DOE/CF-0121
Volume 3

Department of Energy

FY 2017 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
Advanced Tech. Vehicles Manufacturing Loan Program
Title 17 Innovative Tech. Loan Guarantee Program
Office of Indian Energy
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FUNDING BY APPROPRIATION

($K)

	FY 2015 Enacted	FY 2015 Current	FY 2016 Enacted	FY 2017 Request[1]	FY 2017 vs. FY 2016 $	FY 2017 vs. FY 2016 %
Department of Energy Budget by Appropriation						
Energy and Water Development, and Related Agencies						
Energy Programs						
Energy Efficiency and Renewable Energy	1,914,195	1,840,847	2,069,194	2,898,400	+829,206	+40.1%
Electricity Delivery and Energy Reliability	146,975	143,901	206,000	262,300	+56,300	+27.3%
Nuclear Energy	833,379	821,883	986,161	993,896	+7,735	+0.8%
Office of Technology Transitions	0	0	0	8,400	+8,400	N/A
21st Century Clean Transportation Plan Investments	0	0	0	1,335,000	+1,335,000	N/A
Fossil Energy Programs						
Clean Coal Technology	-6,600	-2,876	0	0	0	N/A
Fossil Energy Research and Development	560,587	548,885	632,000	600,000	-32,000	-5.1%
Use of Prior Year Balances	0	0	0	-240,000	0	N/A
Naval Petroleum and Oil Shale Reserves	19,950	20,640	17,500	14,950	-2,550	-14.6%
Elk Hills School Lands Fund	15,580	15,580	0	0	0	N/A
Strategic Petroleum Reserve	200,000	200,000	212,000	257,000	+45,000	+21.2%
Northeast Home Heating Oil Reserve	1,600	1,600	7,600	6,500	-1,100	-14.5%
Total, Fossil Energy Programs	**791,117**	**783,829**	**869,100**	**638,450**	**-230,650**	**-26.5%**
Uranium Enrichment Decontamination and Decommissioning (UED&D) Fund	625,000	625,000	673,749	673,749	0	N/A
Energy Information Administration	117,000	117,000	122,000	131,125	+9,125	+7.5%
Non-Defense Environmental Cleanup	246,000	246,030	255,000	218,400	-36,600	-14.4%
Science	5,067,738	5,132,813	5,347,000	5,672,069	+325,069	+6.1%
Advanced Research Projects Agency - Energy (ARPA-E)	279,982	279,982	291,000	500,000	+209,000	+71.8%
Departmental Administration	125,043	135,686	130,971	144,866	+13,895	+10.6%
Office of Indian Energy	0	0	0	22,930	+22,930	N/A
Office of the Inspector General	40,500	40,500	46,424	44,424	-2,000	-4.3%
Title 17 - Innovative Technology						
Loan Guarantee Program	17,000	17,000	17,000	10,000	-7,000	-41.2%
Advanced Technology Vehicles Manufacturing Loan Program	4,000	4,000	6,000	5,000	-1,000	-16.7%
Total, Energy Programs	**10,207,929**	**10,188,471**	**11,019,599**	**13,559,009**	**+2,539,410**	**+23.0%**
Atomic Energy Defense Activities						
National Nuclear Security Administration						
Weapons Activities	8,180,359	8,180,609	8,846,948	9,243,147	+396,199	+4.5%
Defense Nuclear Nonproliferation	1,615,248	1,612,651	1,940,302	1,807,916	-132,386	-6.8%
Naval Reactors	1,233,840	1,233,840	1,375,496	1,420,120	+44,624	+3.2%
Office of the Administrator	-413	-413	0	0	0	N/A
Federal Salaries and Expenses	370,000	370,000	363,766	412,817	+49,051	+13.5%
Total, National Nuclear Security Administration	**11,399,034**	**11,396,687**	**12,526,512**	**12,884,000**	**+357,488**	**+2.9%**
Environmental and Other Defense Activities						
Defense Environmental Cleanup	4,990,017	4,989,555	5,289,742	5,226,950	-62,792	-1.2%
Other Defense Activities	753,449	753,449	776,425	791,552	+15,127	+1.9%
Total, Environmental and Other Defense Activities	**5,743,466**	**5,743,004**	**6,066,167**	**6,018,502**	**-47,665**	**-0.8%**
Total, Atomic Energy Defense Activities	**17,142,500**	**17,139,691**	**18,592,679**	**18,902,502**	**+309,823**	**+1.7%**
Power Marketing Administrations						
Southeastern Power Administration	0	0	0	0	0	N/A
Southwestern Power Administration	11,400	11,400	11,400	11,057	-343	-3.0%
Western Area Power Administration	91,740	91,740	93,372	95,581	+2,209	+2.4%
Falcon and Amistad Operating and Maintenance Fund	228	228	228	232	+4	+1.8%
Colorado River Basins Power Marketing Fund	-23,000	-23,000	-23,000	-23,000	0	N/A
Total, Power Marketing Administrations	**80,368**	**80,368**	**82,000**	**83,870**	**+1,870**	**+2.3%**
Federal Energy Regulatory Commission (FERC)	0	0	0	0	0	N/A
Subtotal, Energy and Water Development and Related Agencies	**27,430,797**	**27,408,530**	**29,694,278**	**32,545,381**	**+2,851,103**	**+9.6%**
Uranium Enrichment Decontamination and Decommissioning Fund Discretionary Payments	-463,000	-463,000	0	-155,100	-155,100	N/A
Uranium Enrichment Decontamination and Decommissioning Fund Contribution	463,000	463,000	0	155,100	+155,100	N/A
Excess Fees and Recoveries, FERC	-28,485	-17,325	-23,587	-9,426	+14,161	+60.0%
Title XVII Loan Guarantee Program Section 1703 Negative Credit Subsidy Receipt	0	0	-68,000	-37,000	+31,000	+45.6%
Total, Funding by Appropriation	**27,402,312**	**27,391,205**	**29,602,691**	**32,498,955**	**+2,896,264**	**+9.8%**

[1] FY 2017 Request includes mandatory spending: $1.335B for Clean Transportation Plan, $674M for UED&D Fund, $150M for ARPA-E, and $100M for Science.

