 | 13,945 |
| **Total, Direct-Funded Maintenance and Repair** | **15,140** | **13,145** | **13,539** | **13,945** |

**Report on FY 2014 Expenditures for Maintenance and Repair**

This report responds to legislative language set forth in Conference Report (H.R. Conf. Rep. No. 108-10) accompanying the Consolidated Appropriations Resolution, 2003 (Public Law 108-7) (pages 886-887), which requests the Department of Energy provide an annual year-end report on maintenance expenditures to the Committees on Appropriations. This report compares the actual maintenance expenditures in FY 2014 to the amount planned for FY 2014, including Congressionally directed changes.

**Total Costs for Maintenance and Repair ($K)**

| | FY 2014 Actual Cost | FY 2014 Planned Cost |
|---|---|---|
| National Energy Technology Laboratory | 15,140 | 13,145 |
| **Total, Direct-Funded Maintenance and Repair** | **15,140** | **13,145** |

In review of the planned vs actual costs for FY 2014, National Energy Technology Laboratory utilized the additional $1,995K toward multiple small projects for maintenance and repair in an effort to limit or reduce growth in deferred maintenance levels.

**Fossil Energy Research and Development**
**Research and Development ($K)**

| | FY 2014 Current[1] | FY 2015 Enacted | FY 2016 Request | FY 2016 vs FY 2015 |
|---|---|---|---|---|
| Basic | 4,256 | 4,270 | 4,114 | -156 |
| Applied | 157,485 | 157,998 | 152,221 | -5,777 |
| Development | 263,894 | 264,753 | 255,072 | -9,681 |
| Subtotal, R&D | 425,635 | 427,021 | 411,407 | -15,614 |
| Equipment | 16,032 | 15,782 | 18,044 | 2,262 |
| Construction | 0 | 0 | 0 | 0 |
| **Total, R&D** | **441,667** | **442,803** | **429,451** | **-13,352** |

[1] Funding reflects the SBIR/STTR amounts transferred to the Office of Science

**Fossil Energy Research and Development**
**Small Business Innovative Research/Small Business Technology Transfer (SBIR/STTR) ($K)**

| | FY 2014 Transferred | FY 2015 Projected | FY 2016 Request | FY 2016 vs FY 2015 Projected |
|---|---|---|---|---|
| Coal | | | | |
| SBIR | 8,951 | 9,476 | 9,405 | -71 |
| STTR | 1,279 | 1,307 | 1,412 | +105 |
| Natural Gas Technologies | | | | |
| SBIR | 543 | 685 | 1,241 | +556 |
| STTR | 77 | 94 | 185 | +91 |
| Unconventional Fossil Energy Technologies | | | | |
| SBIR | 395 | 123 | 0 | -123 |
| STTR | 56 | 17 | 0 | -17 |
| **Total, SBIR/STTR** | **11,301** | **11,702** | **12,243** | **+541** |

**Fossil Energy Research and Development**
**Safeguards and Security ($K)**

| | FY 2014 Current | FY 2015 Enacted | FY 2016 Request | FY 2016 vs FY 2015 |
|---|---|---|---|---|
| Protective Forces | 2,624 | 2,176 | 2,228 | 52 |
| Physical Security Systems | 211 | 158 | 164 | 6 |
| Information Security | 59 | 52 | 54 | 2 |
| Cyber Security | 1,320 | 1,335 | 1,750 | 415 |
| Personnel Security | 106 | 109 | 110 | 1 |
| Material Control and Accountability | 0 | 0 | 0 | 0 |
| Program Management | 215 | 222 | 229 | 7 |
| Security Investigations | 0 | 0 | 0 | 0 |
| Transportation Security | 0 | 0 | 0 | 0 |
| Research and Development | 5 | 5 | 5 | 0 |
| Construction | 0 | 0 | 0 | 0 |
| **Total, Safeguards and Security** | **4,540** | **4,057** | **4,540** | 483 |

**Department Of Energy**
**FY 2016 Congressional Budget**
**Funding By Appropriation By Site**
**($K)**

| Fossil Energy Research and Development | FY 2014 Current | FY 2015 Enacted | FY 2016 Request |
|---|---|---|---|
| **Ames Laboratory** | | | |
| **CCS and Power Systems** | | | |
| Cross Cutting Reasearch | 1,367 | 925 | 925 |
| **Total, Ames Laboratory** | **1,367** | **925** | **925** |
| **Lawrence Berkeley National Laboratory** | | | |
| **CCS and Power Systems** | | | |
| Carbon Storage | 525 | 1,354 | 1,045 |
| Cross Cutting Reasearch | 2,300 | 3,025 | 1,400 |
| **Total, CCS and Power Systems** | **2,825** | **4,379** | **2,445** |
| **Natural Gas Technologies** | | | |
| Natural Gas Technologies | 890 | 857 | 250 |
| **Total, Lawrence Berkeley National Laboratory** | **3,715** | **5,236** | **2,695** |
| **Lawrence Livermore National Laboratory** | | | |
| **CCS and Power Systems** | | | |
| Cross Cutting Reasearch | 2,200 | 3,025 | 1,400 |
| **Total, Lawrence Livermore National Laboratory** | **2,200** | **3,025** | **1,400** |
| **Los Alamos National Laboratory** | | | |
| **CCS and Power Systems** | | | |
| Carbon Capture | 686 | 686 | 0 |
| Carbon Storage | 491 | 953 | 874 |
| Cross Cutting Reasearch | 2,200 | 3,025 | 1,400 |
| **Total, CCS and Power Systems** | **3,377** | **4,664** | **2,274** |
| **Natural Gas Technologies** | | | |
| Natural Gas Technologies | 600 | 600 | 250 |
| **Total, Los Alamos National Laboratory** | **3,977** | **5,264** | **2,524** |

Department Of Energy
FY 2016 Congressional Budget
Funding By Appropriation By Site
($K)

| Fossil Energy Research and Development | FY 2014 Current | FY 2015 Enacted | FY 2016 Request |
|---|---|---|---|
| **National Energy Technology Lab** | | | |
| **CCS and Power Systems** | | | |
| Carbon Capture | 88,133 | 86,048 | 116,468 |
| Carbon Storage | 103,924 | 92,723 | 101,591 |
| Advanced Energy Systems | 95,330 | 101,425 | 38,885 |
| Cross Cutting Reasearch | 25,336 | 31,029 | 40,579 |
| STEP (Supercritical CO2) | 0 | 10,000 | 19,300 |
| NETL Coal R&D | 50,011 | 50,000 | 34,031 |
| **Total, CCS and Power Systems** | **362,734** | **371,225** | **350,854** |
| **Natural Gas Technologies** | | | |
| Natural Gas Technologies | 17,332 | 21,487 | 40,920 |
| **Program Direction** | | | |
| National Energy Technology Center Program Direction | 84,963 | 87,239 | 83,893 |
| **Fossil Energy Environmental Restoration** | | | |
| Fossil Energy Environmental Restoration | 4,477 | 4,477 | 6,777 |
| **Unconventional Fossil Energy Technologies** | | | |
| Unconventional Fossil Energy Technologies | 14,167 | 4,208 | 0 |
| **Super Computer** | | | |
| Super Computer | 0 | 0 | 5,500 |
| **Total, National Energy Technology Lab** | **483,673** | **488,636** | **487,944** |
| **Oak Ridge National Laboratory** | | | |
| **CCS and Power Systems** | | | |
| Advanced Energy Systems | 1,175 | 1,575 | 500 |
| Cross Cutting Reasearch | 2,013 | 1,800 | 1,249 |
| **Total, CCS and Power Systems** | **3,188** | **3,375** | **1,749** |
| **Total, Oak Ridge National Laboratory** | **3,188** | **3,375** | **1,749** |
| **Pacific Northwest National Laboratory** | | | |
| **CCS and Power Systems** | | | |
| Carbon Capture | 412 | 1,266 | 163 |
| Cross Cutting Reasearch | 2,900 | 3,325 | 1,700 |
| **Total, CCS and Power Systems** | **3,312** | **4,591** | **1,863** |
| **Natural Gas Technologies** | | | |
| Natural Gas Technologies | 80 | 50 | 0 |
| **Total, Pacific Northwest National Laboratory** | **3,392** | **4,641** | **1,863** |

**Department Of Energy**
**FY 2016 Congressional Budget**
**Funding By Appropriation By Site**
**($K)**

| Fossil Energy Research and Development | FY 2014 Current | FY 2015 Enacted | FY 2016 Request |
|---|---|---|---|
| **Sandia National Laboratories** | | | |
| **CCS and Power Systems** | | | |
| Carbon Storage | 291 | 184 | 78 |
| Cross Cutting Reasearch | 300 | 300 | 300 |
| **Total, CCS and Power Systems** | **591** | **484** | **378** |
| **Natural Gas Technologies** | | | |
| Natural Gas Technologies | 250 | 250 | 250 |
| **Total, Sandia National Laboratories** | **841** | **734** | **628** |
| **Washington Headquarters** | | | |
| **CCS and Power Systems** | | | |
| Carbon Storage | 262 | 4,786 | 5,180 |
| Cross Cutting Reasearch | 2,116 | 2,546 | 2,289 |
| **Total, CCS and Power Systems** | **2,378** | **7,332** | **7,469** |
| **Natural Gas Technologies** | | | |
| Natural Gas Technologies | 828 | 1,877 | 2,330 |
| **Program Direction** | | | |
| Headquarters Program Direction | 35,037 | 31,761 | 30,309 |
| **Fossil Energy Environmental Restoration** | | | |
| Fossil Energy Environmental Restoration | 1,420 | 1,420 | 1,420 |
| **Plant & Capital Equipment** | | | |
| Plant & Capital Equipment | 16,032 | 15,782 | 18,044 |
| **Special Recruitment Programs** | | | |
| Special Recruitment Programs | 700 | 700 | 700 |
| **Unconventional Fossil Energy Technologies** | | | |
| Unconventional Fossil Energy Technologies | 382 | 292 | 0 |
| **Total, Washington Headquarters** | **56,777** | **59,164** | **60,272** |
| **Total, Fossil Energy Research and Development** | **559,130** | **571,000** | **560,000** |

# Naval Petroleum and Oil Shale Reserves

# Naval Petroleum and Oil Shale Reserves

## Naval Petroleum and Oil Shale Reserves
## Proposed Appropriation Language

For Department of Energy expenses necessary to carry out naval petroleum and oil shale reserve activities, [$19,950,000] *$17,500,000* to remain available until expended: *Provided*, That, notwithstanding any other provision of law, unobligated funds remaining from prior years shall be available for all naval petroleum and oil shale reserve activities.

### Explanation of Changes

Reduction in Naval Petroleum Reserve No. 3 (NPR-3) Production and Operations and Management requirements are a result of the FY 2015 transfer of ownership and subsequent FY 2016 closure of the Casper, Wyoming office and offsetting increase in environmental remediation activities at the previously sold Naval Petroleum Reserve 1 (NPR-1) in California.

**Public Law Authorizations**

- P.L. 94-258, U.S. Naval Petroleum reserves Production Act of 1977
- P.L. 95-91, U.S. Department of Energy Organization Act of 1977
- P.L. 104-106, The National Defense Authorization Act For Fiscal Year 1996
- P.L. 105-261, The Strom Thurmond National Defense Act for Fiscal Year 1999
- P.L. 109-58, Energy Policy Act of 2005

## Naval Petroleum and Oil Shale Reserves

| ($K) | | | |
|---|---|---|---|
| FY 2014 Enacted | FY 2014 Current | FY 2015 Enacted | FY 2016 Request |
| 19,999 | 22,457 | 19,950 | 17,500 |

**Overview**

The Naval Petroleum and Oil Shale Reserves (NPOSR) program manages a number of legal agreements that were executed as part of the 1998 sale of Naval Petroleum Reserve No. 1 (NPR-1) in California. These agreements direct post-sale work including environmental restoration and remediation, contract closeout, and records disposition. Legal agreements include payment for post-employment medical and dental benefits to former Management & Operating (M&O) contractor employees. The NPR-1 program continues to work towards closing out the remaining environmental findings, as required by the 2008 agreement between DOE and the California Department of Toxic Substances Control (DTSC).

DOE also operates Naval Petroleum Reserve 3 (NPR-3) and the Rocky Mountain Oilfield Testing Center (RMOTC), co-located near Casper, Wyoming. A three-phased implementation plan for selling the facility and closing out the office has been developed. Phase I involved the preparation of NPR-3 for sale. Phase II will be the competitive sale process and transfer NPR-3 to a new owner anticipated in the second quarter of FY 2015. Phase III will be the final closeout of the Casper office estimated to be completed in the second quarter of FY 2016. Over the course of the three phases, DOE will mitigate any issues identified; comply with relevant laws and regulations; and protect the safety and health of the NPR-3 staff, contractors, and visitors.

National Environmental Policy Act (NEPA), Wyoming Department of Environmental Quality (WDEQ), and State Historic Preservation Officer (SHPO) regulatory requirements will continue to be completed as required at NPR-3. Cultural resource mitigation activities will continue with the SHPO in compliance with the National Historic Preservation Act (NHPA). Administrative staff will complete closeout process of contracts and disposal of remaining personal property and office equipment once these items are no longer required.

**Highlights and Major Changes in the FY 2016 Budget Request**

NPR-1 will continue to work with California Resources Corporation (CRC) (formerly Occidental), Chevron, and the California DTSC on the environmental remediation and cultural resource activities in accordance with the 2008 DTSC Corrective Action Consent Agreement. Also included is the payment to former Management and Operating (M&O) contractor employees for post-employment medical and dental benefits.

NPR-3 will complete Phase III of the disposition plan - the closeout of the Casper office - with activities including closure of contracts, any remaining work to mitigate and close the landfill, any remaining work to implement the cultural resources agreement with the SHPO, preparation of field IT and equipment for disposal, records management processing, and disposal of personal property.

**FY 2014 Key Accomplishments**

NPR-1

- Investigated 63 Areas of Concern (AOC) with 187 sub-areas for environmental contamination.
- Submitted quarterly and annual reports required by the Incidental Take Permit that was approved by California Department of Fish and Wildlife in August 2013 – key elements include use of 1998 set-aside lands, re-vegetation plan and monitoring, training and on-site biologist during field activities.
- Completed 17 work plans to investigate 32 AOCs.
- Completed CEQA (NEPA) documentation for removal action.

NPR-3

- Improved production capabilities in preparation for sale of NPR-3.
- Issued Invitation for Bids for NPR-3 and received bids in the competitive sale process.

**Naval Petroleum and Oil Shale Reserves**
**Funding by Congressional Control ($K)**

| | FY 2014 Enacted | FY 2014 Current | FY 2015 Enacted | FY 2016 Request | FY 2016 vs FY 2015 |
|---|---|---|---|---|---|
| **Naval Petroleum and Oil Shale Reserves** | | | | | |
| Production Operations | 12,999 | 15,457 | 13,271 | 13,330 | +59 |
| Management | 7,000 | 7,000 | 6,679 | 4,170 | -2,509 |
| **Total, Naval Petroleum and Oil Shale Reserves** | **19,999** | **22,457**[1] | **19,950** | **17,500** | **-2,450** |
| **Federal FTEs** | **20** | **10** | **10** | **8** | **-2** |

[1] Includes new budget authority and $2,458K in proceeds from NPR-3 asset sale. These proceeds are available during FY 2014 and FY 2015 for purchase of replacement property. Any unused proceeds will be returned to the Treasury as miscellaneous receipts.

## Production Operations

**Overview**

The NPR-1 program continues to close out the remaining environmental restoration and remediation activities, as required by the 2008 agreement between DOE and California's DTSC. NPR-1 will continue the oversight of environmental remediation of the Elk Hills site and the work on records disposition.

The NPR-3 program will complete Phase III of the disposition plan - the closeout of the Casper office – following transfer of ownership of NPR-3 in FY 15.

**Highlights of the FY 2016 Budget Request**

NPR-1 continues the ongoing activities to attain release from the remaining environmental findings related to the sale of NPR-1 Elk Hills. The FY 2016 request includes the following activities: Remedial Action Work plans will be developed for six sumps that exceed safe life and human health levels for consolidation and clean closure. A burn dump that is currently graded and used for oil production is planned to be covered with a clay cap. FY 2014 field work indicated that abandoned shallow oil zone tank settings have contaminated material. The site has been identified to be clean closed by hauling the material to another contaminated site and combining the material.

Implementation of the NPR-3 Disposition Plan Phase III will continue. Disposition activities will include completion of cultural resource mitigation activities in compliance with the NHPA and the agreement with the SHPO, completion of any remaining environmental remediation work including landfill mitigation per WDEQ requirements, and addressing any remaining mitigation factors identified through the NEPA Environmental Assessment (EA) regulatory review.

## Production Operations
## Funding ($K)

| | FY 2014 Enacted | FY 2014 Current | FY 2015 Enacted | FY 2016 Request | FY 2016 vs FY 2015 |
|---|---|---|---|---|---|
| **Production Operations** | | | | | |
| NPR-1 Closeout | 8,826 | 8,826 | 8,680 | 12,330 | +3,650 |
| NPR-3 Disposition | 4,173 | 6,631 | 4,591 | 1,000 | -3,591 |
| **Total, Production Operations** | **12,999** | **15,457** | **13,271** | **13,330** | **+59** |

**Production Operations**
**Explanation of Major Changes ($K)**

| | FY 2016 vs FY 2015 |
|---|---|
| **NPR-1 Closeout:** The increase provides for an acceleration of environmental remediation activities, thereby reducing the current projected schedule for completion of DOE's legal responsibilities related to environmental remediation at NPR-1 (Elk Hills, CA) and potentially lowering total remediation cost. | **+3,650** |
| **NPR-3 Disposition:** The decrease is due to the sale of NPR-3 and the anticipated completion of in FY 2015 of nearly all of the environmental remediation work related to the mitigation and closure of the landfill, funding of the land trust to implement the cultural resources agreement with the SHPO**.** The transfer to the new owner is anticipated to occur in the second quarter of FY 2015. | **-3,591** |
| **Total, Production Operations** | **+59** |

## Production Operations

**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **Production and Operations $13,271,000** | **$13,330,000** | **+$59,000** |
| **NPR-1 Closeout $8,680,000** | **$12,330,000** | **+$3,650,000** |
| NPR-1 continues the ongoing activities to attain release from the remaining environmental findings related to the sale of NPR-1 Elk Hills. Environmental remediation will be conducted for those sites exceeding human health risk levels. Extensive confirmatory sampling will be conducted following remediation in order to support DOE's request for release from further correction action. | NPR-1 continues the ongoing activities to attain release from the remaining environmental findings related to the sale of NPR-1 Elk Hills. Work plans will be developed for additional characterization, surface samples, and borings for sumps that exceed safe life and human health levels to determine full vertical and lateral extent of the arsenic contamination. Remedial Action Work plans will be developed for six sumps that exceed safe life and human health levels for consolidation and clean closure. A burn dump that is currently graded and used for oil production is planned to be covered with a clay cap. Abandoned shallow oil zone tank settings containing contaminated material are to be clean closed by hauling the material to another contaminated site and combining the material. | Increased funding enables work on Area of Concern (AOC) 018 that comprises a well pad, a primary sump and an adjacent secondary (overflow) sump, located 15 feet below well pad elevation. Sump was used during past operations, and a RCRA Facility Assessment identified arsenic and compounds as chemicals of concern. Confirmatory sampling determined that additional work will be required for removal of a sizable amount of contaminated soil. The well pad measures approximately 135 feet by 35 feet. The combined measurement of AOC 018 is 180 feet by 90 feet. |
| **NPR-3 Disposition $4,591,000** | **$1,000,000** | **-$3,591,000** |
| Continue implementation of NPR-3 Disposition Plan with the sale of NPR-3 through a competitive bidding process. Production operations will continue until the sale is completed and the property is transferred to new owners at which time Federally managed production operations will cease, as will deposits into the U.S. Treasury. Post-sale activities include environmental remediation work related to the landfill and the mitigating factors required by the agreement with the SHPO. | Completion of Phase III of the NPR-3 Disposition Plan. | The decrease is due to the sale of NPR-3/RMOTC and the discontinuation of production activities; the completion of most of the cultural resource mitigation activities in compliance with the NHPA and the agreement with the SHPO, and the completion of most of remaining mitigation factors identified through the NEPA, including environmental remediation related to the landfill. |

## Management

**Overview**

Management provides the Federal staffing resources and associated costs required to provide overall direction and execution of the Naval Petroleum and Oil Shale Reserves (NPOSR). There are a variety of functions that are inherently governmental (e.g., program management, contract administration, budget formulation and execution that require a dedicated Federal workforce). NPOSR uses contractor support services and other related expenses to support the management of the program.

**Highlights of the FY 2016 Budget Request**

The NPR-1 Elk Hills funding supports Federal staff that monitor environmental clean-up, oversight and records disposition activities. The Sales agreement also includes payments to former Management and Operating (M&O) contractor employees for post-medical and dental benefits.

NPR-3/RMOTC will continue administrative closure activities to close down the office in Casper, Wyoming. Final office closeout will be completed by the second quarter of 2016. Office closeout activities will include closure of contracts, preparation of IT equipment for disposal, records management processing, and disposal of personal property.