Energy Efficiency and Renewable Energy

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Energy Efficiency and Renewable 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 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, [$2,073,000,000] *$2,898,400,000*, to remain available until expended: *Provided*, That of such amount, [$155,000,000] *$170,900,000* shall be available until September 30, [2017] *2018*, 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.).].

Explanation of Changes

Deleted Defense Production Act Fund transfer authority provided in FY 2016.

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 2015 Enacted	FY 2015 Current[1]	FY 2016 Enacted	FY 2017 Request
1,914,195	1,840,847	2,069,194	2,898,400

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 research, develop, demonstrate and deploy cutting-edge technologies and work to break down market barriers in sustainable transportation, renewable power, and energy efficiency. EERE implements a range of strategies aimed at reducing U.S. reliance on oil, increasing energy affordability, ensuring environmental responsibility, enhancing energy security, offering Americans a broader range of energy choices, and creating jobs.

After four decades of investments in American innovation, a wide array of technologies — from solar power and wind power to plug-in electric vehicles, solid-state lighting and cellulosic biofuels — are demonstrating and 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. The diverse portfolio of EERE clean energy technologies create new economic potential in every State in the Nation and we have the opportunity to accelerate the adoption of this portfolio. EERE's investment in clean energy technologies of today and tomorrow support American innovation and manufacturing, providing our Nation an opportunity to win the clean energy race. This would ensure that the U.S. captures a significant and growing share of the multi-trillion dollar global clean energy market and the jobs, energy security and other opportunities that will be created along the way.

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. To date, third party evaluators have assessed one-third of EERE's total R&D portfolio (by amount invested from 1976 to 2012) through multiple impact evaluations covering R&D investments in PV energy systems, wind energy, vehicle combustion engines, advanced battery technologies for electric-drive vehicles, and geothermal technologies. The combined results of these studies show that the total EERE taxpayer investment of $12 billion (inflation-adjusted 2013 dollars) for the R&D investments evaluated has already yielded an estimated net economic benefit to the United States of more than $230 billion, with an overall annual rate of return on investment of more than 20%.[2]

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:

- 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;

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

[2] 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.

- 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.

Highlights and Major Changes in the FY 2017 Budget Request

In FY 2017, EERE will invest $2,898,400,000 in growing the domestic clean energy industry, increasing energy productivity for American consumers and businesses, and expanding access to renewable power and alternative vehicles. EERE will also continue to streamline and enhance its operations, conduct rigorous analysis and evaluations of its portfolio, and achieve the greatest possible impact in each of its three sectors (Sustainable Transportation, Renewable Power, and Energy Efficiency) and its key organization-wide initiatives.

- Sustainable Transportation ($852,900,000)
  EERE's sustainable transportation portfolio supports comprehensive and analysis-based strategies to accelerate the development and widespread use of a variety of promising sustainable transportation technologies. Broadly, EERE pursues two key parallel solution pathways: (1) using less petroleum-derived fuel to move people and freight (vehicle efficiency) and (2) replacing conventional fuels with cost-competitive, domestically produced, sustainable alternatives (alternative fuels) that reduce carbon pollution.
  - Vehicle Technologies: The Budget provides $468,500,000 in FY 2017 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 2017 funding will continue to support awards for the "SuperTruck II" initiative to achieve improved freight-hauling efficiency goals, as well as work to more rapidly deploy lightweight materials and manufacturing processes for automotive use through the Advanced Materials for Energy Innovation crosscut. Building on prior-year and ongoing fuel properties and advanced combustion activities, Vehicle Technologies will continue to support the Co-Optimization of Fuels and Engines 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. New in FY 2017, the Systems and Modeling for Accelerated Research in Transportation (SMART) Consortia initiative will explore opportunities for energy efficiency above the program's traditional vehicle-level focus, at a system level. Major funding changes are the result of enhanced support for these activities, in particular, and for increased investment in next-generation lithium-ion technology and beyond lithium-ion R&D, which show great promise in meeting battery cost and performance goals.
  - Bioenergy Technologies: The Budget provides $278,900,000 in FY 2017, with emphasis on developing 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 by the end of 2017. RD&D emphasizes the development of processes to produce "drop-in" hydrocarbon biofuels, from non-food sources, useable interchangeably with petroleum. In collaboration with the Vehicles Technology Program, FY 2017 funds will be used to develop biofuels for effective use in next-generation engines through the Fuel and Vehicle Systems Co-Optimization of Fuels and EnginesProject. The development of a Synthetic Biology Foundry effort will leverage recently developed synthetic biology tools (ways of redesigning biological processes and systems) to improve efficiencies in the conversion of biomass to fuels and products. Major funding changes are the result of increased investment in the algae program and in R&D to overcome technical barriers to the integrated production of fuels. Funding will also fully support competitively selected pilot or demonstration projects for advanced biofuels technologies through cost-shared partnerships.
  - Hydrogen and Fuel Cell Technologies: The Budget provides $105,500,000 in FY 2017 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 (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 by 2020. In FY 2017, 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 advance the development of quality control tools for the manufacturing of fuel cell components and systems.