**Management**
**Funding ($K)**

| Program Direction Summary | FY 2014 Enacted | FY 2014 Current | FY 2015 Enacted | FY 2016 Request | FY 2016 vs FY 2015 |
|---|---|---|---|---|---|
| **Washington Headquarters** | | | | | |
| Salaries and Benefits | 700 | 700 | 525 | 525 | 0 |
| Travel | 50 | 50 | 50 | 50 | 0 |
| Support Services | 275 | 275 | 450 | 450 | 0 |
| Other Related Expenses | 948 | 948 | 1,045 | 1,045 | 0 |
| **Total, Washington Headquarters** | **1,973** | **1,973** | **2,070** | **2,070** | **0** |
| | | | | | |
| **NPR – Wyoming** | | | | | |
| Salaries and Benefits | 1,285 | 1,285 | 1,350 | 860 | -490 |
| Travel | 70 | 70 | 70 | 35 | -35 |
| Support Services | 3,120 | 3,120 | 2,634 | 905 | -1,729 |
| Other Related Expenses | 552 | 552 | 555 | 300 | -255 |
| **Total, NPR – Wyoming** | **5,027** | **5,027** | **4,609** | **2,100** | **-2,509** |
| | | | | | |
| **Total Program Direction** | | | | | |
| Salaries and Benefits | 1,985 | 1,985 | 1,875 | 1,385 | -490 |
| Travel | 120 | 120 | 120 | 85 | -35 |
| Support Services | 3,395 | 3,395 | 3,084 | 1,355 | -1,729 |
| Other Related Expenses | 1,500 | 1,500 | 1,600 | 1,345 | -255 |
| **Total, Program Direction** | **7,000** | **7,000** | **6,679** | **4,170** | **-2,509** |
| **Federal FTEs** | **20** | **20** | **10** | **8** | **-2** |

| | FY 2014 Enacted | FY 2014 Current | FY 2015 Enacted | FY 2016 Request | FY 2016 vs FY 2015 |
|---|---|---|---|---|---|
| **Support Services and Other Related Expenses** | | | | | |
| **Support Services** | | | | | |
| Technical Support | | | | | |
| Environmental, Safety, Security & Health | 755 | 755 | 505 | 270 | -235 |
| Technical Services | 1,525 | 1,525 | 1,450 | 450 | -1,000 |
| Total, Technical Support | **2,280** | **2,280** | **1,955** | **720** | **-1,235** |
| Management Support | | | | | |
| Business Administration | 695 | 695 | 704 | 360 | 344 |
| IT Support | 420 | 420 | 425 | 275 | 150 |
| Total Management Support | **1,115** | **1,115** | **1,129** | **635** | **-494** |
| **Total, Support Services** | **3,395** | **3,395** | **3,084** | **1,355** | **-1,729** |
| **Other Related Expenses** | | | | | |
| Rent to Others | 206 | 206 | 210 | 115 | -95 |
| Communications, Utilities & Misc. | 160 | 160 | 170 | 90 | -80 |
| Other Services | 1,072 | 1,072 | 1,185 | 1,120 | -65 |
| Operation and Maintenance of Equipment | 15 | 15 | 10 | 5 | -5 |
| Supplies and Materials | 47 | 47 | 25 | 15 | -10 |
| **Total, Other Related Expenses** | **1,500** | **1,500** | **1,600** | **1,345** | **-255** |

**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 Enacted |
|---|---|---|
| **Management $6,679,000** | **$4,170,000** | **-$2,509,000** |
| **Salaries and Benefits $1,875,000** | **$1,385,000** | **-$490,000** |
| Continue monitoring (environmental clean-up, oversight and audits) activities. | Continue monitoring (cultural resources mitigation, environmental clean-up, oversight and audit) activities. | The decrease is the result of closure of the NPR-3/RMOTC Casper site office, anticipated to occur in the second quarter of FY 2016. |
| **Travel $120,000** | **$85,000** | **-$35,000** |
| Federal travel remains at prior reduced levels and will be available to accomplish disposition process and environmental clean-up. | Federal travel remains at prior reduced levels and will be available to accomplish disposition process and environmental clean-up. | The decrease is due to the closure of NPR-3/RMOTC Casper site office, anticipated to occur in the second quarter of FY 2016. |
| **Support Services $3,084,000** | **$1,355,000** | **-$1,729,000** |
| Support Services provided for ESS&H, IT, Finance, and Technical Services support in preparation of disposition of the site and environmental clean-up of NPR-1. | Support Services provided for ESS&H, IT, Finance, and Technical Services support in preparation of disposition of the site at NPR-3 and environmental clean-up of NPR-1. | The decrease is due to reduction of technical services, ESS&H support, and Management support as a result of NPR-3 disposition. |
| **Other Related Expenses $1,600,000** | **$1,345,000** | **-$255,000** |
| Funding provides for communication services materials and supplies, services; lease of Casper office and NPR Headquarters other expenses. | Funding provides for communication services, materials and supplies, services; lease of Casper office and NPR Headquarters other expenses. Office lease expires December 2015. | The decrease is due to NPR-3 disposition - reduction of other services required, reduced maintenance of equipment due to disposal of property and the purchases of materials and supplies will be reduced. |

## Naval Petroleum and Oil Shale Reserves
## Facilities Maintenance and Repair

The Department's Facilities Maintenance and Repair activities are tied to its programmatic missions, goals, and objectives. Facilities Maintenance and Repair activities funded by this budget are displayed below.

**Costs for Direct-Funded Maintenance and Repair (including Deferred Maintenance Reduction) ($K)**

| | FY 2014 Actual Cost | FY 2014 Planned Cost | FY 2015 Planned Cost | FY 2016 Planned Cost |
|---|---|---|---|---|
| Naval Petroleum and Oil Shale Reserves, NPR-3 | 900 | 900 | 490 | 0 |
| Total, Direct-Funded Maintenance and Repair | 900 | 900 | 490 | 0 |

**Naval Petroleum and Oil Shale Reserves**

**Safeguards and Security ($K)**

| | FY 2014 Current | FY 2015 Request | FY 2016 Request | FY 2016 vs FY 2015 Request |
|---|---|---|---|---|
| Protective Forces | 0 | 0 | 0 | 0 |
| Physical Security Systems | 4 | 4 | 0 | 0 |
| Information Security | 61 | 26 | 0 | -26 |
| Cyber Security | 0 | 0 | 0 | 0 |
| Personnel Security | 0 | 0 | 0 | 0 |
| Material Control and Accountability | 0 | 0 | 0 | 0 |
| Program Management | 67 | 57 | 0 | -57 |
| Program Direction | 0 | 0 | 0 | 0 |
| Transportation Security | 0 | 0 | 0 | 0 |
| Research and Development | 0 | 0 | 0 | 0 |
| Construction | 0 | 0 | 0 | 0 |
| **Total, Safeguards and Security** | **132** | **83** | **0** | **-83** |

**Department Of Energy**

**FY 2016 Congressional Budget**

**Funding By Appropriation By Site**

**($K)**

| Naval Petroleum and Oil Shale Reserves | FY 2014 Current | FY 2015 Enacted | FY 2016 Request |
|---|---|---|---|
| **Naval Petroleum Reserve No 1** | | | |
| **Naval Petroleum and Oil Shale Reserves** | | | |
| Productions Operations | 8,826 | 8,680 | 12,330 |
| Management | 903 | 1,000 | 1,000 |
| **Total, Naval Petroleum and Oil Shale Reserves** | **9,729** | **9,680** | **13,330** |
| **Total, Naval Petroleum Reserve No 1** | **9,729** | **9,680** | **13,330** |
| **Naval Petroleum Reserve No 3** | | | |
| **Naval Petroleum and Oil Shale Reserves** | | | |
| Productions Operations | 6,631 | 4,591 | 1,000 |
| Management | 5,027 | 4,609 | 2,100 |
| **Total, Naval Petroleum and Oil Shale Reserves** | **11,658** | **9,200** | **3,100** |
| **Total, Naval Petroleum Reserve No 3** | **11,658** | **9,200** | **3,100** |
| **Washington Headquarters** | | | |
| **Naval Petroleum and Oil Shale Reserves** | | | |
| Management | 1,070 | 1,070 | 1,070 |
| **Total, Washington Headquarters** | **1,070** | **1,070** | **1,070** |
| **Total, Naval Petroleum and Oil Shale Reserves** | **22,457** | **19,950** | **17,500** |

# Strategic Petroleum Reserve

# Strategic Petroleum Reserve

## Strategic Petroleum Reserve
## Proposed Appropriation Language

For necessary expenses for Strategic Petroleum Reserve facility development and operations and program management activities pursuant to the Energy Policy and Conservation Act (42 U.S.C. 6201 et seq.), [200,000,000] *$257,000,000* to remain available until expended.

### Explanation of Changes

Increase reflects additional Major Maintenance and Cavern Integrity activities to assure storage capability and integrity at SPR's underground storage caverns.

**Public Law Authorizations**
Public Law 109-58, "Energy Policy Act of 2005"

## Strategic Petroleum Reserve

**($K)**

| FY 2014 Enacted | FY 2014 Current | FY 2015 Enacted | FY 2016 Request |
|---|---|---|---|
| 189,360 | 189,360 | 200,000 | 257,000 |

**Overview**

The Strategic Petroleum Reserve (SPR) protects the U.S. from disruptions in critical petroleum supplies and meets the U.S. obligations under the International Energy Program (Energy Policy and Conservation Act, P.L. 94-163, as amended, Section 151).

Most recently, the SPR performed an operational Test Sale to test the sales and distribution capabilities within the TEXOMA distribution group which includes the SPR sites at Big Hill, Texas and West Hackberry, Louisiana. The test sale helped evaluate how significant changes in domestic crude oil production, increased imports of Canadian crude oil, and changes in the crude oil distribution infrastructure upon which the SPR relies impact the ability to distribute SPR crude oil. There is 691 million barrels of inventory remaining in the Reserve that provides 112 days of net import protection. The FY 2016 Budget Request addresses delayed maintenance on the aging infrastructure and cavern integrity activities as well as management, security, and operational readiness of the Reserve.

**Highlights and Major Changes in the FY 2016 Budget Request**

This level of funding in FY 2016 will provide the program with full SPR operational readiness and drawdown capability. The program will continue the degasification of crude oil inventory to ensure its availability and conduct wellbore testing and cavern remediation. Major changes from FY 2015 include: an increase in the number of cavern remediations from 6 to 10; a significant reduction in the deferred maintenance backlog; the addition of a custody transfer flow metering skid; and suspension of the Capacity Maintenance Program.

**FY 2014 Key Accomplishments**

- Met all objectives of the operational Test Sale, completing delivery of 4,998,146 barrels of crude oil over a 47 day period resulting in $468,564,599 of cash receipts to the U.S. Government.
- Restarted degas plant operations at West Hackberry in August 2014.
- Transitioned to new Management & Operations contractor (Fluor Federal Petroleum Operations).

**Crosscutting Initiatives**

The Department is organized into three Under Secretariats—Science and Energy, Nuclear Security, and Management and Performance—which recognize the complex interrelationship among DOE Program Offices. The FY 2016 Budget continues crosscutting programs which coordinate across the Department and seek to tap DOE's full capability to effectively and efficiently address the U.S.'s energy, environmental, and national security challenges. These crosscutting initiatives will be discussed further within the programs in which the crosscuts are funded. The FY 2016 Request for SPR contains the following crosscuts:

**Cybersecurity:** DOE is engaged in three categories of cyber-related activities: protecting the DOE enterprise from a range of cyber threats that can adversely impact mission capabilities; bolstering the U.S. Government's capabilities to address cyber threats; and, improving cybersecurity in the electric power subsector and the oil and natural gas subsector. The cybersecurity crosscut supports central coordination of the strategic and operational aspects of cybersecurity and facilitates cooperative efforts such as the Joint Cybersecurity Coordination Center for incident response and the implementation of Department-wide Identity Credential and Access Management.

| | Cyber-security | Total |
|---|---|---|
| Facilities Development and Operations | 2,102 | 2,102 |

**Strategic Petroleum Reserve**
**Funding by Congressional Control ($K)**

| | FY 2014 Enacted | FY 2014 Current | FY 2015 Enacted | FY 2016 Request | FY 2016 vs FY 2015 |
|---|---|---|---|---|---|
| **Strategic Petroleum Reserve** | | | | | |
| Facilities Development and Operations | 164,714 | 164,714 | 174,999 | 229,710 | +54,711 |
| Management | 24,646 | 24,646 | 25,001 | 27,290 | +2,289 |
| **Total, Strategic Petroleum Reserve** | **189,360** | **189,360** | **200,000** | **257,000** | **+57,000** |
| **Federal FTEs** | **126** | **126** | **126** | **126** | **0** |

## Strategic Petroleum Reserve

### Overview

The SPR benefits the Nation by providing an insurance policy against potential interruptions in U.S. petroleum supplies whether originating from international supply problems, hurricanes, accidents or terrorist activities. The SPR, with currently available crude oil stocks in underground storage, provides a strong deterrent to hostile efforts. A release of petroleum from the SPR can mitigate the potential economic damage of an actual disruption in international or domestic petroleum supplies and the accompanying price increases. The SPR avails the United States of international emergency assistance through its IEA participation. IEA members are required to maintain 90 days of strategic and commercial stocks and participate with other stockholding nations in a coordinated release of stocks in the event of a major supply disruption. The 691 million barrels of inventory provided 112 days of net import protection.

To accomplish its mission and address the challenges outlined above, the SPR program is organized into two subprograms: Facilities Development and Operations and Management. The Facilities Development and Operations subprogram funds all requirements associated with developing and maintaining facilities for the storage of petroleum, operations activities associated with placing petroleum into storage, and operational readiness initiatives associated with drawing down and distributing the inventory within 13 days' notice in the event of an emergency. The Management subprogram funds personnel and administrative expenses related to maintaining the Project Management Office (New Orleans, LA) and the Program Office (Washington, DC), as well as contract services required to support management and the technical analysis of program initiatives and issues.

### Highlights of the FY 2016 Budget Request

SPR's underground storage caverns require maintenance to assure their storage capability and integrity. Likewise, the continued degasification of SPR stocks is required for the crude oil to be available for emergency use and to prevent the off-gassing of volatile organic compounds (VOCs) above safe levels during oil movements through commercial distribution points. This request proposes to suspend the SPR's remedial leaching program that slowed (but did not offset) the loss of cavern storage capacity. This program will be re-considered upon determination of future crude oil inventory requirements

Cavern Integrity

The Casing Inspection and Cavern Remediation Program was developed in 2010 to remediate the anomalies in wellbore casings. This prevents the well and cavern from being removed from service and prevents potential environmental hazards. Cavern remediation costs have grown, reflecting the increased scope and higher cost of diagnostic services and materials that have been experienced. Additionally, the number of remediations has increased from 6 (in FY 2015) to 10 (in FY 2016) due to the number of cavern wellbores which have either failed hydraulically or failed state-required, 5-year Mechanical Integrity Tests.

Distribution Flexibility and Reliability

The Big Hill site has multiple delivery points from which SPR crude oil can be shipped. However, design of the distribution system allows delivery to only a single delivery point at any time, limiting distribution flexibility. This limitation was observed during the test sale when two purchasers requested simultaneous deliveries from Big Hill to different delivery points, and one delivery had to be rescheduled. Additionally, during the test sale, the custody transfer flow metering skid suffered an equipment failure which required the metering skid to be taken out-of-service for 72 hours until repairs could be completed. This single-point failure identified a need for redundancy in this critical drawdown equipment. This request includes the addition of a custody transfer flow metering skid to facilitate simultaneous deliveries to multiple delivery points (flexibility) and provides redundancy (reliability).

Deferred Major Maintenance Backlog

The Major Maintenance construction program maintains the SPR's facilities, equipment, and physical systems in an efficient operating condition. Currently there is a back log of projects that have been delayed. The FY 2016 Request initiates buy-down of the existing backlog. The schedule requires flexibility to allow for unanticipated failures to major equipment/pipelines that impact drawdown and distribution capability which would require a re-prioritization of major maintenance projects. In the event that occurs, draw down and distribution capability projects would be designated as top priority.

Major changes from 2015 include increased funding for Major Maintenance projects to address the backlog of deferred major maintenance. Funding is also included for full operation of 3 workover rigs for continuous maintenance and integrity testing of cavern crude oil and brine piping and casing. As a result of the experienced limitations of Big Hill's distribution configuration, the program is proposing a project to increase drawdown flexibility by installing equipment to allow for simultaneous delivery to multiple points.

**Strategic Petroleum Reserve**

**Funding ($K)**

| | FY 2014 Enacted | FY 2014 Current | FY 2015 Enacted | FY 2016 Request | FY 2016 vs FY 2015 Request |
|---|---|---|---|---|---|
| **Strategic Petroleum Reserve** | | | | | |
| Facilities Development and Operations | 164,714 | 164,714 | 174,999 | 229,710 | +54,711 |
| Management | 24,646 | 24,646 | 25,001 | 27,290 | +2,289 |
| **Total, Strategic Petroleum Reserve** | **189,360** | **189,360** | **200,000** | **257,000** | **+57,000** |

**Strategic Petroleum Reserve**
**Explanation of Major Changes ($K)**

| | FY 2016 vs FY 2015 |
|---|---|
| **Facilities Development and Operations:** The request supports increases in the Operations and Cavern Integrity Program (+8,581) including the use of 3 drill rigs for 10 routine cavern workovers and 10 cavern remediations. Increases are also attributed to radio replacements, IT hardware purchases, and software upgrades for intrusion protection and prevention systems (+2,522). The requested FY 2016 funding level supports a larger Major Maintenance program required to add a custody transfer flow metering skid at the Big Hill Site (+17,000); reduce the backlog of deferred maintenance projects (+20,000); and continue to address the ageing infrastructure (+6,608). | **+54,711** |
| **Management:** No change in scope. The increase reflects escalation, building lease increases, and an IT study for Cloud computing capabilities. | **+2,289** |
| **Total, Strategic Petroleum Reserve** | **+57,000** |

## Strategic Petroleum Reserve
## Facilities Development and Operations

**Description**

The Facilities Development and Operations subprogram provides funding for protection from supply disruptions. The U.S. reliance on petroleum combined with location of significant global reserves in regions of the world subject to political unrest have made the U.S. vulnerable to supply disruptions.

SPR's underground storage caverns require maintenance to assure their storage capability and integrity. SPR maintains a cavern casing inspection and remediation program to comply with state regulations and mitigate the risk of potential casing leaks and environmental damage. When Bryan Mound Tank 2 is returned to service in 2016, the overall maximum SPR drawdown rate is restored to 4.4 million barrels per day.

**FY 2017 – FY 2020 Key Milestones**

- (January 2019) Complete degas operations at West Hackberry.

## Facilities Development and Operations

**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **Facilities Development and Operations** | | |
| **$174,999,000** | **$229,710,000** | **+$54,711,000** |
| *Cavern Maintenance Program*<br>• Cavern leaching at a level of 24,000 barrels per day at Bryan Mound. | *Cavern Maintenance Program*<br>• No activity. | *Cavern Maintenance Program*<br>Capacity is sufficient for current inventory. Program is suspended until completion of the policy study regarding the size and configuration of the SPR. |
| *Casing Inspections and Remediations*<br>• Six cavern remediation workovers with the addition of a second subcontracted workover rig. | *Casing Inspections and Remediations*<br>• Ten remediation workovers using second subcontracted rig. | *Casing Inspections and Remediations*<br>Supports four additional cavern remediation workovers to minimize the chance of wellbore leaks, regulatory noncompliance, and caverns being removed from service. |
| *Major Maintenance*<br>• Begins a robust major maintenance program including Bryan Mound Tank 2 roof repair to bring unit back into service and restore the program's drawdown rate. | *Major Maintenance*<br>• Continues the robust major maintenance program and accelerates the schedule for delayed projects as well as addressing distribution capability issues at Big Hill. | *Major Maintenance*<br>Funding supports a more robust Major Maintenance Program for timely replacements and distribution flexibility. Completion of these scheduled projects initiates buy down of the existing deferred maintenance backlog. |

**Strategic Petroleum Reserve**
**Capital Summary[1] ($K)**

| | Total | Prior Years | FY 2014 Enacted | FY 2014 Current | FY 2015 Enacted | FY 2016 Request | FY 2016 vs FY 2015 |
|---|---|---|---|---|---|---|---|
| **Capital Operating Expenses Summary (including MIE)** | | | | | | | |
| Capital Equipment > $500K (including MIE) | n/a | n/a | 6,127 | 6,127 | 18,340 | 52,808 | +34,468 |
| Plant Projects (GPP >$10M) | n/a | n/a | 0 | 0 | 0 | 0 | +0 |
| **Total, Capital Operating Expenses** | **n/a** | **n/a** | **6,127** | **6,127** | **18,340** | **52,808** | **+34,468** |
| | | | | | | | |
| **Capital Equipment > $500K (including MIE)** | | | | | | | |
| Total Non-MIE Capital Equipment (>$500K) | n/a | n/a | 3,765 | 3,765 | 3,849 | 13,587 | +9,738 |
| Rework Crude Oil Pipeline Mainline Valves (BH-658) | 0 | 0 | 1,406 | 1,406 | 0 | 0 | 0 |
| Replace Brine Disposal System Header (WH-767) | 0 | 0 | 956 | 956 | 0 | 0 | 0 |
| Replace Crude Oil Header Piping (BC-792) | 0 | 0 | 0 | 0 | 2,521 | 0 | -2,521 |
| Convert BMT-2 to External Floating Roof (BM-740) | 0 | 0 | 0 | 0 | 8,875 | 0 | -8,875 |
| Replace Piping Headers (BM-1027) | 0 | 0 | 0 | 0 | 1,435 | 0 | -1,435 |
| Replace Brine Disposal Pipeline (WH-826A) | 0 | 0 | 0 | 0 | 1,660 | 0 | -1,660 |
| Replace Section Of 36-Inch CO Pipeline (BH-756) | 0 | 0 | 0 | 0 | 0 | 2,190 | +2,190 |
| Rework Crude Oil Pipeline Mainline Valves (WH-659) | 0 | 0 | 0 | 0 | 0 | 4,088 | +4,088 |
| Replace 24-Inch Brine Disposal Pipeline (WH-826) | 0 | 0 | 0 | 0 | 0 | 3,313 | +3,313 |
| Convert Tank-4 to External Floating Roof (BM-1055) | 0 | 0 | 0 | 0 | 0 | 9,300 | +9,300 |
| Close Anhydrite Pond 9 (BH-1253) | 0 | 0 | 0 | 0 | 0 | 1,592 | +1,592 |
| Big Hill Meter Skid (BH-1307) | 0 | 0 | 0 | 0 | 0 | 15,895 | +15,895 |
| Replace Raw Water Discharge Piping/Recycle Line | 0 | 0 | 0 | 0 | 0 | 2,843 | +2,843 |
| **Total, Capital Equipment (including MIE)** | **n/a** | **n/a** | **6,127** | **6,127** | **18,340** | **52,808** | **+34,468** |
| | | | | | | | |
| **Plant Projects (GPP - Total Estimated Cost >$10M)** | | | | | | | |
| **Total, Plant Projects (GPP – Total Estimated Cost** | **0** | **0** | **0** | **0** | **0** | **0** | **0** |

[1]Each MIE Total Estimated Cost (TEC) > $2M; Each Plant Project (GPP/IGPP) Total Estimated Cost (TEC) > $5M

## Management

**Overview**

Management provides funding for the salaries and related requirements of the Headquarters federal workforce responsible for providing policy and overall guidance in the areas of planning, budget formulation and financial management, mission performance, and analysis for programmatic activity of the SPR. The additional Federal workforce of the SPR Project Management Office directs program execution and establishes technical performance standards as well as scope, cost, and schedule milestones for the Management and Operations contractor.