- Renewable Power ($620,600,000)
  Through its renewable power portfolio, EERE will address opportunities and challenges to make solar, wind, water, and geothermal power generation technologies directly cost competitive with conventional sources of electricity, and address the wide range of related market issues to facilitate their widespread deployment across the country. This will include approaches to address upfront capital, finance, projected operations and maintenance, and other "soft costs" associated with permitting and siting renewable power projects
  - Solar Energy: The Budget provides $285,100,000 in FY 2017 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. In FY 2017, a major emphasis will be supporting DOE's Grid Modernization crosscut through advanced power electronic solutions for distributed solar, coordinated demonstration projects targeting multiple grid attributes, improved accuracy and availability of solar forecasting technologies, and partnerships with utilities on future business and operational models to reduce "soft costs" of solar installation. SunShot will also support the Clean Energy Manufacturing Initiative by developing and demonstrating innovative manufacturing technologies to increase U.S. competitiveness. Additionally, funds will support developing the next generation of photovoltaic modules, integrating advanced concentrating solar power components, and researching solar thermal-based desalination technologies in support of DOE's Energy-Water Nexus crosscut.
  - Wind Energy: The Budget provides $156,000,000 in FY 2017, including funding to demonstrate the huge potential of America's offshore wind resources through advanced demonstration projects, as well as complementary research and development targeting technology and deployment challenges unique to U.S. waters. This will put Wind Energy on track towards achieving a 16.7 cents/kWh cost target for offshore wind by 2020. Funding will also support first-of-a-kind innovative concepts for taller wind towers and associated turbines and systems capable of accessing and using the stronger and more consistent winds at elevation, and expanding wind deployment in the U.S. Additionally, funding will advance the Atmosphere to Electrons Initiative focused on optimizing entire wind farms, wind power system activities supporting DOE's Grid Modernization Initiative, and ongoing efforts to address the impacts of wind development on wildlife. Combined efforts lead towards achieving a 5.7 cents/kWh cost target for land-based wind by 2020.
  - Water Power: The Budget provides $80,000,000 in FY 2017 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. In FY 2017, HydroNEXT will focus on innovative, low-cost water diversion technologies to enable new stream reach hydropower, to progress to a cost target of 10.9 cents/kWh by 2020 from small, low-head new stream developments. FY 2017 funding also supports RD&D of marine and hydrokinetic technologies, including procurement of materials and construction of a grid-connected open-water test facility and development of concepts for revolutionary wave-energy converters.
  - Geothermal Technologies: The Budget provides $99,500,000 in FY 2017, supporting full implementation of the Frontier Observatory for Research in Geothermal Energy (FORGE), including on-site research and development in enhanced geothermal technologies. FORGE is a dedicated site focused on creating an accelerated commercial pathway to large-scale EGS power generation in the U.S. FY 2017 funding also supports DOE's Subsurface Technology and Engineering RD&D (Subsurface) crosscut. The crosscut seeks to reduce the cost and risk of geothermal development, by targeting R&D in four specific categories that leverage advances in other subsurface sectors. Additionally, FY 2017 funding will expand temperature-gradient well drilling under 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 will reduce the industry's drilling and development risks, and will identify new prospective areas for geothermal exploration and development. Combined efforts will help to achieve a cost target of 6 cents/kWh by 2030 from newly developed geothermal systems.

- Energy Efficiency ($919,000,000)
  EERE's energy efficiency portfolio will build on the considerable progress made over the last 40 years and pursue a comprehensive portfolio of programs to improve the energy efficiency of America's homes, buildings, and industries, with an overall goal of cutting energy waste in half. Businesses and consumers will have compelling new energy-

efficiency options, including products that perform at higher efficiency and with improved performance, new ways to design homes and buildings, and new approaches to improve the vast stock of existing buildings.

- Advanced Manufacturing: The Budget provides $261,000,000 in FY 2017 to enable the research, development, demonstration, and deployment of industrial efficiency and crosscutting clean energy manufacturing technologies. In support 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, this funds the establishment of one additional Clean Energy Manufacturing Innovation Institutes, along with continued support of five existing institutes. This funding also supports the establishment of an Energy Innovation Hub to develop integrated technological system solutions and enable technologies for de-energizing, de-carbonizing, and reducing the cost of desalination. Finally, funding will also support the President's goal of 40 gigawatts of new CHP capacity by 2020 per EO 13264, and the Presidential Better Building's initiative to help American commercial and industrial buildings become at least 20 percent more energy efficient over the next 10 years.
- Federal Energy Management Program (FEMP): The Budget provides $43,000,000 in FY 2017 to continue FEMP's core activities to assist Federal agencies to meet energy-related goals and provide Federal energy leadership to the country. FY 2017 funds will support Federal agency investments to implement commercially available, but underused technologies, to achieve deep energy savings. Additionally, FY 2017 funding will support a new voluntary leadership challenge to reduce energy use in energy-intensive Federal facilities, and target the 450 largest Federal campuses for significant campus-level energy retrofits.
- Building Technologies: The Budget provides $289,000,000 in FY 2017 to support an increased emphasis on emerging technologies R&D in areas such as lighting, heating and cooling, and building envelope. FY 2017 funding will also establish a Low-Global Warming Potential (Low-GWP) Advanced Cooling (HVAC) R&D effort to address near-term and long-term needs to reduce climate impacts of HVAC and refrigeration technologies, in support of the President's Climate Action Plan and the recently proposed amendment to the Montreal Protocol by the U.S., Canada, and Mexico. Investments will continue for the building-to-grid integration activities focused on improving the efficiency and resiliency of the electric grid, including connected buildings and building systems. In addition to R&D activities, the Budget will fund market-focused initiatives to overcome market barriers to widespread adoption of cost-effective energy efficient technologies and solutions, support rulemaking, standards certification and enforcement, as well as provide technical assistance to state and local jurisdictions on building energy code compliance. Funding for Metropolitan Systems, part of a new DOE new initiative, will support attainment of local government climate and energy goals leading to cities that are low carbon, affordable, livable, economically viable, and resilient to extreme events. Combined efforts will work to reduce the energy use intensity of buildings by 30 percent by 2030.
- Weatherization and Intergovernmental Program: The Budget provides $326,000,000 in FY 2017, including $230,000,000 to support the Weatherization Assistance Program, which provides access to home weatherization services for low-income households across the country to reduce their comparatively large percentage of available income spent on energy. The State Energy Program will continue to provide formula and competitive grants to state energy offices, support core capacity and innovation, as well as disseminate best practices with a goal of helping state and local government facilities and operations reduce annual energy use by 2 percent by 2020. A new Cities, Counties, and Communities Energy Program will be established to provide support to local governments, public housing authorities, non-profits and other stakeholders to catalyze more extensive clean energy investments in revitalization efforts. Competitive funding and technical assistance will be provided to Climate Action Champions, Choice Neighborhood grantees, and other locally-focused eligible entities for energy efficiency and renewable energy integration planning and implementation projects. The program will coordinate with the Neighborhood Revitalization Initiative to harmonize efforts as appropriate.