**Highlights of the FY 2016 Budget Request**

The Federal headcount remains at 126 FTEs with continued technical support contractors. Travel is for operational field support and oversight including site and vendor visits. Other related expenses include field building leases, telecommunications, and annual hurricane preparedness activities**.**

**Management**
**Funding ($K)**

| | FY 2014 Enacted | FY 2014 Current | FY 2015 Enacted | FY 2016 Request | FY 2016 vs FY 2015 |
|---|---|---|---|---|---|
| **Program Direction Summary** | | | | | |
| **Washington Headquarters** | | | | | |
| Salaries and Benefits | 4,370 | 4,370 | 5,066 | 5,476 | +410 |
| Travel | 160 | 160 | 150 | 100 | -50 |
| Support Services | 2,007 | 2,007 | 1,570 | 1,660 | +90 |
| Other Related Expenses | 792 | 792 | 821 | 500 | -321 |
| **Total, Washington Headquarters** | **7,329** | **7,329** | **7,607** | **7,736** | **+129** |
| **Strategic Petroleum Reserve Project Management Office** | | | | | |
| Salaries and Benefits | 13,538 | 13,538 | 13,651 | 13,828 | +177 |
| Travel | 485 | 458 | 507 | 673 | +166 |
| Support Services | 166 | 166 | 197 | 205 | +8 |
| Other Related Expenses | 3,128 | 3,128 | 3,039 | 4,848 | +1,809 |
| **Total, SPR Project Management Office** | **17,317** | **17,317** | **17,394** | **19,554** | **+2,160** |
| **Total Management** | | | | | |
| Salaries and Benefits | 17,908 | 17,908 | 18,717 | 19,304 | +587 |
| Travel | 618 | 618 | 657 | 773 | +116 |
| Support Services | 2,173 | 2,173 | 1,767 | 1,865 | +98 |
| Other Related Expenses | 3,920 | 3,920 | 3,860 | 5,348 | +1,488 |
| **Total, Management** | **24,646** | **24,646** | **25,001** | **27,290** | **+2,289** |
| **Federal FTEs** | **126** | **126** | **126** | **126** | **0** |
| **Support Services** | | | | | |
| Technical Support | | | | | |
| Economic & Environmental Analysis | 547 | 547 | 560 | 560 | +0 |
| Total, Technical Support | 547 | 547 | 560 | 560 | +0 |

| | FY 2014 Enacted | FY 2014 Current | FY 2015 Enacted | FY 2016 Request | FY 2016 vs FY 2015 |
|---|---|---|---|---|---|
| Management Support | | | | | |
| Training and OPM Recruitment | 166 | 166 | 197 | 205 | +8 |
| Technical Support | 1,460 | 1,460 | 1,010 | 1,100 | +90 |
| Total Management Support | 1,626 | 1,626 | 1,207 | 1,305 | +98 |
| **Total, Support Services** | **2,173** | **2,173** | **1,767** | **1,865** | **+98** |
| | | | | | |
| **Other Related Expenses** | | | | | |
| Rent to Others | 566 | 566 | 726 | 976 | +250 |
| Communications, Utilities, Misc. | 100 | 100 | 173 | 178 | +5 |
| Other Services | 2,236 | 2,236 | 1,910 | 3,122 | +1,212 |
| Supplies and Materials | 626 | 626 | 639 | 652 | +13 |
| Equipment | 392 | 392 | 412 | 420 | +8 |
| **Total, Other Related Expenses** | **3,920** | **3,920** | **3,860** | **5,348** | **+1,488** |

## Management

**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **Management $25,001,000** | **$27,290,000** | **+$2,289,000** |
| **Salaries and Benefits $18,717,000** | **$19,304,000** | **+587,000** |
| The funding supports salaries and benefits for 126 FTEs and associated costs required to provide overall direction and execution of the SPR. The SPR mission is carried out by a workforce composed largely of M&O contractors, although there are a variety of functions that are inherently governmental (i.e., program management, contract administration, budget formulation, and interagency/international coordination) that require a dedicated Federal workforce. | Continue management and oversight activities. | Increase reflects escalation and relocation and training to backfill retirements. |
| **Travel $657,000** | **$773,000** | **+116,000** |
| Instituted travel ceilings in accordance with Secretarial initiative to accomplish a reduction in travel costs. | Continue constrained travel. | No significant change. |
| **Support Services 1,767,000** | **1,865,000** | **+98,000** |
| Activities support project-planning efforts to maintain technical, mission essential support capabilities. | Continue support services activities | No significant change. |
| **Other Related Expenses 3,860,000** | **$5,348,000** | **+1,488,000** |
| Provides teleconferencing capabilities between sites; field site building leases; and contingency for DOE field employee evacuation expenses in the event of a hurricane. | Continue support activities. | Increases to the field site building leases and initiation of an IT study for Cloud computing capabilities. |

**Strategic Petroleum Reserve**
**Performance Measures**

In accordance with the GPRA Modernization Act of 2010, the Department sets targets for, and tracks progress toward, achieving performance goals for each program. For more information, refer to the Department's FY 2014 Annual Performance Report.

| | FY 2014 | FY 2015 | FY 2016 |
|---|---|---|---|
| Performance Goal (Measure) | **Drawdown Readiness - Ensure drawdown readiness by achieving greater than 95% of monthly maintenance and accessibility goals.** | | |
| Target | 95 % of monthly maintenance achieved | 95 % of monthly maintenance achieved | 95 % of monthly maintenance achieved[1] |
| Result | 95 % of monthly maintenance achieved | TBD | TBD |
| Endpoint Target | Achieve 95% of monthly maintenance and accessibility goals in all years. | | |
| Performance Goal (Measure) | **SPR Operating Cost - Ensure cost efficiency of SPR operations by achieving low operating cost per barrel of capacity** | | |
| Target | < 0.25 $ operating cost per barrel | < 0.25 $ operating cost per barrel | < 0.25 $ operating cost per barrel |
| Result | < 0.25 $ operating cost per barrel | TBD | TBD |
| Endpoint Target | Achieve < $0.25 operating cost per barrel. | | |
| Performance Goal (Measure) | **Sustained (90 day) Drawdown Rate - Enable ready distribution of SPR oil by achieving maximum sustained (90 day) drawdown rate of 4.4 million barrels per day.** | | |
| Target | 4.25 MMB/Day drawdown readiness rate | 4.25 MMB/Day drawdown readiness rate | 4.4MMB/Day drawdown readiness rate |
| Result | 4.25 MMB/Day drawdown readiness rate | TBD | TBD |
| Endpoint Target | Maintain a 90 day drawdown rate of 4.4 million barrels per day. | | |

[1] Beginning in FY 2016 transition to measuring projects placed into operation to conform to Endpoint Target.

## Strategic Petroleum Reserve
## Facilities Maintenance and Repair

The Department's Facilities Maintenance and Repair activities are tied to its programmatic missions, goals, and objectives. Facilities Maintenance and Repair activities funded by this budget are displayed below.

**Costs for Direct-Funded Maintenance and Repair (including Deferred Maintenance Reduction) ($K)**

| | FY 2014 Actual Cost | FY 2014 Planned Cost | FY 2015 Planned Cost | FY 2016 Planned Cost |
|---|---|---|---|---|
| Strategic Petroleum Reserve | | 35,032 | 46,386 | 89,018 |
| **Total, Direct-Funded Maintenance and Repair** | | **35,032** | **46,386** | **89,018** |

**Total Costs for Maintenance and Repair ($K)**

| | FY 2014 Actual Cost | FY 2014 Planned Cost |
|---|---|---|
| Strategic Petroleum Reserve | | 35,032 |
| **Total, Direct-Funded Maintenance and Repair** | | **35,032** |

## Strategic Petroleum Reserve – Petroleum Account

**($K)**

| FY 2014 Enacted | FY 2014 Current | FY 2015 Enacted | FY 2016 Request |
|---|---|---|---|
| 0 | 0 | 0 | 0 |

**Overview**

The Strategic Petroleum Reserve (SPR) – Petroleum Account was established in the Treasury pursuant to the provisions of the Omnibus Budget Reconciliation Act of 1981 (P.L. 97-35). This account funds all Strategic Petroleum Reserve petroleum inventory acquisitions, associated transportation costs, U.S. Customs duties, terminal throughput charges and other related miscellaneous costs. During an emergency drawdown and sale, the SPR Petroleum Account is the source of funding for the incremental costs of withdrawing oil from the storage caverns and transporting it to the point where purchasers take title. As a component of the SPR, the Northeast Gasoline Supply Reserve (NGSR) was established in the SPR Petroleum Account and funds all aspects of the refined gasoline reserve - acquired and owned by the U.S. government, and stored at leased commercial storage terminals along the East Coast.

**Highlights and Major Changes in the FY 2016 Budget Request**

Test sale receipts were the source for all NGSR requirements including annual independent audits, third-party quality assurance and inventory certifications of government-owned stocks commingled with commercial stocks, and sales platform readiness. There is no request for FY 2016. Continued oversight and management is funded by prior-year balances.

**FY 2014 Key Accomplishments**

Established refined product reserve in the following commercial storage locations:

- BP - New York Harbor (200,000 barrels)
- Buckeye – New York Harbor (500,000 barrels); South Portland, Maine (100,000 barrels)
- Global – Revere, Massachusetts (200,000 barrels)

**Strategic Petroleum Reserve – Petroleum Account**
**Funding by Congressional Control ($K)**

| | FY 2014 Enacted | FY 2014 Current[1]* | FY 2015 Enacted | FY 2016 Request | FY 2016 vs FY 2015 |
|---|---|---|---|---|---|
| **Strategic Petroleum Reserve – Petroleum Account** | | | | | |
| **Strategic Petroleum Reserve –** Petroleum Account | 0 | 0 | 0 | 0 | 0 |
| **Non-adds** | | | | | |
| Rescission of PY Balances | -2,738,178 | -2,738,178 | 0 | 0 | 0 |
| SPR Test Sale Proceeds | 0 | 468,565 | 0 | 0 | 0 |
| Northeast Gasoline Supply Reserve (NERRPPR) | 0 | -235,587 | 0 | 0 | 0 |
| SPR Oil Acquisition | 0 | -232,978 | 0 | 0 | 0 |
| **Total, Non-adds** | **-2,738,178** | **-2,738,178** | **0** | **0** | **0** |
| **Total, Strategic Petroleum Reserve – Petroleum Account** | **0** | **0** | **0** | **0** | **0** |

[1] Test Sale proceeds were used to establish NGSR. The remaining balance is set-aside for inventory re-fill in compliance with EPCA.

## Strategic Petroleum Reserve – Petroleum Account

**Overview**

The SPR Petroleum Account funds all SPR petroleum inventory acquisitions, associated transportation and custom duties, and incremental drawdown expenses. As a component of the SPR, the NGSR was established in the SPR Petroleum Account.

To ensure transparency, the SPR Petroleum Account is organized into two subprograms: SPR Oil Acquisition and Northeast Gasoline Supply Reserve (NGSR). The Oil Acquisition subprogram funds all crude oil acquisition, transportation, drawdown and distribution of the inventory in the SPR within 13 days' notice in the event of an emergency. The NGSR subprogram funds all aspects of the refined petroleum product reserve of gasoline - acquired and owned by the U.S. government, and stored at leased commercial storage terminals along the East Coast to help mitigate the impacts of sudden and unexpected supply interruptions.

In April 2014, the SPR performed an operational Test Sale to test the sales and distribution capabilities within the TEXOMA distribution group which includes the SPR sites at Big Hill, Texas and West Hackberry, Louisiana. This sale resulted in over $468 million of cash receipts to the U.S. Government and created mandatory budget authority in the same amount in the SPR Petroleum account.

On May 2, 2014, as part of the Administration's response to Hurricane Sandy, DOE announced the creation of a gasoline reserve in locations near New York Harbor and in New England. With major product supply and distribution infrastructure located along U.S. coasts, Northeast energy supply and reliability is vulnerable to the impacts of hurricane winds, tidal surges, severe wind, snow and icing conditions. Establishing a reserve of gasoline – acquired and owned by the U.S. government, and stored at leased commercial storage terminals along the East Coast – will help mitigate the impacts of sudden and unexpected supply interruptions. Each location stores enough gasoline to provide some short-term relief in the event of significant disruptions. As a component of the SPR, the gasoline is sold upon a finding by the President that (1) there is or is likely to become "a domestic or international energy supply shortage of significant scope or duration," and (2) the sale of petroleum products "would assist directly and significantly in preventing or reducing the adverse impact of such shortage." The new reserve complements the Northeast Home Heating Oil Reserve, a one million barrel supply of diesel for the Northeast. NGSR utilized $235 million of the sales receipts for 4.5 years of commercial storage, acquisition of 1 million barrels of gasoline, and initial oversight and administration activities.

**Highlights and Major Changes in the FY 2016 Budget Request**

There is no request for FY 2016. Continued oversight and administration activities will be funded with prior-year NGSR balances.

**Strategic Petroleum Reserve – Petroleum Account**
**Explanation of Major Changes ($K)**

| | FY 2016 vs FY 2015 |
|---|---|
| **There is no request for FY 2015 or FY 2016. Activities are funded with prior-year NGSR balances.** | **+0** |
| **Total, SPR Petroleum Account** | **+0** |

**Strategic Petroleum Reserve – Petroleum Account**

**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **SPR Petroleum Account $0** | **$0** | **+$0** |
| **NGSR** | | |
| *Oversight and Management*<br>• Annual independent audits, third-party quality assurance and inventory certifications of government-owned stocks commingled with commercial stocks, and sales platform readiness. | *Oversight and Management*<br>• Annual independent audits, third-party quality assurance and inventory certifications of government-owned stocks commingled with commercial stocks, and sales platform readiness. | *Oversight and Management*<br>FY 2015 and FY 2016 activities are funded with prior-year balances. |

**Strategic Petroleum Reserve**
**Safeguards and Security ($K)**

| | FY 2014 Current | FY 2015 Enacted | FY 2016 Request | FY 2016 vs FY 2015 |
|---|---|---|---|---|
| Protective Forces | 18,199 | 18,732 | 18,920 | 188 |
| Physical Security Systems | 857 | 939 | 949 | 10 |
| Information Security | 281 | 247 | 247 | 0 |
| Cyber Security | 1,969 | 1,464 | 2,102 | 638 |
| Personnel Security | 604 | 661 | 664 | 3 |
| Material Control and Accountability | 0 | 0 | 0 | 0 |
| Program Management | 1,641 | 1,524 | 1,542 | 18 |
| Security Investigations | 0 | 0 | 0 | 0 |
| Transportation Security | 0 | 0 | 0 | 0 |
| Research and Development | 0 | 0 | 0 | 0 |
| Construction | 243 | 0 | 800 | 800 |
| **Total, Safeguards and Security** | **23,794** | **23,567** | **25,224** | 1,**657** |

Department Of Energy
FY 2016 Congressional Budget
Funding By Appropriation By Site
($K)

| Strategic Petroleum Reserve | FY 2014 Current | FY 2015 Enacted | FY 2016 Request |
|---|---|---|---|
| National Energy Technology Lab | | | |
| SPR Geotechnical Analytical Support | | | |
| SPR - Facilities Development | 243 | 446 | 446 |
| **Total, National Energy Technology Lab** | **243** | **446** | **446** |
| Oak Ridge National Laboratory | | | |
| SPR Econometric Modelling Support | | | |
| Management | 400 | 490 | 490 |
| **Total, Oak Ridge National Laboratory** | **400** | **490** | **490** |
| Sandia National Laboratories | | | |
| SPR Geotechnical Analytical Support | | | |
| SPR - Facilities Development | 3,260 | 3,335 | 3,412 |
| **Total, Sandia National Laboratories** | **3,260** | **3,335** | **3,412** |
| **Strategic Petroleum Reserve - Bayou Choctow** | | | |
| SPR Geotechnical Analytical Support | | | |
| SPR - Facilities Development | 10,720 | 12,737 | 14,203 |
| **Total, Strategic Petroleum Reserve - Bayou Choctow** | **10,720** | **12,737** | **14,203** |
| **Strategic Petroleum Reserve - Big Hill** | | | |
| SPR Geotechnical Analytical Support | | | |
| SPR - Facilities Development | 20,751 | 20,866 | 44,468 |
| **Total, Strategic Petroleum Reserve - Big Hill** | **20,751** | **20,866** | **44,468** |
| **Strategic Petroleum Reserve - Bryan Mound** | | | |
| SPR Geotechnical Analytical Support | | | |
| SPR - Facilities Development | 17,938 | 26,067 | 28,384 |
| **Total, Strategic Petroleum Reserve - Bryan Mound** | **17,938** | **26,067** | **28,384** |
| **Strategic Petroleum Reserve - West Hackberry** | | | |
| SPR Geotechnical Analytical Support | | | |
| SPR - Facilities Development | 24,643 | 22,760 | 35,603 |
| **Total, Strategic Petroleum Reserve - West Hackberry** | **24,643** | **22,760** | **35,603** |
| Strategic Petroleum Reserve Project Office | | | |
| SPR Geotechnical Analytical Support | | | |
| SPR - Facilities Development | 87,146 | 88,788 | 103,194 |
| SPR Econometric Modelling Support | | | |
| Management | 17,317 | 17,394 | 19,554 |
| **Total, Strategic Petroleum Reserve Project Office** | **104,463** | **106,182** | **122,748** |

**Department Of Energy**

**FY 2016 Congressional Budget**

**Funding By Appropriation By Site**

**($K)**

| Strategic Petroleum Reserve | FY 2014 Current | FY 2015 Enacted | FY 2016 Request |
|---|---|---|---|
| **Washington Headquarters** | | | |
| **SPR Econometric Modelling Support** | | | |
| Management | 6,942 | 7,117 | 7,246 |
| **Total, Washington Headquarters** | **6,942** | **7,117** | **7,246** |
| **Total, Strategic Petroleum Reserve** | **189,360** | **200,000** | **257,000** |

# Northeast Home Heating Oil Reserve

# Northeast Home Heating Oil Reserve

## Northeast Home Heating Oil Reserve
## Proposed Appropriation Language

For necessary expenses for the Northeast Home Heating Oil Reserve storage, operation, and management activities pursuant to the Energy Policy and Conservation Act, $7,600,000 to remain available until expended. **[**:*Provided*, That of the unobligated balances from prior year appropriations available under this heading, $6,000,000 is hereby rescinded: *Provided further*, That no amounts may be rescinded from amounts that were designated by the Congress as an emergency requirement pursuant to a concurrent resolution on the budget or the Balanced Budget and Emergency Deficit Control Act of 1985.**]**

### Explanation of Changes

No changes.

**Public Law Authorizations**

- P.L. 109-58, Energy Policy Act of 2005

## Northeast Home Heating Oil Reserve

($K)

| FY 2014 Enacted | FY 2014 Current | FY 2015 Request | FY 2016 Request |
|---|---|---|---|
| 8,000 | 8,000 | 7,600 | 7,600 |

**Overview**

The Northeast Home Heating Oil Reserve (NEHHOR) provides a short-term supplement to the Northeast systems' commercial supply of heating oil in the event of a supply interruption. In FY 2012 NEHHOR converted from 2 million barrels of high sulfur heating oil to 1 million barrels of Ultra Low Sulfur Diesel (ULSD), to meet new Northeast states' emission standards. The FY 2016 program will continue operation of the 1 million barrel Reserve in sites to be determined by the FY 2015 storage terminal contract re-solicitation of ULSD.

**Highlights and Major Changes in the FY 2016 Budget Request**

FY 2016 activity will focus on an acceptable and effective transition to the new storage terminal contracts. The Program will continue to focus on oversight, management and quality analysis of the Reserve as well as information technology for sales system support.

**FY 2014 Key Accomplishments**

Actively monitored Northeast heating oil supplies and terminal distribution as part of the assessment of the developing winter situation.

**Northeast Home Heating Oil Reserve**
**Funding by Congressional Control ($K)**

| | FY 2014 Enacted | FY 2014 Current | FY 2015 Enacted | FY 2016 Request | FY 2016 vs FY 2015 |
|---|---|---|---|---|---|
| **Northeast Home Heating Oil Reserve** | | | | | |
| Northeast Home Heating Oil Reserve | 8,000 | 8,000 | 7,600 | 7,600 | +0 |
| **Subtotal, Northeast Home Heating Oil Reserve** | **8,000** | **8,000** | **7,600** | **7,600** | **+0** |
| Rescission of Prior Year Balances | 0 | | -6,000 | 0 | -6,000 |
| **Total, Northeast Home Heating Oil Reserve** | **8,000** | **8,000** | **1,600** | **7,600** | -6,000 |
| **Federal FTEs** | **0** | **0** | **0** | **0** | **0** |

## Northeast Home Heating Oil Reserve

**Overview**

In support of the Department of Energy's Strategic Plan's goal of "Transform our Energy Systems: Protecting the nation against interruptions in its critical heating oil supplies," the Northeast Home Heating Oil Reserve (NEHHOR) provides protection from severe heating oil supply disruptions throughout the Northeast. The NEHHOR provides a short-term supplement to the Northeast systems' commercial supply of heating oil in the event of a supply interruption. The heating oil reserve has been designed to augment commercial supplies during an emergency. The Reserve is not designed to displace the private market. It provides a buffer to assist the heating oil industry in mitigating short-term supply interruptions. The Reserve is a valuable component of America's energy readiness efforts, separate from the Strategic Petroleum Reserve.

**Highlights of the FY 2016 Budget Request**

After re-solicitation of commercial storage contracts that will become effective October 1, 2015 (FY 2016), NEHHOR activity will consist of oversight, management, sales system support, and quality analysis by an independent quality assurance and inspection service.

Current commercial storage contracts expire on September 30, 2015, so the re-solicitation for new commercial storage contracts will begin in early 2015. Storage costs are subject to normal price escalation in market rates which may require the use of prior year balances to supplement the new FY 2015 budget authority. Additionally, a change in the location of either storage site could increase contract cost. Additional transportation cost would be incurred to move the ULSD if new terminals are selected.

Beginning in FY 2015, DLA-Energy will no longer provide quality assurance and monthly inventory certification services for the NEHHOR. To assure proper validation and verification of inventories at all times, DOE will solicit Independent Quality Assurance and Inspection Services (QAIS) to assure proper validation and verification of inventories.