- Crosscutting Innovation Initiatives ($215,000,000)
  In order to enable the required acceleration of clean energy innovation and commercialization in the U.S., EERE is establishing a new Crosscutting Innovation Initiatives program in FY 2017. This program will strengthen regional clean energy innovation ecosystems, accelerate next-generation clean energy technology pathways, and encourage clean energy innovation and commercialization collaborations between our National Laboratories and American entrepreneurs. First, the program will support a Regional Energy Innovation Partnerships, a new competition to establish regionally-focused clean energy innovation partnerships around the country. These regionally focused and directed partnerships will support regionally relevant technology neutral clean energy RD&D needs and opportunities to support accelerated clean energy technology commercialization, economic development, and manufacturing.

Second, through a Next-Generation Innovation funding opportunity, the program will accelerate next-generation clean energy technology pathways. This funding opportunity will be open to off-roadmap RD&D projects with the greatest potential to change the trajectory of EERE core program technology pathways. Third, a new Small Business Partnerships program will competitively provide technology RD&D resources to small businesses through the DOE's National Labs to support their efforts to commercialize promising new clean energy technologies. Fourth, Energy Technology Innovation Accelerators will leverage the technical assets and facilities of the National Laboratories to enable American entrepreneurs to conduct RD&D that leads to the creation of new clean energy businesses.

EERE Key Initiatives

The Clean Energy Manufacturing Initiative (CEMI) is a comprehensive DOE-wide approach to enhance U.S. competitiveness in clean energy manufacturing while advancing progress toward the Nation's energy goals. CEMI aligns resources across DOE to increase the impact of investments in advanced manufacturing-related technology research, development, and demonstration (RD&D), developing advanced manufacturing approaches and technologies applicable to multiple energy sectors. CEMI efforts also address market barriers that will help companies competitively manufacture clean energy technology products in the U.S. Under CEMI, EERE works with stakeholders to build an innovation infrastructure that supports advanced and clean energy manufacturing in the United States. EERE will continue to explore the effectiveness of various funding and organizational structures, such as user facilities and manufacturing demonstration facilities, that have the potential to enhance access to and efficient use of advanced physical and virtual tools for demonstrating new manufacturing technologies and optimizing critical processes.

EERE Programs will collaborate in joint efforts across the Department to apply advanced manufacturing technologies for specific energy needs and to carry out advanced materials manufacturing R&D that will accelerate the development of materials from the point of discovery through functional design to qualification, while incorporating manufacturing processing, scale-up considerations and end-use performance. This approach supports the Department's Advanced Materials crosscut, the Administration's Materials Genome Initiative (MGI) and the Advanced Manufacturing Partnership 2.0. EERE executes a number of these advanced materials R&D activities through the Energy Materials Network (EMN), a robust public-private partnership that could form the basis of a new approach to materials process development.

The EMN is comprised of a broad set of National Laboratory-led consortia for accelerated advanced materials RD&D, where each consortia is focused on a specific class of materials and the most pressing challenges related to clean energy. These consortia will form the basis for a resource network of world-class capabilities in materials design, synthesis, characterization, manufacturing, and digital data management and informatics. EMN directly supports the MGI, which addresses challenges in clean energy, health and human welfare, national security, and the next generation workforce by enabling discovery, development, manufacturing, and deployment of advanced materials at least twice as fast as possible today at a fraction of the cost.

Initial focus areas and lab-led consortia for EMN include materials for solar energy conversion, non-vapor-compression refrigeration systems, non-platinum group metal catalysts, and vehicle lightweighting. Across these preliminary classes, EMN will focus on the following research priorities:

- Increasing access of computational resources to the experimental community, and vice versa, to accelerate both stages of RD&D;
- Developing and experimentally validating tools that predict a material's performance at service conditions;
- Developing a suite of validated predictive tools, sensors and diagnostics, and other methodologies to qualify the ability of manufacturing processes to reliably generate the requisite materials characteristics;
- Developing equipment and automation algorithms for the manufacture of novel materials, along with experimental and computational tools to predict material properties, at industry-ready scales; and
- Developing digital data repositories of material properties that can be networked, are machine discoverable, and are accessible to data analytics algorithms that can rapidly identify unique trends or correlations and harmonizing digital data storage standards to be extensible, accessible, reliable, and interoperable.

In addition, EERE is developing and implementing a coordinated strategy to create an enduring role for the National Laboratories to advance scientific and technical clean energy solutions, which is imperative to ensure America's aptitude for technological innovation and competitiveness and our continued economic growth and energy security. The DOE National Laboratory infrastructure is a world-leading scientific enterprise and EERE's strategy aims to increase meaningful

interactions between the clean energy sector and DOE National Laboratories to help commercialize EERE technologies and strengthen clean energy R&D at the laboratories. The strategy focuses on increasing and enhancing laboratory-private sector relationships; increasing and streamlining access to National Laboratory capabilities, as appropriate; and evaluating laboratory-developed technologies.

Crosscutting Initiatives

EERE supports the following Departmental Crosscuts:

- Advanced Materials (Adv Mat): Affordable, reliable, and high-performance materials are critical for clean energy applications and for global manufacturing competitiveness in the 21st century. The new Advanced Materials crosscut, identified as a priority in both the 2015 Quadrennial Technology Review and Quadrennial Energy Review, will employ advanced synthesis, modeling, and characterization to accelerate and reduce the cost of materials qualification in a wide variety of clean energy applications, from discovery through deployment. While materials RD&D underpins much of DOE's historic and current portfolio across both basic science and applied offices, this newly formed crosscut focuses on a subset of materials R&D that will involve close coordination among the participating offices in forming a cohesive network with the following capabilities: (1) materials design and synthesis, (2) functional (applied) design, (3) process scale-up, (4) qualification, and (5) digital data and informatics.
- Grid Modernization (Grid): 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 building on analysis and findings of the QER; ensure the development of a secure and resilient grid; and collaborate with stakeholders to test and demonstrate combinations of promising new technologies.
- Subsurface Science, Technology and Engineering RD&D (Subsurface): 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 will address identified challenges in the subsurface through highly focused and coordinated research in Wellbore Integrity, Subsurface Stress State and Induced Seismicity, Permeability Manipulation, and New Subsurface Signals to enhance renewable energy supply, ensure material impact on climate change via CO2 storage, and significantly mitigate environmental impacts from energy-related subsurface activities and operations.
- Energy-Water Nexus (EWN): There is increasing urgency to address the energy-water nexus in an integrated way due to changing precipitation and temperature patterns, accelerated drawdown of critical water supplies, population growth and regional migration trends, and the introduction of new technologies that could shift water and energy demands 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 two categories of cyber-related activities: protecting the DOE enterprise from a range of cyber threats that can adversely impact mission capabilities 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, Credentials, and Access Management (ICAM).

FY 2017 Crosscuts ($K)

	Adv Mat	GRID	Subsurface	EWN	Cyber-security	Total
Vehicle Technologies	39,300	18,000				57,300
Bioenergy Technologies				4,000		4,000
Hydrogen and Fuel Cell Technologies		5,000				5,000
Solar Energy		93,000		15,000		108,000
Wind Energy		12,730				12,730
Water Power				6,000		6,000
Geothermal Technologies			80,640	2,000		82,640
Advanced Manufacturing	24,000			25,000		49,000
Building Technologies		25,000				25,000
Facilities and Infrastructure		36,000			2,190	38,190
Total, Energy Efficiency and Renewable Energy	63,300	189,730	80,640	52,000	2,190	387,860

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

	FY 2015 Enacted	FY 2015 Current[1]	FY 2016 Enacted	FY 2017 Request	FY 2017 vs FY 2016 Enacted
Vehicle Technologies	280,000	272,526	310,000	468,500	+ 158,500
Bioenergy Technologies	225,000	175,915	225,000	278,900	+ 53,900
Hydrogen and Fuel Cell Technologies	97,000	94,830	100,950	105,500	+ 4,550
Solar Energy	233,000	230,800	241,600	285,100	+ 43,500
Wind Energy	107,000	105,936	95,450	156,000	+ 60,550
Water Power	61,000	59,999	70,000	80,000	+ 10,000
Geothermal Technologies	55,000	54,288	71,000	99,500	+ 28,500
Advanced Manufacturing	200,000	194,175	228,500	261,000	+ 32,500
Federal Energy Management Program	27,000	27,000	27,000	43,000	+ 16,000
Building Technologies	172,000	168,153	200,500	289,000	+ 88,500
Weatherization and Intergovernmental Programs					
Weatherization Assistance Program					
Weatherization Assistance	189,600	189,600	211,600	225,000	+13,400
Training and Technical Assistance	3,000	3,000	3,000	5,000	+2,000
NREL Site-Wide Facility Support	400	400	400	0	-400
Total, Weatherization Assistance Program	193,000	193,000	215,000	230,000	+15,000
State Energy Program	50,000	50,000	50,000	70,000	+20,000
Cities, Counties and Communities Energy Program	0	0	0	26,000	+26,000
Total, Weatherization and Intergovernmental Program	**243,000**	**243,000**	**265,000**	**326,000**	**+61,000**
Crosscutting Innovation Initiatives	0	0	0	215,000	+215,000
Program Direction	160,000	160,750	155,000	170,900	+15,900
Strategic Programs	21,000	21,000	21,000	28,000	+7,000
Facilities and Infrastructure	56,000	56,000	62,000	92,000	+30,000
Subtotal, Energy Efficiency and Renewable Energy	**1,937,000**	**1,864,372**	**2,073,000**	**2,898,400**	**+825,400**

[1] Funding reflects the SBIR/STTR amounts transferred to the Office of Science.

	FY 2015 Enacted	FY 2015 Current[1]	FY 2016 Enacted	FY 2017 Request	FY 2017 vs FY 2016 Enacted
Use of Prior Year Balances	0	-720	0	0	0
Rescission of Prior Year Balances	-22,805	-22,805	-3,806	0	+3,806
Total, Energy Efficiency and Renewable Energy	**1,914,195**	**1,840,847**	**2,069,194**	**2,898,400**	**+829,206**
Federal FTEs	**697**	**697**	**697**	**707**	**+10**

SBIR/STTR:

- FY 2015 Transferred: SBIR: $25,045,000; STTR: $3,333,000
- FY 2016 Projected: SBIR: $26,240,000; STTR: $3,936,000
- FY 2017 Request: SBIR $46,793,000; STTR: $6,580,000

Vehicle Technologies

Overview

The U.S. transportation sector accounts for two-thirds of U.S. petroleum use and on-road vehicles consume nearly 85 percent of the petroleum used for transportation. U.S. dependence on oil for transportation affects the national economy and its potential for future growth–the U.S. sends more than ten billion dollars per month overseas for oil (this amount has been well over one billion dollars per day in recent years)[1]. 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 around $1.50 to over $4 per gallon, causing fluctuations in annual household budgets by as much as $1,200 per year for the average personal vehicle. In addition, the U.S. transportation sector accounts for approximately one-third of U.S. carbon pollution, and, despite recent progress in reducing other emissions, remains a significant source of air pollution.[2]

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 productively. 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 (GHG) emissions, and strengthen U.S. global economic competitiveness.

Aligning with the President's Climate Action Plan and the Administration's clean energy goals, the Vehicle Technologies Program supports a broad technology portfolio that adheres to a comprehensive and analysis-based strategy of research, development, demonstration, and market barrier reduction activities, and creates strategic public-private partnerships to develop new technologies and move them from the laboratory onto the road. 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 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 very low cost to the Government.