**Northeast Home Heating Oil Reserve**
**Funding ($K)**

| | FY 2014 Enacted | FY 2014 Current | FY 2015 Enacted | FY 2016 Request | FY 2016 vs FY 2015 |
|---|---|---|---|---|---|
| **Northeast Home Heating Oil Reserve** | | | | | |
| Commercial Leases | 7,500 | 7,500 | 7,600 | 7,600 | 0 |
| Information Technology Support | 400 | 400 | 0 | 0 | 0 |
| Quality Control and Analysis | 100 | 100 | 0 | 0 | 0 |
| **Subtotal, Northeast Home Heating Oil Reserve** | **8,000** | **8,000** | **7,600** | **7,600** | **0** |
| Rescission of Prior Year Balances | 0 | 0 | -6,000 | 0 | -6,000 |
| **Total, Northeast Home Heating Oil Reserve** | **8,000** | **8,000** | **1,600** | **7,600** | **-6,000** |

**Northeast Home Heating Oil Reserve**
**Explanation of Major Changes ($K)**

| | FY 2016 vs FY 2015 |
|---|---|
| **Northeast Home Heating Oil Reserve:** No change. | **0** |
| **Total, Northeast Home Heating Oil Reserve** | **0** |

| Northeast Home Heating Oil Reserve Account | FY 2014 Current | FY 2015 Enacted | FY 2016 Request |
|---|---|---|---|
| **Washington Headquarters** | | | |
| **Northeast Home Heating Oil Reserve** | | | |
| Northeast Home Heating Oil Reserve | 8,000 | 7,600 | 7,600 |
| **Total, Washington Headquarters** | **8,000** | **7,600** | **7,600** |
| **Total, Northeast Home Heating Oil Reserve Account** | **8,000** | **7,600** | **7,600** |

# Elk Hills School Lands Fund

# Elk Hills School Lands Fund

**Explanation of Changes**

The State of California's claim has been satisfied and no additional funding is required.

**Public Law Authorizations**

Elk Hills School Lands Fund:

- P.L. 104-106, National Defense Authorization Act for FY 1996

## Elk Hills School Lands Fund

**($K)**

| FY 2014 Enacted | FY 2014 Current | FY 2015 Enacted | FY 2016 Request |
|---|---|---|---|
| 0 | 0 | 15,580 | 0 |

**Overview**

The Elk Hills School Lands Fund, subject to appropriation, provided a source of compensation for the California State Teachers' Retirement System as a result of a settlement with the State of California with respect to its longstanding claim to title of two sections of land within NPR-1.

DOE and the State of California entered into a "Settlement Agreement" on October 11, 1996, in which DOE agreed, subject to appropriation, to compensate the State of California for its claim to title to two sections of land within NPR-1. The "Settlement Agreement" stipulated installments totaling nine percent of the net proceeds from the sale to be paid to the State of California. Installment payments totaling $299,520,000 were paid from the fund prior to the final payment.

On April 22, 2011, the Department settled NPR-1 final equity with Chevron. Under the terms of the settlement, Chevron paid $108,000,000 to the United States. That, in turn, increased the net proceeds of the sale. On August 3, 2011, the Department and the State of California agreed on the final payment of $15,579,815 with respect to the longstanding claim on the two sections of land. That final payment was appropriated in FY 2015.

**Highlights and Major Changes in the FY 2016 Budget Request**

The State of California's claim has been satisfied and no additional funding is required.

**Elk Hills School Lands Fund**
**Funding by Congressional Control ($K)**

| | FY 2014 Enacted | FY 2014 Current | FY 2015 Enacted | FY 2016 Request | FY 2016 vs FY 2015 |
|---|---|---|---|---|---|
| **Elk Hills School Lands Fund** | | | | | |
| Elk Hills School Lands Fund | 0 | 0 | 15,580 | 0 | -15,580 |
| **Total, Elk Hills School Lands Fund** | **0** | **0** | **15,580** | **0** | **-15,580** |
| **Federal FTEs** | **0** | **0** | **0** | **0** | **0** |

**Elk Hills School Lands Fund**
**Explanation of Major Changes ($K)**

| | FY 2016 vs FY 2015 |
|---|---|
| On August 3, 2011, the Department and the State of California agreed on the final payment of $15,579,815 with respect to the longstanding claim on the two sections of land. That final payment was made in FY 2015. | **-15,580** |
| **Total, Elk Hills School Lands Fund** | **-15,580** |

# Clean Coal Technology

# Clean Coal Technology

**Clean Coal Technology**

Proposed Appropriation Language

**[**(Including Rescission of Funds)**]**

**[**Of the unobligated balances from prior year appropriations under this heading, $6,600,000 is hereby permanently rescinded: *Provided*, That no amounts may be rescinded from amounts that were designated by the Congress as an emergency requirement pursuant to a concurrent resolution on the budget or the Balanced Budget and Emergency Deficit Control Act of 1985, as amended.**]**

**Explanation of Changes**

The Clean Coal Technology Program was established in the 1980s to perform commercial-scale demonstrations of advanced coal-based technologies. All projects have concluded and only closeout activities remain.

# Advanced Technology Vehicles Manufacturing Loan Program

# Advanced Technology Vehicles Manufacturing Loan Program

**Advanced Technology Vehicles Manufacturing Loan Program**
**Proposed Appropriation Language**

For Department of Energy administrative expenses necessary in carrying out the Advanced Technology Vehicles Manufacturing Loan Program, [$4,000,000]*$6,000,000*, to remain available until September 30, [2016] *2017.*

**Explanation of Changes**

$6 million is requested for administrative expenses in FY 2016, which is an increase of $2 million over the FY 2015 administrative appropriation. This increase is needed to process and underwrite an increasing volume of loan applications. Consistent with the President's Climate Action Plan, the Department of Energy (DOE) Loan Programs Office (LPO) is working to utilize existing loan authority to support advanced technology vehicle manufacturing projects. In April 2014, The Secretary of Energy announced a number of program improvements to clarify eligibility and improve customer service for applicants. These improvements included clarified eligibility for component suppliers, improved responsiveness to applicants, and revisions to the ATVM application process. As a result, DOE anticipates processing additional ATVM applications in FY 2016. The appropriation will cover ATVM's administrative expenses, including salaries for its full time employees as well as the cost of outside advisors for financial, legal, engineering, credit, and market analysis. The ATVM appropriation must cover the costs for originating new loans as well as monitoring existing loans.

**Public Law Authorizations**
P.L. 110-140, Energy Independence and Security Act of 2007

## Advanced Technology Vehicles Manufacturing Loan Program

**($K)**

| FY 2014 Enacted | FY 2014 Current | FY 2015 Enacted | FY 2016 Request |
|---|---|---|---|
| $6,000 | $6,000 | $4,000 | $6,000 |

**Overview**

Section 136 of the Energy Independence and Security Act of 2007 established the Advanced Technology Vehicles Manufacturing (ATVM) Loan Program, consisting of direct loans of up to $25 billion in total loan authority to support the development and manufacturing of advanced technology vehicles and associated components in the United States. The ATVM Loan Program has issued more than $8 billion in loans to date that have resulted in the domestic manufacture of more than 4 million fuel-efficient advanced vehicles, supported approximately 35,000 direct jobs, and saved more than 900 million gallons of gasoline. The Program has remaining authority to support additional domestic manufacturing of advanced vehicles and components, which will accelerate the deployment of fuel-efficient vehicle technology and enhance U.S. manufacturing capabilities.

**Highlights and Major Changes in the FY 2016 Budget Request**

DOE requests $6 million for administrative expenses in FY 2016, which is an increase of $2 million over the FY 2015 Request. This increase is needed to process and underwrite an increasing volume of loan applications, which is expected due to the Secretary of Energy's program improvements and existing applications.

Consistent with the President's Climate Action Plan, the Department of Energy (DOE) Loan Programs Office (LPO) is working to utilize existing loan authority to support advanced technology vehicle manufacturing projects. In April 2014, the Secretary of Energy announced a number of program improvements to clarify eligibility and improve customer service for applicants. These improvements included clarified eligibility for component suppliers, improved responsiveness to applicants, and revisions to the ATVM application process. As a result, DOE anticipates processing additional ATVM applications in FY 2016. The appropriation will cover ATVM's administrative expenses, including salaries for its full time employees as well as the forecasted increase in the cost of outside advisors for financial, legal, engineering, credit, and market analysis due to increased underwriting activities. The ATVM appropriation must cover the costs for originating new loans as well as monitoring existing loans.

**Advanced Technology Vehicles Manufacturing Loan Program**
**Funding by Congressional Control ($K)**

| | FY 2014 Current | FY 2015 Enacted | FY 2016 Request | FY 2016 vs FY 2015 |
|---|---|---|---|---|
| **Advanced Technology Vehicles Manufacturing Loan Program** | | | | |
| Administrative Operations, ATVM | 6,000 | 4,000 | 6,000 | +2,000 |
| **Total, Advanced Technology Vehicles Manufacturing Loan Program** | **6,000** | **4,000** | **6,000** | **+2,000** |
| **Federal FTEs** | **13** | **14** | **14** | **0** |

**Administrative Operations**
**Funding ($K)**

| | FY 2014 Enacted | FY 2015 Enacted | FY 2016 Request | FY 2016 vs FY 2015 |
|---|---|---|---|---|
| **Administrative Operations** | | | | |
| Salaries & Benefits | 2,400 | 2,450 | 2,500 | +50 |
| Travel | 100 | 250 | 150 | -100 |
| Support Services | 3,200 | 1,000 | 2,600 | +1,600 |
| Other Related Expenses | 300 | 300 | 750 | +450 |
| **Total, Administrative Operations** | **6,000** | **4,000** | **6,000** | **+2,000** |

**Advanced Vehicles Technology Manufacturing Loan Program**
**Explanation of Major Changes ($K)**

| | FY 2016 vs FY 2015 |
|---|---|
| **Salaries and Benefits:** Provide salaries and benefits to 14 full time equivalent employees to administer the following functions to the office: Director, Legal, Loan Origination, Management Operations, Environmental Compliance, Portfolio Management, Risk Management, and Technical and Project Management. Increase to match expected salary requirements. | +50 |
| **Travel:** Supports the travel of staff members for site visits, training, and attending meetings and conferences. Decrease to match anticipated travel requirements. | -100 |
| **Support Services:** Funds outside expertise in finance, legal, engineering, technology, credit analysis, and market assessments. The increase in funding supports anticipated underwriting and loan monitoring of new projects. Underwriting new loans is not possible without increased funds for support services. | +1,600 |
| **Other Related Expenses:** Supports DOE Working Capital Fund and LGP federal staff training. Increase to ensure ATVM program pays appropriate share of overhead expenses. | +450 |
| **Total, Administrative Operations** | **+2,000** |

## Administrative Operations

**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **Administrative Operations $4,000,000** | **$6,000,000** | **+2,000,000** |
| **Salaries and Benefits $2,450,000** | **$2,500,000** | **+$50,000** |
| • Provide salaries and benefits to 14 full time equivalent employees to administer the following functions to the office: Director, Legal, Loan Origination, Management Operations, NEPA Compliance, Portfolio Management, Risk Management, and Technical and Project Management. | • Provide salaries and benefits to 14 full time equivalent employees to administer the following functions to the office: Director, Legal, Loan Origination, Management Operations, Environmental Compliance, Portfolio Management, Risk Management, and Technical and Project Management. | • Increase to match expected salary requirements. |
| **Travel $250,000** | **$150,000** | **-$100,000** |
| • Supports the travel of staff members for site visits, training, and attending meetings and conferences. | • Continuation of FY 2015 activities. Supports the travel of staff members for site visits, training, and attending meetings and conferences. | • Decrease result of decreased outreach effort. Most of the FY 2016 travel will be related to meetings for loans in underwriting phase and site visits to monitor closed loans. |
| **Support Services $1,000,000** | **$2,600,000** | **+$1,600,000** |
| • Funds outside expertise in finance, legal, engineering, technology, credit analysis, and market assessments. | • Continuation of FY 2015 activities. Provides range of contract services including administrative support, subject matter experts, legal services, information technology, and publications. | • The increase in funding supports underwriting new loans and for additional closed loans that must be monitored. |
| **Other Related Expenses $300,000** | **$750,000** | **+$450,000** |
| • Supports DOE Working Capital Fund, DOE COE expenses, and LGP federal staff training. | • Continuation of FY 2015 activities. Supports DOE Working Capital Fund, DOE IT services and expenses, and LGP federal staff training. | • Increase to ensure ATVM program pays appropriate share of overhead expenses. |

**Advanced Technology Vehicles Manufacturing Loan Program**
**Performance Measures**

In accordance with the GPRA Modernization Act of 2010, the Department sets targets for, and tracks progress toward, achieving performance goals for each program.

| | FY 2014 | FY 2015 | FY 2016 |
|---|---|---|---|
| Performance Goal (Measure) | **Battery production capacity of 100,000 lithium-ion EV batteries (2,400,000 kWh) established.** | | |
| Target | ≥ 100,000 Batteries | ≥ 100,000 Batteries | ≥ 100,000 Batteries |
| Result | ≥ 100,000 Batteries | | |
| Endpoint Target | Assist in the development of advanced battery manufacturing capacity to support 100,000 electric vehicles each year, through 2016. | | |
| Performance Goal (Measure) | **Reduction in petroleum usage (in millions of gallons of fuel per year) achieved through the use of advanced technology vehicles manufactured (at least in part) with funding provided through the ATVM loan program as compared to vehicles available in the base year.** | | |
| Target | 250 million gallons | 290 million gallons | 290 million gallons |
| Result | 306 million gallons | | |
| Endpoint Target | Achieve 290 million gallons per year savings through 2016. | | |

**Department Of Energy**

**FY 2016 Congressional Budget**

**Funding By Appropriation By Site**

**($K)**

| Advance Technology Vehicles Man Loan Program | FY 2014 Current | FY 2015 Enacted | FY 2016 Request |
|---|---|---|---|
| **Washington Headquarters** | | | |
| **Energy Transformation Acceleration Fund** | | | |
| Administrative Expenses | 6,000 | 4,000 | 6,000 |
| **Total, Washington Headquarters** | **6,000** | **4,000** | **6,000** |
| **Total, Advance Technology Vehicles Man Loan Program** | **6,000** | **4,000** | **6,000** |

# Title 17 Innovative Technology Loan Guarantee Program

# Title 17 Innovative Technology Loan Guarantee Program

**Title 17 Innovative Technology Loan Guarantee Program**
**Proposed Appropriation Language**

Such sums as are derived from amounts received from borrowers pursuant to section 1702(b) of the Energy Policy Act of 2005 under this heading in prior Acts, shall be collected in accordance with section 502(7) of the Congressional Budget Act of 1974: *Provided,* That, for necessary administrative expenses to carry out this Loan Guarantee program, $42,000,000 is appropriated, to remain available until September 30, [2016]*2017*: *Provided further,* That [$25,000,000 of the]fees collected pursuant to section 1702(h) of the Energy Policy Act of 2005 shall be credited as offsetting collections to this account to cover administrative expenses and shall remain available until expended, so as to result in a final fiscal year [2015] *2016* appropriation from the general fund estimated at not more than [$17,000,000] *$0*: *Provided further,* That fees collected under section 1702(h) in excess of the amount appropriated for administrative expenses shall not be available until appropriated[: Provided further, That the Department of Energy shall not subordinate any loan obligation to other financing in violation of section 1702 of the Energy Policy Act of 2005 (42 U.S.C. 16512) or subordinate any Guaranteed Obligation to any loan or other debt obligations in violation of section 609.10 of title 10, Code of Federal Regulations]. *(Consolidated and Further Continuing Appropriations Act, 2015.)*

**Explanation of Changes**

The Loan Guarantee Program (LGP) requests $42 million for administrative expenses in FY 2016. All administrative expenses are expected to be entirely offset by fee collections from applicants and borrowers for a net appropriation of $0. This represents a $17 million reduction from P.L. 113-235, the FY 2015 Consolidated and Further Continuing Appropriations Act.

**Public Law Authorizations**
P.L. 109-58, Energy Policy Act of 2005
P.L. 110-5, Revised Continuing Appropriations Resolution, 2007
P.L. 110-161, Consolidated Appropriations Act, 2008
P.L. 111-5, American Recovery and Reinvestment Act of 2009
P.L. 111-8, Omnibus Appropriations Act, 2009
P.L. 112-10, Department of Defense and Full-Year Continuing Appropriations Act, 2011

## Title 17 Innovative Technology Loan Guarantee Program

**($K)**

| FY 2014 Enacted | FY 2014 Current | FY 2015 Enacted | FY 2016 Request |
|---|---|---|---|
| $20,000 | $7,857[1] | $17,000[2] | $0 |

**Overview**

The Loan Guarantee Program (LGP), as authorized under Title XVII of the Energy Policy Act of 2005 and executed by the Department of Energy's (DOE) Loan Programs Office (LPO), encourages early commercial use of new or significantly improved technologies in energy projects. Projects supported by DOE loan guarantees must avoid, reduce, or sequester air pollutants or anthropogenic emissions of greenhouse gases; be located in the United States or its territories; employ new or significantly improved technologies compared to commercial technologies in service in the United States at the time the guarantee is issued; and offer a reasonable prospect of repayment of the principal and interest on the guaranteed obligation.

Section 1703 of the Act authorizes DOE to provide loan guarantees for innovative energy projects in categories including renewable energy systems, advanced nuclear facilities, coal gasification, carbon sequestration, energy efficiency, and various other types of projects. Section 406 of the American Recovery and Reinvestment Act of 2009, Pub. L. No. 111-5 (Recovery Act) amended the Loan Guarantee Program's authorizing legislation, by establishing Section 1705 as a temporary program for the rapid deployment of renewable energy and electric power transmission projects, as well as leading edge biofuels projects. The authority to enter into new loan guarantees under Section 1705 expired on September 30, 2011, but LPO continues to administer and monitor these loan guarantees.

**Highlights and Major Changes in the FY 2016 Budget Request**

The LGP has closed over $20 billion in loan guarantees and continues to negotiate conditional commitments of up to $3 billion. As part of the President's Climate Action Plan, LGP issued the Advanced Fossil Energy Projects Solicitation and the Renewable Energy and Efficient Energy (REEE) Projects Solicitation in FY 2014 and the Advanced Nuclear Energy Projects Solicitation in FY 2015. Over the course of 2016, LGP will continue to review applications under the new solicitations and work to obligate the remaining $8 billion in loan guarantee authority to support advanced Fossil energy technologies that reduce greenhouse gas emissions, $2.5 billion in loan guarantee authority and $169 million in appropriated credit subsidy for eligible REEE projects, and $12.5 billion in loan guarantee authority for eligible advanced nuclear projects.

Every transaction supported by LGP is a public-private undertaking. While the Department issues loans and loan guarantees under Sec. 1703 to provide debt financing for innovative energy projects, the project sponsor must provide significant project-level equity investments. Equity invested from private sources must represent at least 20 percent of the total cost of every project, and usually represents more. DOE will not issue a loan or loan guarantee until substantial private equity support is committed.

[1] Reflects net appropriations minus collections as of September 30, 2014.

[2] Reflects the enacted amount under P.L. 113-235, FY 2015 Consolidated and Further Continuing Appropriations Act. However, LGP anticipates collecting $35 million in offsetting fee collections, resulting in a net administrative appropriation for administrative operations of $7 million.

**Title 17 Innovative Technology Loan Guarantee Program**
**Funding by Congressional Control ($K)**

| | FY 2014 Enacted | FY 2014 Current | FY 2015 Enacted | FY 2016 Request | FY 2016 vs FY 2015 |
|---|---|---|---|---|---|
| **Title 17 Innovative Technology Loan Guarantee Program** | | | | | |
| Administrative Operations | 42,000 | 42,000 | 42,000 | 42,000 | 0 |
| Offsetting Receipts | -22,000 | -34,143 | -25,000 | -42,000 | -17,000 |
| **Total, Title 17 Innovative Technology Loan Guarantee Program** | **20,000** | **7,857**[3] | **17,000** | **0** | **-17,000** |
| **Federal FTEs** | **93** | **93** | **100** | **120** | **+20** |

[3] Reflects net appropriations minus collections as of September 30, 2014.