Highlights of the FY 2017 Budget Request

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

- The EV Everywhere Grand Challenge ($282.7 million) will 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 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 modeled high volume battery costs from $264/kWh in 2015 to $125/kWh by 2022;
  - Eliminating almost 30 percent of vehicle weight through light weighting by 2022, compared to a 2012 baseline; and
  - Reducing the cost of electric drive systems from $12/kW in 2015 to $8/kW by 2022.
- SuperTruck II initiative ($60 million) started in FY 2016 to research, develop, and demonstrate a suite of technologies 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 demonstrate applicability of these technologies to heavy-duty regional-haul vehicles as well – with an emphasis on cost-competitiveness. $60 million in FY 2017 fully funds the $80 million SuperTruck II Program ($20 million funded in FY 2016).
- DOE is expanding Advanced Materials R&D efforts across the department to accelerate the life cycle of materials design, development, and deployment, consistent with the goals of the Administration's Materials Genome Initiative

[1] U.S. Energy Information Administration, February 1, 2016. Overseas includes countries and territories outside the 50 States and the District of Columbia. https://www.eia.gov/petroleum/gasdiesel/.

[2] 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 34th Edition, ORNL, 2015. http://cta.ornl.gov/data/tedb34/Edition34_Full_Doc.pdf.

and Advanced Manufacturing Partnership 2.0. In support of the DOE Advanced Materials Crosscut ($39.3 million), Vehicle Technologies will support development of computational tools and techniques for predicting and validating a low-cost polymeric precursor for carbon fiber, designed specifically to meet the mechanical and cost requirements for high-volume automotive applications. The Advanced Materials Crosscut will also work to accelerate the development of high strength, high formability, corrosion resistant, and low cost magnesium sheet alloys for vehicle lightweighting.

- Building on prior-year and ongoing fuel properties and advanced combustion activities, Vehicle Technologies will continue supporting the Co-Optimization of Fuels and Engines effort ($15 million) in coordination with the Bioenergy Technologies Program. Establishing a link across fuels and engines early in the research and development (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, to increase fuel economy up to an additional 15 percent for spark ignition (SI) and 20 percent for advanced compression ignition (CI) and reduce GHG emissions up to 30 percent beyond anticipated reductions associated with achievement of EERE goals by 2030.
- To realize untapped energy efficiency and GHG reduction potential, Vehicle Technologies will support the Transportation as a System (TAS) initiative ($20 million), exploring opportunities for energy efficiency above the program's traditional vehicle-level focus at the overall transportation system level. Transportation as a System will evaluate how transportation assets, travelers, and the transportation system interact and influence each other using multi-scale, multi-system models, with the longer-term goal of optimizing efficiency of the transportation system. There is no program within DOE's transportation portfolio directly exploiting these opportunities, which are likely essential to meeting the Administration's goals of reducing emissions 26 percent - 28 percent by 2025 and 83 percent by 2050.

Multiple activities in the Vehicle Technologies Program support the Department's Clean Energy Manufacturing Initiative. Clean energy manufacturing efforts in the Vehicle Technologies Program include R&D 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, and development of materials and processes for low rare earth content electric drive systems.

As part of the DOE Grid Modernization Initiative, the Vehicle Technologies Program will focus in each of the six technical areas detailed in the Grid Modernization Multi-Year Program Plan (MYPP). Specifically, the Vehicle Technologies contribution supports aspects of vehicle-to-grid integration associated with PEVs, focusing on technologies needed to fully integrate PEVs into the distribution system in a safe, reliable, and cost-effective manner.

FY 2017 Crosscuts ($K)

	Grid	Adv Mat	Total
Vehicle Technologies	**18,000**	**39,300**	**57,300**

Vehicle Technologies
Funding ($K)

	FY 2015 Enacted	FY 2015 Current[1]	FY 2016 Enacted	FY 2017 Request	FY 2017 vs FY 2016
Vehicle Technologies					
Batteries and Electric Drive Technologies	**103,701**	**100,279**	**141,100**	**0**	**-141,100**
Battery Technology R&D	**0**	**0**	**0**	**130,000**	**+130,000**
Electric Drive Technologies R&D	**0**	**0**	**0**	**39,000**	**+39,000**
Vehicle Systems	**40,393**	**39,793**	**30,600**	**90,000**	**+59,400**
Advanced Combustion Engine R&D	**49,000**	**47,383**	**37,141**	**74,800**	**+37,659**
Materials Technology					
Lightweight Materials Technology	28,533	27,591	21,636	71,500	+49,864
Propulsion Materials Technology	7,069	6,836	5,323	11,200	+5,877
Total, Materials Technology	**35,602**	**34,427**	**26,959**	**82,700**	**+55,741**
Fuel and Lubricant Technologies	**20,000**	**19,340**	**22,500**	**20,500**	**-2,000**
Outreach, Deployment, and Analysis					
Vehicle Technologies Deployment	24,000	24,000	34,000	23,000	-11,000
Advanced Vehicle Competitions	2,500	2,500	2,500	2,500	+0
Legislative and Rulemaking	1,804	1,804	1,500	1,500	+0
Analysis	0	0	10,400	4,500	-5,900
Total, Outreach, Deployment, and Analysis	**28,304**	**28,304**	**48,400**	**31,500**	**-16,900**
NREL Site-Wide Facility Support	**3,000**	**3,000**	**3,300**	**0**	**-3,300**
Total, Vehicle Technologies	**280,000**	**272,526**	**310,000**	**468,500**	**+158,500**

SBIR/STTR:

- FY 2015 Transferred: SBIR $6,568,000; STTR $906,000
- FY 2016 Projected: $7,244,000; STTR $1,087,000
- FY 2017 Request: SBIR $12,400,000; STTR $1,744,000

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

Budget Structure Crosswalk ($K)