**Administrative Operations**
**Funding ($K)**

| | FY 2014 Enacted | FY 2014 Current | FY 2015 Enacted | FY 2016 Request | FY 2016 vs FY 2015 |
|---|---|---|---|---|---|
| **Administrative Operations** | | | | | |
| Salaries & Benefits | 13,000 | 13,000 | 15,250 | 20,000 | +4,750 |
| Travel | 500 | 500 | 500 | 800 | +300 |
| Support Services | 24,500 | 24,500 | 21,850 | 18,000 | -3,850 |
| Other Related Expenses | 4,000 | 4,000 | 4,400 | 3,200 | -1,200 |
| **Total, Administrative Operations** | **42,000** | **42,000** | **42,000** | **42,000** | **0** |

**Title 17 Innovative Technology Loan Guarantee Program**
**Explanation of Major Changes ($K)**

| | FY 2016 vs FY 2015 |
|---|---|
| **Administrative Operations** | |
| **Salaries and Benefits:** Provide salaries and benefits to full time equivalent employees to administer the following functions to the office: Director, Legal, Loan Origination, Management Operations, Environmental Compliance, Portfolio Management, Risk Management, and Technical and Project Management. LPO will hire additional staff to monitor portfolio performance in anticipation of new loans closing, further strengthen risk management capabilities, and support loan processing from its open solicitations. | **+4,750** |
| **Travel:** Supports the travel of staff members for site visits, training, and attending meetings. Increase due to anticipated travel requirements for new underwriting and ongoing loan monitoring activities. | **+300** |
| **Support Services:** Provides range of contract services including administrative support, subject matter experts, legal services, information technology, and publications. Decrease in funding due to reduced need for contractor support of underwriting and loan monitoring activities as more federal staff is hired. | **-3,850** |
| **Other Related Expenses:** Supports DOE Working Capital Fund, DOE COE expenses, and LGP federal staff training. Decrease is due to adjustment based on actual historical spending. | **-1,200** |
| **Total, Administrative Operations** | **0** |

## Administrative Operations

**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **Administrative Operations $42,000,000** | **$42,000,000** | **+$0,000,000** |
| **Salaries and Benefits $15,250,000** | **$20,000,000** | **+$4,750,000** |
| • Provide salaries and benefits to 100 full time equivalent employees to administer the following functions to the office: Director, Legal, Loan Origination, Management Operations, NEPA Compliance, Portfolio Management, Risk Management, and Technical and Project Management. | • Provide salaries and benefits to 120 full time equivalent employees to administer the following functions to the office: Director, Legal, Loan Origination, Management Operations, Environmental Compliance, Portfolio Management, Risk Management, and Technical and Project Management. | • Increase to match expected salary requirements and increased federal hiring. Adds 20 additional FTE's |
| **Travel $500,000** | **$800,000** | **+$300,000** |
| • Supports the travel of staff members for site visits, training, and attending meetings and conferences. | • Continuation of FY 2015 activities. Supports the travel of staff members for site visits, training, and to attend consultations. | • Increase travel to originate new loans from 3 open solicitations and continuing monitoring and oversight of additional closed loans at multiple locations. |
| **Support Services $21,850,000** | **$18,000,000** | **-$3,850,000** |
| • Funds outside expertise in finance, legal, engineering, technology, credit analysis, and market assessments. | • Continuation of FY 2015 activities. Provides range of contract services including administrative support, subject matter experts, legal services, information technology, and publications. | • Decrease in funding due to reduced need for contractor support of underwriting and loan monitoring activities as more federal staff is hired. |
| **Other Related Expenses $4,400,000** | **$3,200,000** | **-$1,200,000** |
| • Supports DOE Working Capital Fund, DOE COE expenses, and LGP federal staff training. | • Continuation of FY 2015 activities. Supports DOE Working Capital Fund, DOE COE expenses, and LGP federal staff training. | • Decrease is due to adjustment based on actual historical spending. |

**Title 17 Innovative Technology Loan Guarantee Program**
**Performance Measures**

In accordance with the GPRA Modernization Act of 2010, the Department also sets targets for, and tracks progress toward, achieving other performance goals for each program.

| | FY 2014 | FY 2015 | FY 2016 |
|---|---|---|---|
| Performance Goal (Measure) | **$CO_2$ Reductions of Projects Receiving Loan Guarantees - Estimated $CO_2$ emissions reductions of projects receiving loan guarantees that have achieved commercial operations compared to "business as usual" energy generation** | | |
| Target | ≥ 5,000,000 mt $CO_2$ | ≥ 16,400,000mt $CO_2$ | ≥ 21,200,000 mt $CO_2$ |
| Result | ≥ 8,300,000 mt $CO_2$ | | |
| Endpoint Target | Achieve 16,400,000 mt of avoided $CO_2$ emissions by the end of FY 2016.[4] | | |
| Performance Goal (Measure) | **Generation Capacity of Projects Receiving Loan Guarantees - Annual generation capacity from projects receiving DOE loan guarantees that have achieved commercial operations** | | |
| Target | ≥ 3.8 GW | ≥ 4.0 GW | ≥ 4.0 GW |
| Result | ≥ 3.2 GW | | |
| Endpoint Target | Achieve 4.0 GW of annual electricity generation capacity by FY 2015. | | |

In addition, In April 2014 the Department established FY 2014-2015 agency priority goals (APGs) in the 2014-2018 Strategic Plan. APGs support improvements in near-term outcomes and advance progress toward longer-term, outcome-focused strategic goals and objectives in the Strategic Plan. The Innovative Technology Loan Guarantee Program is responsible for implementing elements of the Climate Action Plan, including providing up to $8 billion in loan guarantees for advanced fossil energy technologies that reduce greenhouse gas emissions by the end of FY 2017. For more information, including quarterly progress updates, planned milestones, and indicators, see the interagency website www.performance.gov.

[4] LPO has revised the methodology for reporting the "Estimated annual greenhouse gas emissions reductions" from projects receiving loan guarantees that have achieved commercial operations. Previously, the emissions reductions had been calculated for each generation project as: $\frac{Additional\ Capcity\ Online}{Nameplate\ Capacity} \times Estimated\ Anuual\ CO_2\ Avoided$ ,"Additional Capacity Online" being the incremental GW capacity brought online in the given quarter. This value was summed for each project, and then represented cumulatively. LPO is now reporting based on its Technical and Project Management Division's (TPMD) methodology, which uses the actual GW hours of energy produced by LGP projects to calculate the emissions reductions in a given quarter along with EIA's conversion factors to determine the emissions reduced.

**Department Of Energy**

**FY 2016 Congressional Budget**

**Funding By Appropriation By Site**

**($K)**

| Innovative Tech Loan Guarantee Prog | FY 2014 Current | FY 2015 Enacted | FY 2016 Request |
|---|---|---|---|
| **Washington Headquarters** | | | |
| **Administrative Operations** | | | |
| Administrative Operations | 42,000 | 42,000 | 42,000 |
| **Total, Washington Headquarters** | **42,000** | **42,000** | **42,000** |
| **Total, Innovative Tech Loan Guarantee Prog** | **42,000** | **42,000** | **42,000** |

# Tribal Indian Energy Loan Guarantee Program

# Tribal Indian Energy Loan Guarantee Program

**Tribal Indian Energy Loan Guarantee Program**
**Proposed Appropriation Language**

*For the cost of guaranteed loans, $9,000,000, to remain available until expended, as authorized by section 2602(c) of the Energy Policy Act of 1992 (25 U.S.C. 3502(c)): Provided, That such costs, including the cost of modifying such loans, shall be as defined in section 502 of the Congressional Budget Act of 1974: Provided further, That, for necessary administrative expenses to carry out this Loan Guarantee program, $2,000,000 is appropriated, to remain available until September, 30, 2017.*

**Explanation of Changes**

To date no funds have been appropriated to implement the Tribal Indian Energy Loan Guarantee Program (TIELGP). The Department requests $2 million in administrative funding in FY 2016 to issue a final rule and establish the TIELGP, and $9 million in credit subsidy so that LPO may issue a solicitation and begin accepting applications. Appropriated credit subsidy funds will cover the estimated long-term costs associated with loan guarantees committed in 1992 and beyond (including modifications of direct loans or loan guarantees that resulted from obligations or commitments in any year), as required by the Federal Credit Reform Act of 1990.

**Public Law Authorizations**
P. L. 109-58, Energy Policy Act of 2005

## Tribal Indian Energy Loan Guarantee Program

**($K)**

| FY 2014 Enacted | FY 2014 Current | FY 2015 Enacted | FY 2016 Request |
|---|---|---|---|
| $0 | $0 | $0 | $11,000 |

**Overview**

Section 2602(c) of the Energy Policy Act of 2005 authorizes the Director of the Office of Indian Energy Policy and Programs (IE) within DOE to establish a Tribal Indian energy loan guarantee program to provide, or expand the provision of, electricity on Indian land. In FY 2016, the Department proposes $2 million in administrative Budget Authority and $9 million in credit subsidy for the Tribal Indian Energy Loan Guarantee Program (TIELGP). The loan guarantees will support the development or expansion of generation projects which employ commercially proven and available clean energy technologies. The aggregate outstanding amount guaranteed by DOE at any time shall not exceed $2 billion.

It is well documented that Indian tribes have considerable challenges accessing capital to support infrastructure development.[1] Indian lands have an estimated 7,000,000 MW of renewable energy potential, however only 125-130MW has been installed due to lack of capital. Although other credit programs exist, the eligibility criteria for these programs preclude most tribes from participating. For example, the maximum guaranteed loan amount available under many programs is insufficient to develop clean energy projects. While the USDA Rural Utilities Service allows for higher maximum guaranteed loan amounts, it is focused on transmission and distribution, not on generation projects, and requires participants in the program to be an organization or business structure similar to that of a utility. The TIELGP will provide much-needed capital to support energy security and economic development on Indian lands.

**Highlights and Major Changes in the FY 2016 Budget Request**

The FY 2016 Budget Request includes an additional $9 million in credit subsidy and $2 million for administrative costs for loan guarantees to tribes that will support the deployment of small to medium-sized energy generation projects. Executed through the Loan Programs Office (LPO), an initial solicitation will support one to two loan guarantees for medium-sized projects, estimated at 1MW – 10MW installed capacity. LPO will administer the program and coordinate with IE. This will allow the TIELGP to utilize existing staff and expertise within LPO, while minimizing overhead costs and other related expenses typically associated with establishing a new program, as well as the ongoing costs of administering the program.

[1] *Growing Economies in Indian Country: Taking Stock of Progress and Partnership, available online*: http://www.federalreserve.gov/newsevents/conferences/GEIC-white-paper-20120501.pdf

**Tribal Indian Energy Loan Guarantee Program**
**Funding by Congressional Control ($K)**

| | FY 2014 Enacted | FY 2015 Current | FY 2015 Enacted | FY 2016 Request | FY 2016 vs FY 2015 |
|---|---|---|---|---|---|
| **Tribal Indian Energy Loan Guarantee Program** | | | | | |
| Loan Guarantee Credit Subsidy Costs | 0 | 0 | 0 | 9,000 | +9,000 |
| Administrative Operations | 0 | 0 | 0 | 2,000 | +2,000 |
| **Total, Tribal Indian Energy Loan Guarantee Program** | **0** | **0** | **0** | **11,000** | **+11,000** |
| **Federal FTEs** | **0** | **0** | **0** | **5** | **5** |

**Administrative Operations**
**Funding ($K)**

| | FY 2014 Enacted | FY 2014 Current | FY 2015 Enacted | FY 2016 Request | FY 2016 vs FY 2015 |
|---|---|---|---|---|---|
| **Administrative Operations** | | | | | |
| Salaries and Benefits | 0 | 0 | 0 | 800 | +800 |
| Travel | 0 | 0 | 0 | 150 | +150 |
| Support Services | 0 | 0 | 0 | 975 | +975 |
| Other Related Expenses | 0 | 0 | 0 | 75 | +75 |
| **Total, Administrative Operations** | **0** | **0** | **0** | **2,000** | **+2,000** |

**Administrative Operations**
**Explanation of Major Changes ($K)**

| | FY 2016 vs FY 2015 |
|---|---|
| **Administrative Operations** | |
| **Salaries and Benefits:** Provide salaries and benefits to 5 full time equivalent employees. LPO will provide staff to support the following functions: Legal, Loan Origination, Management Operations, Environmental Compliance, Portfolio Management, Risk Management, and Technical and Project Management. | **+800** |
| **Travel:** Supports the travel of staff members for outreach to applicants, site visits, as well as attending meetings and conferences. | **+150** |
| **Support Services:** Funds outside expertise in finance, legal, engineering, technology, credit analysis, and market assessments to assist in the review of applications, as well as underwriting new loans and monitoring loans after they close. | **+975** |
| **Other Related Expenses:** Supports only the direct costs for TIELGP will be billed to LPO via DOE Working Capital Fund, such as the cost of publishing a Federal Register Notice. LPO anticipates such costs will be minimal. | **+75** |
| **Total, Administrative Operations** | **+2,000** |

## Administrative Operations

**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **Administrative Operations $0** | **$2,000,000** | **+$2,000,000** |
| **Salaries and Benefits $0** | **$800,000** | **+$800,000** |
| No funds have been appropriated to date. | To provide salaries and benefits to 5 full time equivalent employees to administer the following functions to the office: Director, Legal, Loan Origination, Management Operations, Environmental Compliance, Portfolio Management, Risk Management, and Technical and Project Management. | Increase in salaries and benefits reflect FTE hours for existing IE and LPO staff that will be working on the new loan guarantee program. |
| **Travel $0** | **$150,000** | **+$150,000** |
| No funds have been appropriated to date. | Supports the travel of staff members for outreach to applicants, site visits, as well as attending meetings and conferences. | Increased costs reflect the travel needs associated with conducting outreach and site visits for the new loan guarantee program. |
| **Support Services $0** | **$975,000** | **+$975,000** |
| No funds have been appropriated to date. | Funds outside expertise in finance, legal, engineering, technology, credit analysis, and market assessments to assist in the review of applications, as well as underwriting new loans and monitoring loans after they close. | Increase reflects amounts needed to begin implementing the new loan guarantee program and reviewing loan applications. |
| **Other Related Expenses $0** | **$75,000** | **+$75,000** |
| No funds have been appropriated to date. | Supports only the direct costs for TIELGP will be billed to LPO via DOE Working Capital Fund, such as the cost of publishing a Federal Register Notice. LPO anticipates such costs will be minimal. | Increased costs reflects estimate of the needs of new loan guarantee program. LPO anticipates such costs will be minimal. |

**Department Of Energy**

**FY 2016 Congressional Budget**

**Funding By Appropriation By Site**

**($K)**

| Tribal Indian Energy Loan Guarantee Program | FY 2014 Current | FY 2015 Enacted | FY 2016 Request |
|---|---|---|---|
| **Washington Headquarters** | | | |
| **Tribal Indian Energy Loan Guarantee Program** | | | |
| Administrative Operations | 0 | 0 | 2,000 |
| Loan guarantee credit subsidy costs | 0 | 0 | 9,000 |
| **Total, Tribal Indian Energy Loan Guarantee Program** | **0** | **0** | **11,000** |
| **Total, Washington Headquarters** | **0** | **0** | **11,000** |
| **Total, Tribal Indian Energy Loan Guarantee Program** | **0** | **0** | **11,000** |

# Office of Indian Energy Policy and Programs

# Office of Indian Energy Policy and Programs

**Office of Indian Energy Policy and Programs**
**Proposed Appropriation Language**

*For necessary expenses for Indian Energy activities in carrying out the purposes of the Department of Energy Organization Act (42 U.S.C. 7101 et seq.), $20,000,000, to remain available until expended. Provided, That, of the amount appropriated under this heading, $3,510,000 shall be available until September 30, 2017, for program direction.*

**Explanation of Changes**

This is a new appropriation

**Public Law Authorizations**
Public Law 109–58, "Energy Policy Act of 2005," Title V

## Office of Indian Energy Policy and Programs

**($K)**

| FY 2014 Enacted[1] | FY 2014 Current | FY 2015 Enacted | FY 2016 Request |
|---|---|---|---|
| 0 | 0 | 0 | 20,000 |

**Overview**

The Office of Indian Energy Policy and Programs (IE) directs, fosters, coordinates, and implements energy planning, education, management, and competitive grant programs to assist Tribes with clean energy development and infrastructure, capacity building, energy costs, and electrification of Indian lands and homes. IE coordinates programmatic activities across DOE related to the development of clean energy resources on Indian lands and works with other Government agencies and Indian Tribes and organizations to promote Indian energy policies and initiatives. IE performs these functions consistent with the federal government's trust responsibility, Tribal self-determination policy, and government-to-government relationship with Indian Tribes.

IE accomplishes its mission through technical assistance, education, and capacity building; research and analysis; and financial assistance to Indian Tribes, Alaska Native Tribes and corporations, and Tribal energy resource development organizations. Technical assistance entails utilizing subject matter experts to assist Tribes with deploying clean energy projects, as well as high-level technical support for energy planning, project development, transmission interconnection, and utility formation. Research and analysis involves surveying energy needs of Tribal lands, including available infrastructure support and natural resources, and developing subsequent strategies for electrification and energy deployment. Financial assistance via grant opportunities to Tribes supports the deployment of energy generation and energy efficiency projects, reducing the cost/use of energy on Indian lands.

**Highlights and Major Changes in the FY 2016 Budget Request**

Through FY 2015, funding for the Office of Indian Energy Policy and Programs was provided within the Departmental Administration appropriation. In FY 2016, funding for these programs is requested as a new separate appropriation.

In FY 2016, $20,000,000 is requested to fund the Office of Indian Energy Policy and Programs. The funding request includes $3,510,000 to support 9 FTEs (+2 FTE), other program direction costs, and administrative costs; and $16,490,000 to provide increased technical assistance and competitive grant programs to support clean energy development, energy efficiency improvements, electrification projects, remote community renewable energy hybrid systems, microgrid deployment, water-energy project support, and other greenhouse gas emission mitigation technologies for Indian Tribes.

The Department is organized into three Under Secretariats—Science and Energy, Nuclear Security, and Management and Performance—which recognize the complex interrelationship among DOE Program Offices. The FY 2016 Budget continues crosscutting programs which coordinate across the Department and seek to tap DOE's full capability to effectively and efficiently address the U.S.'s energy, environmental, and national security challenges. These crosscutting initiatives will be discussed further within the programs in which the crosscuts are funded. The FY 2016 Request for IE contains the following crosscuts:

[1] In FY 2014, the Office of Indian Energy was funded within the Departmental Administration appropriation and the Tribal Energy Program was funded within the Energy Efficiency and Renewable Energy appropriation. In FY 2015, the Tribal Energy Program was transferred to the Office of Indian Energy and both were funded within the Departmental Administration appropriation.

**Water-Energy:** The water-energy nexus crosscut is an integrated set of cross-program collaborations designed to accelerate the Nation's transition to more resilient energy and coupled energy-water systems. The crosscut supports: (1) an advanced, integrated data, modeling, and analysis platform to improve understanding and inform decision-making for a broad range of users and at multiple scales; (2) investments in targeted technology research opportunities within the system of water-energy flows that offer the greatest potential for positive impact; and (3) policy analysis and stakeholder engagement designed to build from and strengthen the two preceding areas while motivating more rapid community involvement and response.

**Grid Modernization:** U.S. prosperity and energy innovation in a global clean energy economy depends on the modernization of the National Electric Grid. To support this transformation, DOE's Grid Modernization Initiative will create tools and technologies that measure, analyze, predict, and control the grid of the future; focus on key policy questions related to regulatory practices, market designs, and business models; ensure the development of a secure and resilient grid; and collaborate with stakeholders to test and demonstrate combinations of promising new technologies.

**FY 2016 Crosscuts ($K)**

| | Energy-Water Nexus | Grid Moderni-zation | Total |
|---|---|---|---|
| **Tribal Energy Program** | 700 | 500 | **1,200** |

**Office of Indian Energy Policy and Programs**
**Funding by Congressional Control ($K)**

| | FY 2014 Enacted[2] | FY 2014 Current | FY 2015 Enacted | FY 2016 Request | FY 2016 vs FY 2015 |
|---|---|---|---|---|---|
| **Office of Indian Energy Policy and Programs** | | | | | |
| Program Direction | 0 | 0 | 0 | 3,510 | +3,510 |
| Tribal Energy Program | 0 | 0 | 0 | 16,490 | +16,490 |
| **Total, Office of Indian Energy Policy and Programs** | **0** | **0** | **0** | **20,000** | **+20,000** |
| **Federal FTEs** | **0** | **0** | **0** | **9** | **+9** |

**Office of Indian Energy Policy and Programs**
**Funding by Congressional Control (Comparable) ($K)**

| | FY 2014 Enacted | FY 2014 Current | FY 2015 Enacted | FY 2016 Request | FY 2016 vs FY 2015 |
|---|---|---|---|---|---|
| **Office of Indian Energy Policy and Programs** | | | | | |
| Program Direction[3] | 1,171 | 1,171 | 2,510 | 3,510 | +1,000 |
| Tribal Energy Program[4] | 8,331 | 8,331 | 13,490 | 16,490 | +3,000 |
| **Total, Office of Indian Energy Policy and Programs** | **9,502** | **9,502** | **16,000** | **20,000** | **+4,000** |
| **Federal FTEs** | **5** | **5** | **7** | **9** | **+2** |

[2]In FY 2014, the Office of Indian Energy was funded as Program Direction within the Departmental Administration appropriation and the Tribal Energy Program was funded within the Energy Efficiency and Renewable Energy appropriation. In FY 2015, the Tribal Energy Program was transferred to the Office of Indian Energy and both were funded within the Departmental Administration appropriation.

## Office of Indian Energy Policy and Programs
## Proposed Budget Structure Change

The Office of Indian Energy was originally established in the Congressional and Intergovernmental Affairs Office, and to date has been funded within the Departmental Administration appropriation. In FY 2015, DOE consolidated the Office of Indian Energy and EERE's Tribal Energy Program into the Office of Indian Energy Policy and Programs. This Office currently reports directly to the Under Secretary for Science and Energy and is fully integrated into the portfolio of science and energy programs. To better align Departmental program management structure with the budget and to improve Congressional transparency, the FY 2016 Budget proposes to remove it from the Departmental Administration appropriation and establish it as a separate appropriation.

### Budget Structure Crosswalk ($K)
### Proposed FY 2016 Budget Structure

| | Office of Indian Energy Policy and Programs | | Total |
|---|---|---|---|
| **FY 2015 Budget Structure** | **Program Direction** | **Tribal Energy Program** | |
| Departmental Administration | | | |
| Office of Indian Energy Policy and Programs | | | |
| Program Direction | 3,510 | 0 | 3,510 |
| Tribal Energy Program | 0 | 16,490 | 16,490 |
| **Total** | **3,510** | **16,490** | **20,000** |

## Program Direction

### Overview

Program Direction provides for Headquarters and field employees responsible for administrative support, including program management and guidance, contract administration, and budget formulation and execution of IE's programs and activities as well as coordination with other agencies.

The Headquarters staff is responsible for providing overall guidance and direction for DOE program offices on Tribal energy activities and initiatives necessary to achieve IE's program objectives. Headquarters staff also provides day-to-day management of national technical assistance, educational activities, and capacity building programs. Anchorage staff performs management functions of IE technical assistance, capacity building, and education programs for Alaska Native villages, Tribes, and corporations. Golden staff performs grant management functions for IE financial assistance programs.

### Highlights of the FY 2016 Budget Request

Through FY 2015, Program Direction was funded within the Departmental Administration account. There are no significant increases from FY 2015 activities. The Office of Indian Energy seeks to increase its program direction funding (+$1,000,000) to support increased activities for remote community renewable energy hybrid system development, and cross-cut microgrid and water-energy outreach activities. Staffing level will increase by 2 FTEs—to 9 FTEs—with one additional FTE in HQ and 1 FTE in Alaska. The Office maintains one FTE in Golden, Colorado to administer the financial assistance programs and related grantee project support requirements. The two Alaska-based FTEs will work closely with the federally recognized tribes, Alaska Native villages and corporations, and coordinate inter-agency cooperative efforts to address energy issues in Alaska Native villages, including the renewable energy implementation activities for the National Strategy for the Arctic Region and the remote community renewable energy hybrid system development project. Additional funding for support services (+$630,000) includes outreach and administrative support activities related to the increased program activities.

**Program Direction**
**Funding ($K)**

| | FY 2014 Enacted[5] | FY 2014 Current | FY 2015 Enacted | FY 2016 Request | FY 2016 vs FY 2015 |
|---|---|---|---|---|---|
| **Program Direction Summary** | | | | | |
| **Washington Headquarters** | | | | | |
| Salaries and Benefits | 0 | 0 | 0 | 1,415 | +1,415 |
| Travel | 0 | 0 | 0 | 100 | +100 |
| Support Services | 0 | 0 | 0 | 1,010 | +1,010 |
| Other Related Expenses | 0 | 0 | 0 | 420 | +420 |
| **Total, Washington Headquarters** | **0** | **0** | **0** | **2,945** | **+2,945** |
| | | | | | |
| **Golden** | | | | | |
| Salaries and Benefits | 0 | 0 | 0 | 205 | +205 |
| Travel | 0 | 0 | 0 | 0 | 0 |
| Support Services | 0 | 0 | 0 | 310 | +310 |
| Other Related Expenses | 0 | 0 | 0 | 50 | +50 |
| **Total, Golden** | **0** | **0** | **0** | **565** | **+565** |
| | | | | | |
| **Total Program Direction** | | | | | |
| Salaries and Benefits | 0 | 0 | 0 | 1,620 | +1,620 |
| Travel | 0 | 0 | 0 | 100 | +100 |
| Support Services | 0 | 0 | 0 | 1,320 | +1,320 |
| Other Related Expenses | 0 | 0 | 0 | 470 | +470 |
| **Total, Program Direction** | **0** | **0** | **0** | **3,510** | **+3,510** |
| **Federal FTEs** | **0** | **0** | **0** | **9** | **+9** |
| | | | | | |
| **Support Services** | | | | | |
| Management Support | | | | | |
| Administrative Support Contract | 0 | 0 | 0 | 460 | +460 |
| Grant Program Management | 0 | 0 | 0 | 310 | +310 |
| Technical Assistance Program Management | 0 | 0 | 0 | 300 | +300 |
| Indian Country Working Group | 0 | 0 | 0 | 250 | +250 |
| **Total Management Support** | **0** | **0** | **0** | **1,320** | **+1,320** |
| **Total, Support Services** | **0** | **0** | **0** | **1,320** | **+1,320** |

[5] In FY 2014 and FY 2015, the Program Direction was funded within the Departmental Administration appropriation.

| | FY 2014 Enacted[5] | FY 2014 Current | FY 2015 Enacted | FY 2016 Request | FY 2016 vs FY 2015 |
|---|---|---|---|---|---|
| **Other Related Expenses** | | | | | |
| Energy IT Services - Desktop Services | 0 | 0 | 0 | 155 | +155 |
| WCF | 0 | 0 | 0 | 270 | +270 |
| Other Services | 0 | 0 | 0 | 45 | +45 |
| **Total, Other Related Expenses** | **0** | **0** | **0** | **470** | **+470** |

**Program Direction**
**Funding (Comparable) ($K)**

| | FY 2014 Enacted[6] | FY 2014 Current | FY 2015 Enacted | FY 2016 Request | FY 2016 vs FY 2015 |
|---|---|---|---|---|---|
| **Program Direction Summary** | | | | | |
| **Washington Headquarters** | | | | | |
| Salaries and Benefits | 905 | 905 | 1,210 | 1,415 | +205 |
| Travel | 40 | 40 | 50 | 100 | +50 |
| Support Services | 0 | 0 | 390 | 1,010 | +620 |
| Other Related Expenses | 226 | 226 | 315 | 420 | +105 |
| **Total, Washington Headquarters** | **1,171** | **1,171** | **1,965** | **2,945** | **+980** |
| **Golden** | | | | | |
| Salaries and Benefits | 0 | 0 | 200 | 205 | +5 |
| Travel | 0 | 0 | 0 | 0 | |
| Support Services | 0 | 0 | 300 | 310 | +10 |
| Other Related Expenses | 0 | 0 | 45 | 50 | +5 |
| **Total, Golden** | **0** | **0** | **545** | **565** | **+20** |
| **Total Program Direction** | | | | | |
| Salaries and Benefits | 905 | 905 | 1,410 | 1,620 | +210 |
| Travel | 40 | 40 | 50 | 100 | +50 |
| Support Services | 0 | 0 | 690 | 1,320 | +630 |
| Other Related Expenses | 226 | 226 | 360 | 470 | +110 |
| **Total, Program Direction** | **1,171** | **1,171** | **2,510** | **3,510** | **+1,000** |
| **Federal FTEs** | **5** | **5** | **7** | **9** | **+2** |

[6] In FY 2014 and FY 2015, the Program Direction was funded within the Departmental Administration appropriation.

| | FY 2014 Enacted[6] | FY 2014 Current | FY 2015 Enacted | FY 2016 Request | FY 2016 vs FY 2015 |
|---|---|---|---|---|---|
| **Support Services** | | | | | |
| Management Support | | | | | |
| Administrative Support Contract | 0 | 0 | 85 | 460 | +375 |
| Grant Program Management | 0 | 0 | 300 | 310 | +10 |
| Technical Assistance Program Management | 0 | 0 | 210 | 300 | +90 |
| Indian Country Working Group | 0 | 0 | 95 | 250 | +155 |
| **Total Management Support** | **0** | **0** | **690** | **1,320** | **+630** |
| **Total, Support Services** | **0** | **0** | **690** | **1,320** | **+630** |
| | | | | | |
| **Other Related Expenses** | | | | | |
| Energy IT Services - Desktop Services | 20 | 20 | 120 | 155 | +35 |
| WCF | 75 | 75 | 205 | 270 | +65 |
| Other Services | 131 | 131 | 35 | 45 | +10 |
| **Total, Other Related Expenses** | **226** | **226** | **360** | **470** | **+110** |

## Program Direction

**Activities and Explanation of Changes**

| FY 2015 Enacted[7] | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **Program Direction $0 ($2,510,000)** | **$3,510,000** | **+$3,510,000 (+$1,000,000)** |
| **Salaries and Benefits $0 ($1,410,000)** | **$1,620,000** | **+$1,620,000 (+$210,000)** |
| No activities. In FY 2015, the following workscope was funded and conducted within the Departmental Administration appropriation. Salaries and Benefits funding supports 7 full-time equivalents (FTEs) who perform program management functions, implement program activities, perform budget execution and procurement functions, and monitor over 200 grantee and contractor activities. Includes funding for 1 FTE deployed in Anchorage, Alaska , to manage technical assistance activities with Alaska Native villages and coordinate with other Federal agencies | Salaries and Benefits funding supports 9 full-time equivalents (FTEs) who perform program management functions, implement program activities, perform budget execution and procurement functions, monitor over 200 grantee and contractor activities, and new cross-cut and remote community renewable energy program activities. | Provides 2 additional FTEs. One new FTE hired for Alaska to manage new program activity, and one new FTE for HQ to manage new microgrid and water energy cross-cut activities. |

[7] In FY 2014 and FY 2015, the Program Direction was funded within the Departmental Administration appropriation.

| FY 2015 Enacted[7] | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **Travel $0 ($50,000)** | **$100,000** | **+$100,000 (+$50,000)** |
| No activities. In FY 2015, the following workscope was funded and conducted within the Departmental Administration appropriation. Travel funding provides for necessary program management functions at field locations. | Travel funding provides for necessary program management functions at field locations, and increased outreach activity for Arctic region | Supports travel requirements for Headquarter and field site staff conducting management and oversight of increased program activity. |
| **Support Services $0 ($690,000)** | **$1,320,000** | **+$1,320,000 (+$630,000)** |
| No activities. In FY 2015, the following workscope was funded and conducted within the Departmental Administration appropriation. Funding provides for administrative support for TEP technical assistance and grant management activities. Support service funding at the Golden Field Site Office ($300) provides funding to a contractor for grant program support. | Maintain funding for administrative support for TEP technical assistance and grant management activities. Support service funding at the Golden Field Site Office ($1,320) provides funding to a contractor for grant program support. | Supports administrative and management activities for new program activity. |
| **Other Related Expenses $0 ($360,000)** | **$470,000** | **+$470,000 (+110,000)** |
| No activities. In FY 2015, the following workscope was funded and conducted within the Departmental Administration appropriation. Funding provides for computer hardware and software services, Working Capital Fund (WCF) contributions, necessary office supplies, and other miscellaneous costs. | Maintain funding for computer hardware and software services, Working Capital Fund (WCF) contributions, necessary office supplies, and other miscellaneous costs. | Supports costs associated with additional FTE. |

## Tribal Energy Program

**Overview**

In FY 2015, the Department consolidated the Tribal Energy Program into IE to achieve significant administrative and program management efficiencies, and to further the Department's efforts in building partnerships with the 566 federally recognized Tribal governments and other federal agencies. Financial and technical assistance to Tribes, Alaska Native villages and corporations is critical and valuable in advancing sustainable energy development and deployment on Tribal lands. The current DOE strategic goal to increase installed clean energy capacity by 25 Megawatts in Indian Country represents a 15% increase over current estimated installed capacity.

The Tribal Energy Program's technical and financial assistance efforts are designed to help Indian Tribes and Alaska Native villages and corporations overcome barriers to deploying small to medium-scale renewable energy generation projects (used for heat and electric power), as well as energy efficiency projects that result in reduced energy costs, stabilized energy costs, and more efficient use of energy. Program activities will continue to support specific DOE goals and objectives at DOE, including reduced energy use and increased clean energy generation capacity on Tribal lands, and leverage participation in the DOE cross-cut activities for microgrid and water energy project efforts. Additionally, the Office of Indian Energy Policy and Programs will address Tribal government priorities for energy sufficiency and associated economic development in Indian Country.

Technical assistance activities include the Strategic Technical Assistance Response Teams (START) program, tribal community energy planning, late-stage project development assistance, and transmission and electrification feasibility assessments. Other activities will address Tribal leader and Tribal staff training, an internship program, and education efforts to build capacity that supports tribal self-determination, self-sufficiency and energy security. Additional efforts will focus on climate change mitigation, adaption and resiliency support for Tribes and Alaska Native villages.

The grant program activities provide funds for clean energy development and deployment; energy efficiency improvements; greenhouse gas emission mitigation technologies; and other projects to address electrification needs on Indian lands.

**Highlights of the FY 2016 Budget Request**

In FY 2016, there are no significant changes from FY 2015 activities. Support is requested for the Tribal Energy Program to expand technical assistance activities and grant program activities. New technical assistance activities will focus on remote community renewable energy hybrid system design and deployment support, in Alaska and elsewhere, and outreach activities for microgrid and water energy cross cut efforts. Grant funding will support deployment of renewable energy hybrid systems for remote tribal communities, in Alaska and elsewhere, as well as demonstration projects on Indian lands identified in the microgrid and water-energy cross-cut efforts.

Within the FY 2016 Budget Request, the Tribal Energy Program supports two Departmental Crosscuts: Grid Modernization and Water-Energy. The goal of the Grid cross-cut efforts will be focused on microgrid technologies which represent a tribal energy opportunity, especially for remote communities and tribal utilities. IE will support outreach activities to tribal entities, and distributed and microgrid technology demonstration projects that can be leveraged into tribal utilities and tribal community energy development efforts. Funding will be $500 for these grid activities.

IE will also support outreach and demonstration projects for water-energy projects identified by the cross-cut efforts that are most relevant to Indian tribes. Initial focus will be on water-energy technologies that improve energy efficiencies of drinking water and waste water systems on tribal lands—an area contemplated in the water-energy demonstration projects proposals. IE anticipates funding up to $700,000 for these water-energy activities

**FY 2016 Crosscuts ($K)**

| | Water Energy | Grid Moderni-zation | Total |
|---|---|---|---|
| **Tribal Energy Program** | **700** | **500** | **1,200** |

**Tribal Energy Program**
**Funding ($K)**

| | FY 2014 Enacted | FY 2014 Current | FY 2015 Enacted | FY 2016 Request | FY 2016 vs FY 2015 |
|---|---|---|---|---|---|
| **Tribal Energy Program** | | | | | |
| Technical Assistance[8] | 0 | 0 | 0 | 3,500 | +3,500 |
| Tribal Energy Grant Program[9] | 0 | 0 | 0 | 12,990 | +12,990 |
| **Total, Tribal Energy Program** | **0** | **0** | **0** | **16,490** | **+16,490** |

**Tribal Energy Program**
**Funding (Comparable) ($K)**

| | FY 2014 Enacted | FY 2014 Current | FY 2015 Enacted | FY 2016 Request | FY 2016 vs FY 2015 |
|---|---|---|---|---|---|
| **Office of Indian Energy Policy and Programs** | | | | | |
| Technical Assistance | 1,335 | 1,335 | 2,500 | 3,500 | +1,000 |
| Tribal Energy Grant Program | 6,996 | 6,996 | 10,990 | 12,990 | +2,000 |
| **Total, Office of Indian Energy Policy and Programs** | **8,331** | **8,331** | **13,490** | **16,490** | **+3,000** |

**Tribal Energy Program**

**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| **Tribal Energy Program $0 ($13,490,000)** | **$16,490,000** | **+$16,490,000 (+$3,000,000)** |
| **Technical Assistance $0 (2,500,000)** | **$3,500,000** | **+$3,500,000 (+$1,000,000)** |
| No activities. In FY 2015, the following workscope was funded and conducted within the Departmental Administration appropriation. Funding for technical assistance programs ($2,500k) to support training, | This is new Program in FY 2016. Funding for technical assistance programs to maintain support for training, education, and capacity building efforts. These efforts include education and training programs to disseminate information to Indian Country through on-line training, | Technical assistance request includes additional resources to support deployment of clean energy projects<br>• Remote community renewable energy hybrid systems. |

[8] In FY 2014 Technical Assistance was funded within the Energy Efficiency and Renewable Energy appropriation.
[9] In FY 2014, Tribal Energy Program was funded within the Energy Efficiency and Renewable Energy appropriation.

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| education, and capacity building efforts. These efforts include education and training programs to disseminate information to Indian Country through on-line training, regional/national workshops, webinars, and printed guides and materials.<br><br>In addition, technical assistance is provided to Tribes through the Strategic Technical Assistance Response Teams (START) program, which provides subject matter experts to assist Tribes with deploying clean energy projects. Other technical assistance efforts include high-level support for energy planning, project development, transmission interconnection, and utility formation.<br><br>Additionally, funding will support the IE Alaska program focused on education, capacity building, and technical assistance, including Alaska START program, project development and finance education, micro-grid integration support, and renewable energy technical analysis support.<br><br>Lastly, internships at DOE National Laboratories and field sites are provided to Native American graduate students interested in careers in the energy sector. | regional/national workshops, webinars, and printed guides and materials.<br><br>In addition, technical assistance is provided to Tribes through the Strategic Technical Assistance Response Teams (START) program, which provides subject matter experts to assist Tribes with deploying clean energy projects. Other technical assistance efforts include high-level support for energy planning, project development, transmission interconnection, and utility formation.<br><br>Additionally, funding will support the IE Alaska program focused on education, capacity building, and technical assistance, including Alaska START program, project development and finance education, micro-grid integration support, and renewable energy technical analysis support.<br><br>Increase our efforts under the National Strategy for the Arctic Region, including initiatives to support deployment of renewable energy hybrid systems in remote Native communities in Alaska and elsewhere, public-private partnerships, and other opportunities to scale up deployment of clean energy in the Arctic region.<br><br>Maintain internships at DOE National Laboratories and field sites for Native American graduate students interested in careers in the energy sector.<br><br>New technical assistance initiatives will include remote community renewable energy hybrid system deployment support, microgrid and water energy project outreach support, and increased efforts to assist tribes and Alaska Native villages with climate change mitigation, adaption, and resiliency efforts. | • Cross-cut activities.<br>• National Strategy for the Arctic Region implementation plan activities.<br>Tribal Climate Change mitigation, adaption, and resiliency assistance. |
| **Tribal Energy Grant Program $0 ($10,990,000)** | **$12,990,000** | **+$12,990,000 (+$2,000,000)** |
| No activities. In FY 2015, the following workscope was funded and conducted within the Departmental | This is new Program in FY 2016. Maintain competitive grant program to support clean energy and energy efficiency | Tribal Energy Grant Program request includes: |

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs FY 2015 |
|---|---|---|
| Administration appropriation. Funding for grant program ($10,990) provides financial assistance to Tribes to assist with electrification projects on Indian lands, including deployment of clean, sustainable energy systems. | deployment on tribal lands and in Alaska Native villages.<br><br>New financial assistance initiatives would support increased funding for remote community renewable energy hybrid system deployment ($5,000), demonstration project support for microgrid and water energy cross cut projects ($1,200), and climate change resiliency projects ($1,000). | • Grant program activities to address the need for clean energy deployment and electrification of Indian lands and homes, in accordance with the Energy Policy Act of 2005 (P.L. 109-58, Title V).<br>• Deployment of renewable energy hybrid systems in remote communities.<br>• Increased support for microgrid and water energy demonstration projects.<br>• Climate change resiliency projects. |

**Department Of Energy**

**FY 2016 Congressional Budget**

**Funding By Appropriation By Site**

**($K)**

| Indian Energy Policy and Programs | FY 2014 Current | FY 2015 Enacted | FY 2016 Request |
|---|---|---|---|
| **Bonneville Power Administration** | | | |
| **Indian Energy Policy and Programs** | | | |
| Technical Assistance | 0 | 100 | 0 |
| **Total, Bonneville Power Administration** | **0** | **100** | **0** |
| **Golden Field Office** | | | |
| **Indian Energy Policy and Programs** | | | |
| Program Direction | 0 | 545 | 565 |
| **Total, Golden Field Office** | **0** | **545** | **565** |
| **National Renewable Energy Laboratory** | | | |
| **Indian Energy Policy and Programs** | | | |
| Technical Assistance | 0 | 900 | 1,200 |
| **Total, National Renewable Energy Laboratory** | **0** | **900** | **1,200** |
| **Sandia National Laboratories** | | | |
| **Indian Energy Policy and Programs** | | | |
| Technical Assistance | 0 | 500 | 700 |
| **Total, Sandia National Laboratories** | **0** | **500** | **700** |
| **Washington Headquarters** | | | |
| **Indian Energy Policy and Programs** | | | |
| Program Direction | 0 | 1,965 | 2,945 |
| Technical Assistance | 0 | 900 | 1,500 |
| Tribal Energy Program | 0 | 10,990 | 12,990 |
| **Total, Indian Energy Policy and Programs** | **0** | **13,855** | **17,435** |
| **Total, Washington Headquarters** | **0** | **13,855** | **17,435** |
| **Western Area Power Administration** | | | |
| **Indian Energy Policy and Programs** | | | |
| Technical Assistance | 0 | 100 | 100 |
| **Total, Western Area Power Administration** | **0** | **100** | **100** |
| **Total, Indian Energy Policy and Programs** | **0** | **16,000** | **20,000** |

# Energy Information Administration

# Energy Information Administration

## Energy Information Administration

### Proposed Appropriation Language

For necessary expenses in carrying out the activities of the Energy Information Administration, [$117,000,000]*$131,000,000*, to remain available until expended.

### Explanation of Change

No changes.

**Public Law (P.L.) Authorizations**
P.L. 83-703, Atomic Energy Act (1954)
P.L. 93-275, 15 U.S.C. 761, Federal Energy Administration Act (1974)
P.L. 93-319, Energy Supply and Environmental Coordination Act (1974)
P.L. 94-163, Energy Policy and Conservation Act (1975)
P.L. 94-385, 15 U.S.C. 790, Energy Conservation and Production Act (1976)
P.L. 95-91, 42 U.S.C. 7135, Department of Energy Organization Act, 1977
P.L. 95-621, Natural Gas Policy Act (1978)
P.L. 95-620, 42 U.S.C. 8301, Powerplant and Industrial Fuel Use Act (1978)
P.L. 96-294, Energy Security Act (1980)
P.L. 97-229, 42 U.S.C. 6245, Energy Emergency Preparedness Act (1982)
P.L. 97-415, Nuclear Regulatory Commission Authorization Act (1983)
P.L. 99-58, National Coal Imports Reporting Act (1985)
P.L. 99-58, 42 U.S.C. 6201, Energy Policy and Conservation Act Amendments of 1985
P.L. 100-42, 42 U.S.C. 8312, Powerplant and Industrial Fuel Use Act Amendments of 1987
P.L. 102-486, 42 U.S.C. 13385, Energy Policy Act (1992)
P.L. 107-347, Title V of E-Government Act of 2002, Confidential Information Protection and Statistical Efficiency Act of 2002
P.L. 109-58, 42 U.S.C. 15801, Energy Policy Act of 2005
P.L. 110-140, Energy Independence and Security Act (2007)
P.L. 112-81, National Defense Authorization Act for Fiscal Year 2012
P.L. 112-158, Iran Threat Reduction and Syria Human Rights Act of 2012
P.L. 113-125, Reliable Home Heating Act (2014)

**Energy Information Administration**
**National Energy Information System (NEIS)**
**($K)**

| FY 2014 Enacted | FY 2014 Current | FY 2015 Enacted | FY 2016 Request |
|---|---|---|---|
| 116,999 | 116,999 | 117,000 | 131,000 |

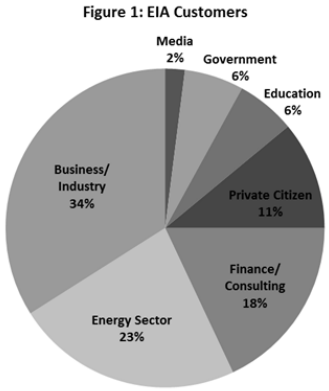
**Overview**

The Energy Information Administration (EIA) is the statistical and analytical agency within the U.S. Department of Energy (DOE). EIA collects, analyzes, and disseminates independent and impartial energy information to promote sound policymaking, efficient markets, and public understanding of energy and its interaction with the economy and the environment. EIA is the Nation's premier source of energy information and, by law, its data, analyses, and forecasts are independent of approval by any other officer or employee of the U.S. Government.

EIA conducts a wide range of data collection, analysis, forecasting, and dissemination activities to ensure that its customers, including Congress, Federal and State Governments, the private sector, the broader public, and the media, have ready access to timely, reliable, and relevant energy information (see Figure 1).

This information is essential to inform a wide range of energy-related decisions, including utilization strategies; availability of energy sources; business and personal investment decisions; and policy development. As the energy industry becomes increasingly more complex and interrelated, EIA must evolve its program to present a comprehensive picture of the energy marketplace to an expanding customer base.

**Figure 1: EIA Customers**




Source: 2013 EIA Customer Satisfaction Survey

Source: 2014 EIA Customer Satisfaction Survey

**Highlights and Major Changes in the FY 2016 Budget Request**

The FY 2016 budget request enables EIA to continue all core activities funded in the FY 2015 appropriation, while also expanding the data collection and analysis program to serve several emergent stakeholder needs.