FY 2016 Budget Structure	Proposed FY 2017 Budget Structure								
	Battery Technology R&D	Electric Drive Technologies R&D	Vehicle Systems	Advanced Combustion Engine R&D	Materials Technology	Fuels and Lubricant Technologies	Outreach, Development, and Analysis	NREL Site-Wide Facility Support	Total
Vehicle Technologies									
Batteries and Electric Drive Technologies	130,000	39,000	0	0	0	0	0	0	**169,000**
Vehicle Systems	0	0	90,000	0	0	0	0	0	**90,000**
Advanced Combustion Engine R&D	0	0	0	74,800	0	0	0	0	**74,800**
Materials Technology	0	0	0	0	82,700	0	0	0	**82,700**
Fuels and Lubricant Technologies	0	0	0	0	0	20,500	0	0	**20,500**
Outreach, Development, and Analysis	0	0	0	0	0	0	31,500	0	**31,500**
NREL Site Wide Facility Support (Moved to F&I)	0	0	0	0	0	0	0	0	**0**
Total, Vehicle Technologies	**130,000**	**39,000**	**90,000**	**74,800**	**82,700**	**20,500**	**31,500**	**0**	**468,500**

Vehicle Technologies
Explanation of Major Changes ($K)

	FY 2017 vs FY 2016 Enacted
Vehicle Technologies	
Batteries and Electric Drive Technologies: Restructured Battery Technology R&D and Electric Drive Technologies R&D as separate subprograms, improving program management alignment (both are former activities under the Batteries and Electric Drive Technologies subprogram).	**-141,100**
Battery Technology R&D: In support of the EV Everywhere Grand Challenge, support continues to significantly advance next generation lithium-ion technology in the three major R&D areas of Battery R&D: Advanced Battery Materials, Advanced Battery Development, and Advanced Processing. Based on battery performance modeling efforts, next generation lithium-ion technology has the potential to meet the 2022 cost target, while meeting vehicle battery performance targets. In addition, the FY 2017 Budget Request supports an increased emphasis on beyond lithium-ion R&D, which complements and strengthens recent beyond lithium-ion advances and is a potential pathway to decrease battery cost below the 2022 target.	**+130,000**
Electric Drive Technologies R&D: In FY 2017, research will continue support for the EV Everywhere Grand Challenge, specifically toward the long-term electric drive system (motor and inverter) goal of a 50 percent cost reduction (compared to a 2012 baseline) by 2022 to $8/kW ($440/system). An Electric Drive Technologies Development FOA topic in FY 2017 will develop integrated electric drive systems that can achieve performance and cost targets with improved reliability and power density. An Electric Drive Technologies Research FOA topic in FY 2017 will develop advanced materials and technologies for Wide Bandgap (WBG) packages and power module designs to accelerate power electronics innovation. Funding also continues at the National Laboratories to strengthen and accelerate advancements in WBG power electronics and non-rare earth motors.	**+39,000**
Vehicle Systems: The FY 2017 Budget Request builds upon the Connected and Autonomous Vehicles work in FY 2016 by supporting the Transportation as a System initiative, which explores opportunities for energy efficiency above the Program's traditional vehicle-level focus. The Vehicle Technologies Budget Request increases support of the Departmental Grid Modernization Initiative by supporting PEV-specific aspects of vehicle and grid integration. In addition, support expands for vehicle systems-specific aspects of the EV Everywhere Grand Challenge and SuperTruck II.	**+59,400**
Advanced Combustion Engine R&D: The Advanced Combustion Engine R&D subprogram will competitively award cost-shared projects with industry to support the development of cost-competitive engine and powertrain systems for light-duty passenger vehicles capable of attaining at least a 35 percent fuel economy improvement for gasoline fueled vehicles and at least 50 percent fuel economy improvement for diesel fueled vehicles while meeting future emissions standards by 2020. The subprogram will continue to support SuperTruck II and the Co-Optimization of Fuels and Engines effort and increase funding for fundamental combustion and emission control research at the National Laboratories. The subprogram will support complementary combustion and emission control research at universities.	**+37,659**

	FY 2017 vs FY 2016 Enacted
Materials Technology: The FY 2017 Budget Request supports an increase for the Advanced Materials Crosscut to develop and apply tools and techniques to predict optimized polymeric precursors and processing for low-cost carbon fiber designed specifically to meet the mechanical and cost requirements for high volume automotive applications. The activities under Lightweight Materials also continue to support the EV Everywhere Grand Challenge and SuperTruck II. Propulsion Materials efforts will target improved integrated computational materials engineering tools to accelerate the development of advanced low cost alloys for high efficiency engines and SuperTruck II powertrain materials requirements to enable increased peak cylinder pressure, reduced friction, and increased system efficiency.	**+55,741**
Fuel and Lubricant Technologies: The FY 2017 Budget Request continues funding fuel properties R&D for the Co-Optimization of Fuels and Engines effort, with the ultimate goal of cost-effective, lower-carbon fuels for high-performance efficient engines. Support continues for developing technologies that reduce petroleum consumption by displacing it with alternative fuels and the development of advanced lubricants that are compatible with future and legacy vehicles to reduce friction loss in engines, transmissions, and axles.	**-2,000**
Outreach, Deployment, and Analysis: The FY 2017 Budget Request reflects a funding decrease as Transportation as a System moves from Analysis to Vehicle Systems; this is consistent with program evolution from foundational exploratory and prioritization analyses to applied vehicle systems modeling and simulation. The FY 2017 Budget Request continues to support core Vehicle Technologies Deployment, Legislative and Rulemaking, and Analysis activities, in addition to year three of the four-year EcoCAR 3 collegiate engineering competition.	**-16,900**
NREL Site-Wide Facility Support: In FY 2017, EERE proposes to move funding for the NREL Site-Wide Facility Support subprogram from individual technology programs to the Facilities and Infrastructure Program. Locating this funding in the Facilities and Infrastructure Program will provide clarity and transparency in communicating EERE's stewardship of NREL, and will simplify planning and execution of EERE's annual budget. This consolidation into a single program allows for better integration and coordination of operations and investments.	**-3,300**
Total, Vehicle Technologies	**+158,500**

Vehicle Technologies
Battery Technology R&D

Description

In support of the EV Everywhere Grand Challenge ($130 million), the Battery Technology R&D subprogram addresses the development of low-cost, high-energy batteries needed for the widespread adoption of plug-in electric vehicles (PEVs, including all-electric vehicles and plug-in hybrid electric vehicles) by developing the technologies necessary to reduce modeled high-volume battery costs from $264/kWh in 2015 to $125/kWh by 2022, a more than 50 percent reduction.[1]

The Battery Technology R&D subprogram funds research programs with partners in academia, National Laboratories, and industry, focusing 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 subprogram supports the development of lower-cost materials and processing technologies to achieve significant cost reductions in major R&D areas: Advanced Battery Materials, Advanced Battery Development, and Advanced Processing.