- **Address Critical Energy Data Gaps (+$5.0 M)**: EIA will address critical energy data gaps to meet the needs of policymakers and markets, including information to better understand the determinants of personal vehicle miles of travel, which have been declining since 2007. This has potential major implications for projected energy use as well as transportation infrastructure requirements and mechanisms used to fund transportation projects. Other data areas to be addressed include: survey and other data on monthly movements of crude oil by rail; monthly estimates of electricity generation by distributed renewable energy sources such as solar photovoltaics; and the use of energy for treatment and pumping in agricultural and potable water systems. In all of these subject areas, EIA will use innovative approaches to minimize cost and respondent burden. For example, leveraging a recent Administration initiative to use data already being collected by other federal programs for statistical purposes, EIA will explore collaborations with agencies such as the Surface Transportation Board, the Bureau of the Census, and the Department of Transportation to use data that they already collect to meet energy data needs. In cases where no suitable data exists within the federal system, EIA will work with other statistical agencies on strategies to collect needed data using existing data collection programs.

- **Increase the Integration of EIA Energy Data with Canada and Mexico (+$1.0 M):** EIA will collaborate with counterparts in Canada and Mexico to improve the quality and transparency of North American energy data through reconciliation of data on energy trade flows among the three countries, extension of energy mapping capabilities (building on EIA's existing platform), and development of common terminologies. The counterparts will also share views to enable improved forward-looking projections and outlooks for within-region energy flows.

- **Crowd-source Consumption Data (+$2.0 M):** EIA will develop an interface that enables groups with common interests to crowd-source, or pool information to determine the actual effectiveness of specific building efficiency technologies, practices, and characteristics in reducing energy use while maintaining energy services. Leveraging its demonstrated ability to protect confidential data from individual participants, EIA would aggregate data made available to it to form statistically relevant inferences on the performance of technologies and practices applied in specific building types and regions (e.g., skyscrapers in Manhattan). This mechanism for performing voluntary studies or experiments would complement EIA's current energy consumption program, which provides valuable information for benchmarking efficiency trends by building type, location, and other key metrics, but is too infrequent and too broad in scope to support targeted state and local efforts to measure and jump-start efficiency improvements. The actual estimates of energy bill impacts relevant to specific categories of buildings in certain locations can prove extremely valuable to all levels of government and the private sector to promote energy efficiency.

- **Expand Mid-Term Energy Analysis Capabilities with Greater International Focus (+$2.5 M)**: EIA's current suite of products provides a depth of coverage of near- and long-term energy markets, but leaves a gap in identifying mid-term infrastructure and logistical issues of vital importance to policymakers and market participants. EIA will address this gap while also enabling a better understanding of domestic energy markets within the broader context of the world energy system, including the global markets for liquefied natural gas, crude oil, and refined products. As part of this effort, EIA will significantly improve both the quality and presentation of its international statistics and analysis products.

- **Accelerate Domestic Energy Coverage and State-level Data Improvements (+$3.5 M):** EIA will provide more timely crude oil and natural gas production data, including data on crude quality; more timely data on petroleum product exports, including gasoline, diesel fuel and propane; additional propane price data for Midwest states; and more granular information on propane inventories in individual states. EIA will further its collaboration with member states of the Ground Water Protection Council to make EIA a repository for well-level data from states and host key databases. EIA will collect near real-time electricity load and flow data for daily dissemination, directly benefiting DOE's view into the system's response to disruptions, unusual weather, and other stresses, while at the same time providing market information needed to assess potential investments in storage, load management, and distributed generation technologies with the potential to improve system operations and lowering cost and emissions. EIA will also improve information accessibility for state and other customers through expanded mapping, data visualizations, and energy disruption response information.

**Energy Data Program**

EIA's comprehensive energy data program conducts surveys of energy suppliers and consumers and then processes and integrates survey responses to produce a full range of publicly available data and reports spanning the energy landscape. EIA strives to make high-quality data available in formats and structures that serve the analytical needs of its customers. The energy data program also provides the basis for EIA's energy analysis and forecasting activities, including key inputs for its short- and long-term energy models.

Energy Supply Surveys

The energy supply survey program represents EIA's data foundation and largest operational area, publishing more than 300 reports a year across weekly, monthly, quarterly, and annual product lines. The program collects comprehensive data that collectively illustrate the complex flows of energy production, distribution, and end-uses across sectors, including oil and gas, coal, refined products, nuclear power, renewables, biofuels, and electric power. The energy supply survey program employs a broad range of statistical expertise in support of its data collection efforts, including sampling, imputation, estimation, and aggregation activities; survey frames maintenance; quality assurance; and periodic development of new data collection and survey instruments. Producers, consumers, investors, traders, and analysts use a wealth of EIA energy statistics in their day-to-day activities in the global energy marketplace. For example, the *Weekly Petroleum Status Report* (WPSR) and the *Weekly Natural Gas Storage Report* (WNGSR) typically spur price formation activity to balance markets.

Energy Consumption and Efficiency Surveys

EIA collects and publishes definitive, national end-use consumption data for commercial buildings, residential buildings, and manufacturing through the use of three complex, large-scale, multi-year surveys. The Commercial Buildings Energy Consumption Survey (CBECS) provides the only statistically reliable source of information on energy consumption, expenditures, and end-uses in U.S. commercial buildings. The Residential Energy Consumption Survey (RECS) collects information from a nationally representative sample of housing units, including data on energy characteristics of homes, usage patterns, and household demographics. Linked with production and employment data from Census Bureau economic surveys, the Manufacturing Energy Consumption Survey (MECS) provides information on energy throughput and economic and operational characteristics of U.S. manufacturers. These surveys are critical to understanding energy use, and are the basis for benchmarking and performance measurement for energy efficiency programs, including the Energy Star and Leadership in Energy and Environmental Design (LEED) certification programs – as well as state-level initiatives.

Integrate Data

EIA integrates data from its multiple collection processes to develop comprehensive national and state-level data sets. These data help inform national and state energy-related decision-making, and they provide vital information for market participants at all levels. The State Energy Portal is the online platform for EIA's state energy statistics. The webpage provides historical time series of energy production, consumption, prices, and expenditures by state that are defined as consistently as possible over time and across sectors for analysis and forecasting purposes. The program also produces the *Monthly Energy Review (MER)* that features more than 90 integrated monthly and annual data tables – a flagship product that celebrated its 40$^{th}$ anniversary in FY 2014.

**Energy Analysis Program**

EIA conducts a robust energy analysis program to bring meaning and context to a rapidly-evolving energy marketplace. In addition to providing timely, relevant analyses covering a range of energy topics, EIA develops and maintains the models that underpin its flagship projections, including the *Annual Energy Outlook* (AEO), *International Energy Outlook* (IEO), and *Short-Term Energy Outlook* (STEO), which will be expanded to provide mid-term three to five year pricing projections. EIA also prepares independent reports and analyses for Congress and the Executive Branch in response to emerging trends and issues, and provides a range of informational products for its stakeholders.

Energy Modeling and Analysis

EIA conducts a wide range of modeling and analysis activities covering each energy sector to produce the AEO, IEO, STEO, international energy products, recurring reports such as *Today in Energy* and *This Week in Petroleum*, and other special topical reports. The agency strives to improve the capabilities of its models while also developing new analytic products to better understand energy markets.

Domestic – EIA's efforts in this area include analysis of the growth of crude oil and shale gas production in the U.S. along with import and export trends; analysis of building and transportation consumption data; and ongoing historical and forward-looking analyses of electricity, coal resources, industrial sectors, and renewable fuels in relation to government policies, energy prices, technology, and other factors.

International – The international program produces a body of country-level analytical products covering oil and gas production, imports, and exports, including mandated reports to Congress and the public on the availability and price of petroleum and petroleum products produced in countries other than Iran.

Energy Model Development

FY 2015 represents the final phase in a multi-year effort to upgrade the National Energy Modeling System (NEMS). NEMS is the Nation's preeminent tool for developing long-term projections of U.S. energy production, consumption, prices, and technologies. The models are used by EIA and other DOE program offices, National Laboratories, non-governmental organizations, and academic researchers for a variety of energy analyses, such as the impacts of proposed energy policies.

Energy and Financial Markets

EIA is analyzing the impacts of planned and unplanned refinery outages on regional supplies and prices, as well as the effects of a possible relaxation of current limitations on U.S. oil exports on key outcomes and indicators. To improve its mid-term price projections and better understand the relationship between energy supply and demand fundamentals and

financial market behavior, EIA conducts studies on the factors influencing price formation for natural gas, crude oil, and petroleum products within different regions of the country.

**Communications**
EIA's comprehensive communications program interfaces with diverse external customer groups and manages the public website (www.eia.gov), press and media relations, marketing and outreach services, and employee intranet. As energy education is a key part of EIA's mission, the agency maintains a roster of energy literacy products and operates the EIA Information Center, the agency's primary point of contact for customer inquiries. EIA is integrating state-of-the-art technologies and best practices on its website, including developing: customizable data browsers; dynamic layered state energy maps that provide views of energy production, distribution, generation assets, and storm-tracking; and making its data available through Application Programming Interfaces (APIs) to allow computers to more easily access EIA's public data. By making EIA data available in this machine-readable format, the creativity in the private, the non-profit, and the public sectors can be harnessed to find new ways to innovate and create value-added services powered by public data. The design and customization of EIA's website and multimedia content features are updated based on continuous external feedback mechanisms, including web traffic analytics and input from the annual customer satisfaction survey. Additionally, as required in the Reliable Home Heating Act of 2014, EIA has established a state outreach initiative, which communicates with governors' offices when the inventories of home heating fuels are below historic levels.

**Resource and Technology Management**
This function provides overall business management, analysis, and mission support to the rest of EIA and in response to requests from other components of DOE. Activities include strategic planning and program evaluation; financial and budget management; contracts management; human resource management; and resource and workforce analysis. The program also manages EIA's IT infrastructure in accordance with data confidentiality and cyber security requirements. The program also facilitates EIA's participation in cost-effective DOE shared services programs, listed under Other Related Expenses, including rent, training, telecommunications, and supplies.

**Using Administrative Data for Statistical Purposes**
In response to OMB Memorandum M-14-06, Guidance for Providing and Using Administrative Data for Statistical Purposes, EIA prepared an inventory of more than 60 administrative data sets that it currently leverages from DOE and other agencies for its reports, analyses, and projections. For example, as more than a quarter of the total sales of fossil fuels in the United States are from federal and Indian lands, EIA needs data from the U.S. Department of Interior to report on sales, well production, and reserves data. As some of the administrative data obtained by EIA cannot be publicly released without aggregation, EIA maintains strict measures to fully protect the privacy and confidentiality afforded to the individuals, businesses, and institutions providing the data. EIA also identified several additional data sets of interest and will continue pursuing interagency agreements for the use and stewardship of those data sets, as well as exploring partnerships on future data collection.

**FY 2016 Crosscuts ($K)**

| | Cyber-security | Total |
|---|---|---|
| **Program Direction** | 851 | **851** |

**Crosscutting Initiatives**
In FY 2015, the Department was reorganized into three Under Secretariats—Science and Energy, Nuclear Security, and Management and Performance —that recognizes the complex interrelationship among DOE Program Offices. The FY 2016 Budget Request continues crosscutting programs, which coordinate across the Department and seek to tap DOE's full capability to effectively and efficiently address the United States' energy, environmental, and national security challenges. These crosscutting initiatives will be discussed further within the Programs in which the crosscuts are funded. EIA contains the following crosscut:

**Cybersecurity**: DOE is engaged in three categories of cyber-related activities: protecting the DOE enterprise from a range of cyber threats that can adversely impact mission capabilities; bolstering the U.S. Government's capabilities to address cyber threats; and, improving cybersecurity in the electric power subsector and the oil and natural gas subsector. The

cybersecurity crosscut supports central coordination of the strategic and operational aspects of cybersecurity and facilitates cooperative efforts such as the Joint Cybersecurity Coordination Center for incident response and the implementation of Department-wide Identity Credential and Access Management.

**FY 2014 Key Accomplishments**

In FY 2014 EIA was entrusted with a 17% funding increase from sequestration levels to address gaps in its core programs and provide better coverage of the rapidly changing energy landscape. The agency implemented a project management and program evaluation framework to ensure tangible results. While many projects using FY 2014 resources are continuing, EIA can report on several noteworthy FY 2014 accomplishments:

- **Drilling Productivity Report (DPR)**: EIA initiated a new monthly Drilling Productivity Report to provide indicators of future oil and natural gas production trends in key producing regions that are more informative than traditional metrics given rapid technological advances. First released in October 2013 with coverage of six key producing regions, the DPR was expanded in August 2014 to include coverage of Ohio's Utica shale.

- **Commercial Buildings Energy Consumption Survey (CBECS)**: EIA released building characteristics data from the latest CBECS, which was conducted during the latter part of FY 2013 and early FY 2014 for a representative sample of the commercial building stock as of 2012. CBECS, which is collected on a quadrennial basis, provides the only statistically reliable source of information on energy consumption, expenditures, and end-uses in U.S. commercial buildings and serves as a basis for benchmarking and performance measurement for energy efficiency programs. The latest CBECS was the largest active field collection in CBECS's 33-year history, with more than 200 trained interviewers visiting nearly 7,000 commercial buildings to collect building characteristics and consumption data through in-person interviews.

- **Energy Data Improvements**: To meet market and policymaker needs for accurate and timely data given recent rapid growth in oil and natural gas production, EIA is preparing to launch monthly collection of oil and natural gas data from operators in 15 producing states. This first-ever monthly collection of onshore oil production data will include American Petroleum Institute (API) gravity, a quality indicator. The new collection will also dramatically improve existing monthly natural gas production data, which currently covers only five states and does not include major producing states such as Pennsylvania. EIA has also received final approval to greatly enhance its electricity data with the collection and publication of hourly electricity data. This will enable EIA to provide updates every 60 minutes on power demand at the 68 balancing authorities that manage the grid for the lower 48 states.

- **Collaboration with the States:** Specific achievements during FY 2014 to increase collaboration with the states on energy data included: hosting well-level data in a national data repository through a partnership with the Groundwater Protection Council; expansion of the State Heating Oil and Propane Program (SHOPP) to collect weekly wholesale and retail price data for propane and heating oil from 38 states during the 2014-15 winter (up from 24 states during the 2013-14 winter); updates to EIA's state energy pages; and the addition of new data layers and functionality to EIA's scalable energy mapping tools to meet the needs of state energy officials.

- **Improved Access to EIA Data**: EIA launched three advanced, interactive web applications to improve customer access to the agency's data. The STEO Data Browser provides enhanced capabilities for analysis and visualization of the historical and projected STEO data and covers everything from U.S. energy production, consumption, inventories, imports, exports, and prices to international petroleum supply and demand. The Coal Data Browser provides easy-to-use access to more than 10 years of current and historical coal data, including information about coal production, sales, prices, and exports. Finally, the Crude Oil Import Tracking Tool allows users to follow trends in U.S. oil import flows, such as country source, port of entry, processing company, crude type (i.e., light, medium, heavy), processing refinery, and more.

**Energy Information Administration**
**Performance Measures**

In accordance with the GPRA Modernization Act of 2010, the Department sets targets for, and tracks progress toward, achieving performance goals for each program.

| | FY 2014 | FY 2015 | FY 2016 |
|---|---|---|---|
| **Performance Goal (Measure 1)** | **Quality of EIA Information Products - Percentage of customers who are satisfied or very satisfied with the quality of EIA information.** | | |
| Target | 90% customer satisfaction rating | 90% customer satisfaction rating | 90% customer satisfaction rating |
| Result | 95% | Not applicable | Not applicable |
| Endpoint Target | This is an ongoing annual performance measure, as information quality is central to EIA's mission. | | |
| **Performance Goal (Measure 2)** | **Timeliness of EIA Information Products - Percentage of selected EIA recurring products meeting their release date targets (all product types).** | | |
| Target | 95% of products released on schedule | 95% of products released on schedule | 95% of products released on schedule |
| Result | 96%. | Not applicable | Not applicable |
| Endpoint Target | This is an ongoing annual performance measure, as timely delivery of energy information is central to EIA's mission. | | |

| | Program Direction Funding ($K) | | | | |
|---|---|---|---|---|---|
| | FY 2014 Enacted | FY 2014 Current | FY 2015 Enacted | FY 2016 Request | FY 2016 vs FY 2015 |
| **Program Direction Summary** | | | | | |
| **Program Direction** | | | | | |
| Salaries and Benefits | 53,563 | 51,096 | 55,598 | 57,082 | 1,484 |
| Travel | 278 | 247 | 278 | 278 | - |
| Support Services | 48,190 | 43,375 | 42,996 | 53,823 | 10,827 |
| Other Related Expenses | 14,968 | 22,281 | 18,128 | 19,817 | 1,689 |
| **Total, Program Direction** | **116,999** | **116,999** | **117,000** | **131,000** | **14,000** |
| **Federal FTEs** | **370** | **339** | **370** | **375** | **5** |
| | | | | | |
| **Support Services** | | | | | |
| Technical Support | | | | | |
| Administrative Support Services | 9 | 14 | 9 | 9 | 0 |
| Human Resources Support Services | 4 | 7 | 4 | 4 | 0 |
| E-Government Support Services | 1 | 1 | 1 | 1 | 0 |
| Scientific/Technical and IT Training | 116 | 31 | 40 | 40 | 0 |
| Data Center (Application Hosting/Housing) | 19 | 21 | 21 | 21 | 0 |
| IT Management Services | 5,115 | 5,397 | 5,400 | 5,508 | 108 |
| Other Advisory and Assistance Services | 41,889 | 36,413 | 36,221 | 46,810 | 10,589 |
| Total, Technical Support | 47,153 | 41,884 | 41,696 | 52,393 | 10,697 |
| | | | | | |
| Management Support | | | | | |
| Program Management | 1,037 | 1,491 | 1,300 | 1,430 | 130 |
| Total, Management Support | 1,037 | 1,491 | 1,300 | 1,430 | 130 |
| **Total, Support Services** | **48,190** | **43,375** | **42,996** | **53,823** | **10,827** |
| | | | | | |
| **Other Related Expenses** | | | | | |
| Communications, utilities, and misc. charges | 2,579 | 6,607 | 4,228 | 4,257 | 29 |
| Printing and reproduction | 4 | 2 | 4 | 4 | 0 |
| Training | 390 | 498 | 390 | 390 | 0 |
| Goods and services from Governments accts. | | 294 | 300 | 310 | 10 |
| Working Capital Fund | 9,623 | 9,179 | 9,706 | 9,694 | -12 |
| O&M of IT systems or equipment | 639 | 980 | 1,000 | 1,020 | 20 |
| Supplies and materials | 343 | 863 | 850 | 850 | 0 |

| | | | | | |
|---|---|---|---|---|---|
| Equipment | 1,133 | 3,533 | 1,325 | 2,967 | 1,642 |
| Grants, subsidies, and contributions | 257 | 325 | 325 | 325 | 0 |
| **Total, Other Related Expenses** | **14,968** | **22,281** | **18,128** | **19,817** | **1,689** |

**Program Direction**

**Activities and Explanation of Changes**

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes FY 2016 vs. FY 2015 Request |
|---|---|---|
| **Salaries and Benefits $55,598,000** | **$57,082,000** | **+$1,484,000** |
| Provide salaries and benefits for 370 FTEs supporting:<br>Administrator's office (7 FTEs)<br>• Energy data program (160 FTEs)<br>• Energy analysis (123 FTEs)<br>• Communications (31 FTEs)<br>• Resource and technology management (49 FTEs) | Provide salaries and benefits for 375 FTEs supporting:<br>• Administrator's office (7 FTEs)<br>• Energy data program (163 FTEs)<br>• Energy analysis (125 FTEs)<br>• Communications (31 FTEs)<br>• Resource and technology management (49 FTEs) | Reflects OMB COLA factor of 1.3% and 5 additional FTEs. |
| **Travel $278,000** | **$278,000** | **$0** |
| Provide essential travel for EIA stakeholder engagement—both for representing EIA in public forums and engaging with industry experts. | Maintain FY 2013 travel ceiling, representing a 30% reduction from the FY 2012 level, by prioritizing travel to maximize stakeholder engagement. | No change. |
| **Support Services $42,996,000** | **$53,823,000** | **+$10,827,000** |
| *Energy Supply Surveys $16,129,000*<br>Operate core supply data collection program.<br>• Begin publishing monthly oil and gas operator level production data in 15 states and the Gulf of Mexico.<br>• Produce more timely data on petroleum product exports, including gasoline, diesel fuel, and propane.<br>• Develop more granular petroleum supply surveys, including petroleum terminals and refineries, and crude by rail data collection options.<br>• Collect and report hourly data on electricity power demand at the 67 balancing authorities that manage the grid for the lower 48 states.<br>Develop methodology for estimation of monthly solar distributed generation. | *Energy Supply Surveys $20,900,000*<br>Operate core supply data collection program.<br>• Expand utilization of modernized data processing technologies to core petroleum and natural gas supply surveys.<br>• Release more granular petroleum supply data, as well as possible collection of oil movements by rail data.<br>• Explore methods for collecting data on drilling costs, dry natural gas production, coal resources, and pipeline flows.<br>• Integrate renewables data presentation leveraging current EIA surveys and third-party data. | *Energy Supply Surveys +$4,771,000*<br>Increase reflects costs for expanded surveys and switching to new data processing systems. |

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes<br>FY 2016 vs. FY 2015 Request |
|---|---|---|
| *Energy Consumption and Efficiency Surveys $10,170,000*<br>Conduct commercial, residential, and manufacturing surveys.<br>• CBECS 2012 final publication; CBECS 2016 planning.<br>• RECS 2014 data collection and alternative mode pilots.<br>• MECS 2014 data collection.<br>• Begin survey of densified biomass manufacturers and exporters to better understand this source of energy used for home heating by over 2.5 million households.<br>• Develop RECS cities pilot for targeted questions in a small area samples. | *Energy Consumption and Efficiency Surveys $12,898,000*<br>Conduct commercial, residential, and manufacturing surveys.<br>• Initiate end-use transportation data collection, partnering with Department of Transportation to collect important data on vehicle transportation trends.<br>• CBECS 2016 planning, funding, & collection preparation.<br>• RECS 2014 post-collection processing and publication.<br>• MECS 2014 post-collection processing and publication.<br>• Develop tools and capabilities to crowd-source building consumption data. | *Energy Consumption and Efficiency Surveys +$2,728,000*<br>Reflects additional investment for transportation data collection and fully funding RECS 2014 and MECS 2014. |
| *Integrate Data $1,101,000*<br>Maintain online platform for State Energy Portal and the expanded MER. Integrate quality control, statistical methods, confidentiality, and survey design best practices with modernized data collection technologies. | *Integrate Data $1,120,000*<br>Maintain online platform for State Energy Portal and MER. Continue to streamline and modernize business processes for quality assurance, methods, and survey design. | *Integrate Data +$19,000,000*<br>Maintains scope of data integration program. |
| *Energy Modeling and Analysis $5,197,000*<br>Continue core forecasting and analysis work leading to the AEO, IEO, STEO and other reports and international capabilities.<br>• Produce comprehensive AEO and IEO that addresses recent oil price volatility.<br>• Collaborate with counterparts in Canada and Mexico on North American energy data.<br>• Develop tools and capabilities for mid-term energy analysis.<br>• Continue analysis of global hydrocarbon supplies and impacts of U.S. liquefied natural gas (LNG) | *Energy Modeling and Analysis $8,672,000*<br>Achieve efficiencies in core forecasting and analysis activities and enhance mid-term analysis.<br>• Expand capabilities for mid-term energy analysis, with an emphasis on improving price forecasting models.<br>o Expand STEO world oil supply and demand to three to five year forecasts.<br>o Produce reports on refinery outages and adaptation to light, tight oil.<br>• Produce full AEO with multiple analytic scenarios and Issues in Focus papers; online update to IEO | *Energy Modeling and Analysis +$3,475,000*<br>Expanded mid-term analytical activities. |

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes<br>FY 2016 vs. FY 2015 Request |
|---|---|---|
| exports.<br>• Enhance analysis of U.S. personal transportation trends and global transportation-related modeling.<br>• Complete reports on oil by rail movements.<br>• Enhance international energy statistics. | tables.<br>• Maintain the flexibility and expertise base to respond to ad-hoc policy analysis needs, such as oil export scenarios. | |
| *Energy Model Development $1,219,000*<br>Complete final phase of NEMS upgrades. | *Energy Model Development $0*<br>Multi-year NEMS upgrades completed. | *Energy Model Development -$1,219,000*<br>Reflects completion of the multi-year NEMS upgrades. |
| *Energy and Financial Markets $1,497,000*<br>Continue multi-year project to study role of financial markets in energy price formation.<br>• Study energy price formation to improve price forecasts.<br>• Prepare reports on planned and unplanned refinery outages and their impacts on supply and pricing at the Petroleum Administration for Defense Districts (PADD) level. | *Energy and Financial Markets $1,554,000*<br>Continue multi-year project to study role of financial markets in energy price formation.<br>• Continue studies on price formation, with a focus on petroleum products.<br>• Complete series of reports on the impacts of refinery outages in PADD 1 and 3.<br>• Continue ad-hoc reporting and analysis on topics of interest to policymakers. | *Energy and Financial Markets +$57,000*<br>Maintains scope of the energy and financial markets activities. |
| *Energy Information Dissemination and Communications $1,442,000*<br>Maintain communication activities and invest in flexible web platforms to enhance data delivery.<br>• Build portals for the AEO, STEO and International statistics.<br>• Build data visualization tools for oil import flows and real time electricity load data.<br>• Continue to convert static EIA datasets to open data platforms with Application Programming Interface capabilities, and make EIA data available as for Excel plugins.<br>• Enhance state outreach leveraging social and multimedia.<br>• Work with governors and state energy offices to on more frequent and granular reporting on winter | *Energy Information Dissemination and Communications $2,388,000*<br>Maintain communication activities and invest in flexible web platforms to enhance data delivery.<br>• Develop new dynamic web pages for initiatives such as crude by rail, and the petroleum and natural gas data browsers.<br>• Continue to enhance mapping layers, including possible shale resource maps and pipeline flow data.<br>• Continue digital government strategy to provide open data sources, with integration of other administrative statistical data.<br>• Continue state and social media outreach strategies.<br>Conduct website maintenance, including API servers | *Energy Information Dissemination and Communications +$946,000*<br>Expands scope of communications program. |

| FY 2015 Enacted | FY 2016 Request | Explanation of Changes<br>FY 2016 vs. FY 2015 Request |
|---|---|---|
| propane inventories in the Midwest.<br>• Develop platform to display hourly electricity load data. | and conversion from Cold Fusion to PHP. | |
| *Resource and Technology Management $6,241,000*<br>Provide overall business management, IT and network services, and administrative support to EIA offices and staff. | *Resource and Technology Management $6,291,000*<br>Continue providing business management, IT and network services, and administrative support to EIA's offices and staff. | *Resource and Technology Management +$50,000*<br>Maintains scope of mission support activities. |
| **Other Related Expenses$18,128,000** | ***$19,817,000*** | ***+$1,689,000*** |
| This activity includes goods and services provided through the DOE Working Capital Fund for operations and office space for EIA employees, employee training, communications, supplies and materials, equipment and computers, and SHOPP grants and contributions. | Provide a similar level of services as FY 2015 providing goods and services through the DOE Working Capital Fund, operations and office space for, employee training, communications, supplies and materials, equipment and computers, and SHOPP grants and contributions. | Maintains the scope of other services. |

**Department Of Energy**

**FY 2016 Congressional Budget**

**Funding By Appropriation By Site**

**($K)**

| Energy Information Administration | FY 2014 Current | FY 2015 Enacted | FY 2016 Request |
|---|---|---|---|
| **Washington Headquarters** | | | |
| **Energy Information Administration** | | | |
| National Energy Information System | 116,999 | 117,000 | 131,000 |
| **Total, Washington Headquarters** | **116,999** | **117,000** | **131,000** |
| **Total, Energy Information Administration** | **116,999** | **117,000** | **131,000** |

## GENERAL PROVISIONS – DEPARTMENT OF ENERGY
### (INCLUDING TRANSFER [AND RESCISSIONS] OF FUNDS)

SEC. 301. (a) No appropriation, funds, or authority made available by this title for the Department of Energy shall be used to initiate or resume any program, project, or activity or to prepare or initiate Requests For Proposals or similar arrangements (including Requests for Quotations, Requests for Information, and Funding Opportunity Announcements) for a program, project, or activity if the program, project, or activity has not been funded by Congress.

(b)(1) Unless the Secretary of Energy notifies the Committees on Appropriations of the House of Representatives and the Senate at least 3 full business days in advance, none of the funds made available in this title may be used to—

(A) make a grant allocation or discretionary grant award totaling $1,000,000 or more;

(B) make a discretionary contract award or Other Transaction Agreement totaling $1,000,000 or more, including a contract covered by the Federal Acquisition Regulation;

(C) issue a letter of intent to make an allocation, award, or Agreement in excess of the limits in subparagraph (A) or (B); or

(D) announce publicly the intention to make an allocation, award, or Agreement in excess of the limits in subparagraph (A) or (B).

(2) The Secretary of Energy shall submit to the Committees on Appropriations of the House of Representatives and the Senate within 15 days of the conclusion of each quarter a report detailing each grant allocation or discretionary grant award totaling less than $1,000,000 provided during the previous quarter.

(3) The notification required by paragraph (1) and the report required by paragraph (2) shall include the recipient of the award, the amount of the award, the fiscal year for which the funds for the award were appropriated, the account and program, project, or activity from which the funds are being drawn, the title of the award, and a brief description of the activity for which the award is made.

(c) The Department of Energy may not, with respect to any program, project, or activity that uses budget authority made available in this title under the heading "Department of Energy—Energy Programs", enter into a multiyear contract, award a multiyear grant, or enter into a multiyear cooperative agreement unless—

(1) the contract, grant, or cooperative agreement is funded for the full period of performance as anticipated at the time of award; or

(2) the contract, grant, or cooperative agreement includes a clause conditioning the Federal Government's obligation on the availability of future year budget authority and the Secretary notifies the Committees on Appropriations of the House of Representatives and the Senate at least 3 days in advance.

(d) Except as provided in subsections (e), (f), and (g), the amounts made available by this title shall be expended as authorized by law for the programs, projects, and activities specified in the "Final Bill" column in the "Department of Energy" table included under the heading "Title III—Department of Energy" in the explanatory statement described in section 4 (in the matter preceding division A of this consolidated Act).

(e) The amounts made available by this title may be reprogrammed for any program, project, or activity, and the Department shall notify the Committees on Appropriations of the House of Representatives and the Senate at least 30 days prior to the use of any proposed reprogramming which would cause any program, project, or activity funding level to increase or decrease by more than $5,000,000 or 10 percent, whichever is less, during the time period covered by this Act.

(f) None of the funds provided in this title shall be available for obligation or expenditure through a reprogramming of funds that—

(1) creates, initiates, or eliminates a program, project, or activity;

(2) increases funds or personnel for any program, project, or activity for which funds are denied or restricted by this Act; or

(3) reduces funds that are directed to be used for a specific program, project, or activity by this Act.

(g)(1) The Secretary of Energy may waive any requirement or restriction in this section that applies to the use of funds made available for the Department of Energy if compliance with such requirement or restriction would pose a substantial risk to human health, the environment, welfare, or national security.

(2) The Secretary of Energy shall notify the Committees on Appropriations of the House of Representatives and the Senate of any waiver under paragraph (1) as soon as practicable, but not later than 3 days after the date of the activity to which a requirement or restriction would otherwise have applied. Such notice shall include an explanation of the substantial risk under paragraph (1) that permitted such waiver.

SEC. 302. The unexpended balances of prior appropriations provided for activities in this Act may be available to the same appropriation accounts for such activities established pursuant to this title. Available balances may be merged with funds in the applicable established accounts and thereafter may be accounted for as one fund for the same time period as originally enacted.

SEC. 303. Funds appropriated by this or any other Act, or made available by the transfer of funds in this Act, for intelligence activities are deemed to be specifically authorized by the Congress for purposes of section 504 of the National Security Act of 1947 (50 U.S.C. 414) during fiscal year **[**2015**]***2016* until the enactment of the Intelligence Authorization Act for fiscal year **[**2015**]***2016*.

SEC. 304. None of the funds made available in this title shall be used for the construction of facilities classified as high-hazard nuclear facilities under 10 CFR Part 830 unless independent oversight is conducted by the Office of **[**Independent**]** Enterprise Assessments to ensure the project is in compliance with nuclear safety requirements.

SEC. 305. None of the funds made available in this title may be used to approve critical decision-2 or critical decision-3 under Department of Energy Order 413.3B, or any successive departmental guidance, for construction projects where the total project cost exceeds $100,000,000, until a separate independent cost estimate has been developed for the project for that critical decision.

**[**SEC. 306. (a) SECRETARIAL DETERMINATIONS.—In this fiscal year, and in each subsequent fiscal year, any determination (including a determination made prior to the date of enactment of this Act) by the Secretary of Energy under section 3112(d)(2)(B) of the USEC Privatization Act (110 Stat. 1321–335), as amended, shall be valid for not more than 2 calendar years subsequent to such determination.

(b) CONGRESSIONAL NOTIFICATION.—In this fiscal year, and in each subsequent fiscal year, not less than 30 days prior to the provision of uranium in any form the Secretary of Energy shall notify the Committees on Appropriations of the House of Representatives and the Senate of the following—

(1) the provisions of law (including regulations) authorizing the provision of uranium;

(2) the amount of uranium to be provided;

(3) an estimate by the Secretary of Energy of the gross fair market value of the uranium on the expected date of the provision of the uranium;

(4) the expected date of the provision of the uranium;

(5) the recipient of the uranium;

(6) the value the Secretary of Energy expects to receive in exchange for the uranium, including any adjustments to the gross fair market value of the uranium; and

(7) whether the uranium to be provided is encumbered by any restriction on use under an international agreement or otherwise.**]**

SEC. **[**307**]***306*. Notwithstanding section 301(c) of this Act, none of the funds made available under the heading "Department of Energy—Energy Programs—Science" may be used for a multiyear contract, grant, cooperative agreement, or Other Transaction Agreement of $1,000,000 or less unless the contract, grant, cooperative agreement, or Other Transaction Agreement is funded for the full period of performance as anticipated at the time of award.

**[**SEC. 308. In fiscal year 2015 and subsequent fiscal years, the Secretary of Energy shall submit to the congressional defense committees (as defined in U.S.C. 101(a)(16)) a report, on each major warhead refurbishment program that reaches the Phase 6.3 milestone, that provides an analysis of alternatives. Such report shall include—

(1) a full description of alternatives considered prior to the award of Phase 6.3;
(2) a comparison of the costs and benefits of each of those alternatives, to include an analysis of trade-offs among cost, schedule, and performance objectives against each alternative considered;
(3) identification of the cost and risk of critical technology elements associated with each alternative, including technology maturity, integration risk, manufacturing feasibility, and demonstration needs;
(4) identification of the cost and risk of additional capital asset and infrastructure capabilities required to support production and certification of each alternative;
(5) a comparative analysis of the risks, costs, and scheduling needs for any military requirement intended to enhance warhead safety, security, or maintainability, including any requirement to consolidate and/or integrate warhead systems or mods as compared to at least one other feasible refurbishment alternative the Nuclear Weapons Council considers appropriate; and
(6) a life-cycle cost estimate for the alternative selected that details the overall cost, scope, and schedule planning assumptions.**]**

**[**SEC. 309. (a) Unobligated balances available from prior year appropriations are hereby rescinded from the following accounts of the Department of Energy in the specified amounts:
(1) "Energy Programs—Energy Efficiency and Renewable Energy", $9,740,000.
(2) "Energy Programs—Electricity Delivery and Energy Reliability", $331,000.
(3) "Energy Programs—Nuclear Energy", $121,000.
(4) "Energy Programs—Fossil Energy Research and Development", $10,413,000.
(5) "Energy Programs—Science", $3,262,000.
(6) "Energy Programs—Advanced Research Projects Agency—Energy", $18,000.
(7) "Energy Programs—Departmental Administration", $928,000.
(8) "Atomic Energy Defense Activities—National Nuclear Security Administration— Weapons Activities", $6,298,000.
(9) "Atomic Energy Defense Activities—National Nuclear Security Administration— Defense Nuclear Nonproliferation", $1,390,000.
(10) "Atomic Energy Defense Activities—National Nuclear Security Administration— Naval Reactors", $160,000.
(11) "Atomic Energy Defense Activities—National Nuclear Security Administration—Office of the Administrator", $413,000.
(12) "Environmental and Other Defense Activities—Defense Environmental Cleanup", $9,983,000.
(13) "Environmental and Other Defense Activities—Other Defense Activities", $551,000.
(14) "Power Marketing Administrations—Construction, Rehabilitation, Operation and Maintenance, Western Area Power Administration", $1,632,000.
(b) No amounts may be rescinded by this section from amounts that were designated by the Congress as an emergency requirement pursuant to a concurrent resolution on the budget or the Balanced Budget and Emergency Deficit Control Act of 1985. **]**

**[**SEC. 310. (a) None of the funds made available in this or any prior Act under the heading "Defense Nuclear Nonproliferation" may be made available to enter into new contracts with, or new agreements for Federal assistance to, the Russian Federation.
(b) The Secretary of Energy may waive the prohibition in subsection (a) if the Secretary determines that such activity is in the national security interests of the United States. This waiver authority may not be delegated.
(c) A waiver under subsection (b) shall not be effective until 15 days after the date on which the Secretary submits to the Committees on Appropriations of the House of Representatives and the Senate, in classified form if necessary, a report on the justification for the waiver. **]**

**[**SEC. 311. Of the funds authorized by the Secretary of Energy for laboratory directed research and development, no individual program, project, or activity funded by this or any subsequent Act making appropriations for Energy and Water Development for any fiscal year may be charged more than the statutory maximum authorized for such activities: *Provided*, That this section shall take effect not earlier than October 1, 2015.**]**

**[**SEC. 312. (a) DOMESTIC URANIUM ENRICHMENT.—None of the funds appropriated by this or any other Act or that may be available to the Department of Energy may be used for the construction of centrifuges for the production of enriched uranium for national security needs in fiscal year 2015.

(b) The Department shall provide a report to the Committees on Appropriations of the House of Representatives and the Senate not later than April 30, 2015 that includes:

(1) an accounting of the current and future availability of low-enriched uranium, highly-enriched uranium, and tritium to meet defense needs; and

(2) a cost-benefit analysis of each of the options available to supply enriched uranium for defense purposes, including a preliminary cost and schedule estimate to build a national security train. **]**

**[**SEC. 313. None of the funds made available in this Act may be used—

(1) to implement or enforce section 430.32(x) of title 10, Code of Federal Regulations; or

(2) to implement or enforce the standards established by the tables contained in section 325(i)(1)(B) of the Energy Policy and Conservation Act (42 U.S.C. 6295(i)(1)(B)) with respect to BPAR incandescent reflector lamps, BR incandescent reflector lamps, and ER incandescent reflector lamps. **]**

**[**SEC. 314. None of the funds made available by this Act may be used in contravention of section 3112(d)(2)(B) of the USEC Privatization Act (42 U.S.C. 2297h-10(d)(2)(B)) and all public notice and comment requirements under chapter 6 of title 5, United States Code, that are applicable to carrying out such section.**]**

**[**SEC. 315. (a) NOTIFICATION OF STRATEGIC PETROLEUM RESERVE DRAWDOWN.—None of the funds made available by this Act or any prior Act, or funds made available in the SPR Petroleum Account, may be used to conduct a drawdown (including a test drawdown) and sale or exchange of petroleum products from the Strategic Petroleum Reserve unless the Secretary of Energy provides notice, in accordance with subsection (b), of such exchange, or drawdown (including a test drawdown) to the Committees on Appropriations of the House of Representatives and the Senate.

(b) (1) CONTENT OF NOTIFICATION.—The notification required under subsection (a) shall include at a minimum—

(A) The justification for the drawdown or exchange, including—

(i) a specific description of any obligation under international energy agreements; and

(ii) in the case of a test drawdown, the specific aspects of the Strategic Petroleum Reserve to be tested;

(B) the provisions of law (including regulations) authorizing the drawdown or exchange;

(C) the number of barrels of petroleum products proposed to be withdrawn or exchanged;

(D) the location of the Strategic Petroleum Reserve site or sites from which the petroleum products are proposed to be withdrawn;

(E) a good faith estimate of the expected proceeds from the sale of the petroleum products;

(F) an estimate of the total inventories of petroleum products in the Strategic Petroleum Reserve after the anticipated drawdown;

(G) a detailed plan for disposition of the proceeds after deposit into the SPR Petroleum Account; and

(H) a plan for refilling the Strategic Petroleum Reserve, including whether the acquisition will be of the same or a different petroleum product.

(2) TIMING OF NOTIFICATION.—The Secretary shall provide the notification required under subsection (a)—

(A) in the case of an exchange or a drawdown, as soon as practicable after the exchange or drawdown has occurred; and

(B) in the case of a test drawdown, not later than 30 days prior to a test drawdown.

(c) POST-SALE NOTIFICATION.—In addition to reporting requirements under other provisions of law, the Secretary shall, upon the execution of all contract awards associated with a competitive sale of petroleum products, notify the Committees on Appropriations of the House of Representatives and the Senate of the actual value of the proceeds from the sale.

(d) (1) NEW REGIONAL RESERVES.—The Secretary may not establish any new regional petroleum product reserve—

(A) unless funding for the proposed regional petroleum product reserve is explicitly requested in advance in an annual budget submission and approved by the Congress in an appropriations Act; or

(B) until 90 days after notification of, and approval by, the Committees on Appropriations of the House of Representatives and the Senate.

(2) The budget request or notification shall include—

(A) the justification for the new reserve;

(B) a cost estimate for the establishment, operation, and maintenance of the reserve, including funding sources;

(C) a detailed plan for operation of the reserve, including the conditions upon which the products may be released;

(D) the location of the reserve; and

(E) the estimate of the total inventory of the reserve.

(e) REPORT ON REFINED PETROLEUM PRODUCTS.—Not later than 180 days after the enactment of this Act, the Secretary shall submit to the Committees on Appropriations of the House of Representatives and the Senate a detailed plan for operation of the refined petroleum products reserve, including funding sources and the conditions upon which refined petroleum products may be released.

(f) REPORT ON STRATEGIC PETROLEUM RESERVE EXPANSION.—

(1) The Secretary, through the Office of Energy Policy and Systems Analysis, shall submit to the Committees on Appropriations of the House of Representatives and the Senate not later than 180 days after enactment of this Act the report required in Public Law 111–8 (123 Stat. 617) regarding the expansion of the Strategic Petroleum Reserve.

(2) The report required in paragraph (1) shall include an analysis of the impacts of Northeast Regional Refined Petroleum Product Reserve on the domestic petroleum market. **]** *(Energy and Water Development and Related Agencies Appropriations Act, 2015.)*

## TITLE V – GENERAL PROVISIONS

SEC. 501. None of the funds appropriated by this Act may be used in any way, directly or indirectly, to influence congressional action on any legislation or appropriation matters pending before Congress, other than to communicate to Members of Congress as described in 18 U.S.C. 1913.

**[**SEC. 502. (a) None of the funds made available in title III of this Act may be transferred to any department, agency, or instrumentality of the United States Government, except pursuant to a transfer made by or transfer authority provided in this Act or any other appropriations Act for any fiscal year, transfer authority referenced in the explanatory statement described in section 4 (in the matter preceding division A of this consolidated Act), or any authority whereby a department, agency, or instrumentality of the United States Government may provide goods or services to another department, agency, or instrumentality.

(b) None of the funds made available for any department, agency, or instrumentality of the United States Government may be transferred to accounts funded in title III of this Act, except pursuant to a transfer made by or transfer authority provided in this Act or any other appropriations Act for any fiscal year, transfer authority referenced in the explanatory statement described in section 4 (in the matter preceding division A of this consolidated Act), or any authority whereby a department, agency, or instrumentality of the United States Government may provide goods or services to another department, agency, or instrumentality.

(c) The head of any relevant department or agency funded in this Act utilizing any transfer authority shall submit to the Committees on Appropriations of the House of Representatives and the Senate a semiannual report detailing the transfer authorities, except for any authority whereby a department, agency, or instrumentality of the United States Government may provide goods or services to another department, agency, or instrumentality, used in the previous 6 months and in the year-to-date. This report shall include the amounts transferred and the purposes for which they were transferred, and shall not replace or modify existing notification requirements for each authority.**]**

SEC. **[**503**]***502*. None of the funds made available by this Act may be used in contravention of Executive Order No. 12898 of February 11, 1994 (Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations). (*Energy and Water Development Related Agencies Appropriations Act, 2015*).