The Advanced Battery Materials effort ($48.2 million) will focus on cathode, anode, and electrolyte materials, which account for 50-70 percent of PEV battery cost. Specifically, this work will focus on development of new materials that offer a significant improvement in either energy or power. Advanced Battery Development activities ($38.6 million) will continue developing advanced PEV batteries in cooperation with industry through projects awarded competitively and cost-shared by developers. This work will focus on the development of robust prototype cells that contain new materials and electrodes that reduce the overall battery cost, weight, and volume while improving energy, life, and safety. Advanced Processing activities ($43.2 million) will explore disruptive materials and electrode production technologies that could significantly reduce cost and environmental impact while increasing yield and process control.

In addition to other DOE programs, the Battery Technology R&D subprogram supports the Department's Clean Energy Manufacturing Initiative (CEMI) ($21 million). Continuing CEMI R&D projects will be supported through work at the National Laboratories and battery development awards through the DOE Cooperative Agreement with the U.S. Advanced Battery Consortium (USABC) and through competitively selected awards. The goal is to significantly improve electrochemical performance and scale-up of new materials from laboratory quantities (grams) to batch quantities (10s of kilograms) to enable expanded R&D and develop higher-speed and lower-cost electrode production processes.

[1] 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.

Battery Technology R&D
Activities and Explanation of Changes

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
Batteries and Electric Drive Technologies $141,100,000	**$0**	**-$141,100,000**
Battery Technology R&D $0	**$130,000,000**	**+$130,000,000**
Advanced Battery Materials		
• Initiate up to fifteen 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.	• Support eight to twelve National Laboratory R&D Advanced Battery Materials projects in the following focus areas: synthesis of high capacity cathode material based on combinatorial materials modeling; development of new synthesis routes for making lithium rich materials to mitigate voltage fade problem; modeling and first principles calculations of electrode materials, solid-electrolyte interphase (SEI) layer, and electrode microstructure; and assembly of high density low tortuosity electrodes.	• These new research focus areas build from current work in Advanced Battery Materials to increase material capacity and cycle life and allow the design of low-cost, thicker electrodes without sacrificing power performance and cycle life.
• Support materials research activities through a competitive Lab Call focused on beyond lithium-ion technologies such as lithium metal and non-lithium battery technologies (sulfur, air, and sodium electrodes) through up to seven projects at National Laboratories. • National Laboratory research will also focus on the synthesis and diagnostics of advanced Ni rich high capacity cathodes and the investigation of disordered cathode materials.	• Support one to two beyond lithium-ion research National Lab Consortia that complements and strengthens recent beyond lithium-ion advances. Topics include investigating solvent in salt electrolytes for lithium metal anodes, Sulfur cathodes, and other beyond lithium-ion electrodes. • Initiate up to eight new competitively selected FOA awards for advanced battery materials research to capitalize on recent beyond lithium-ion advances and novel electrolyte concepts. Focus will be on the following: mesoscale heterogeneous electrolytes; organic/inorganic nano-composites; and interface-augmented ion-conductors.	• The increased funding for beyond lithium-ion R&D is driven by the evolution of R&D in advanced battery materials and is a promising pathway for achieving the battery cost target of $125/kWh by 2022. Based on battery performance modeling efforts, beyond lithium-ion materials show great promise in meeting battery cost goals if specific technological challenges (e.g., mitigation of lithium dendrite formation and polysulfide dissolution) are solved.

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
• 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.	• Support multi-National Laboratory consortium in enabling next-generation intermetallic anodes for lithium-ion batteries to address a critical problem in getting to higher energy cells. Research is expected to evolve in FY 2017 to the following topics: non-traditional electrode lamination and coating, concentration gradient particles, and advanced particle coating technologies.	• The subprogram will continue the scientific investigation of operational interactions among all cell components (cathode, anode, electrolyte, binders, conductive additives, and separator) and the mitigation of factors affecting performance and life in advanced cells.
Advanced Battery Development		
• 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 eight to twelve battery development projects under the program's cooperative agreement with the U.S. Advanced Battery Consortium (USABC).	• Continue support of the USABC effort to lower battery costs to $125/kWh by 2022. USABC will issue new solicitations that complement its technology development portfolio to meet DOE cost and performance targets for energy storage devices.	• These activities continue support for a five-year competitively awarded cooperative agreement with the USABC to fund and manage research to design, develop, build and test electrochemical energy storage devices.
• Support the development of Computer Aided Engineering Battery Design Tools, leveraging the unique capabilities of National Laboratories. • Support National Laboratory research to improve computational efficiency of state-of-the-art (SOA) electrochemical models.	• Continue support for up to eight FY 2016 competitively selected National Laboratory projects focused on improving computational efficiency of SOA electrochemical models at the National Laboratories with a focus to develop microstructure models that account for inhomogeneity in electrode structure, and improve SOA mechanically coupled electrochemical models that predict crush events.	• These activities support three-year National Laboratory projects to develop computer aided battery design tools that predict battery performance and are able to reduce the development time of battery cells and packs enabling quicker market entry of new designs and a reduction of product development costs.

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
• Support high fidelity battery performance, life, and safety testing at the National Laboratories.	• Support up to five competitively selected projects at the National Laboratories for high fidelity battery performance, life, and safety testing at National Laboratories, which provides critical insight regarding technology state-of-the-art and helps to identify performance gaps that need to be addressed through R&D activities.	• High fidelity battery testing at the National Laboratories continues.
Advanced Processing		
• Support four to six 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.	• Initiate up to six new competitively selected FOA awards to build on the successes of a FY 2013 FOA entitled "Improvements in Cell Chemistry, Composition, and Processing." • Continue to support R&D at National Laboratories to engineer new materials, develop processes to scale up these materials for expanded R&D, and to develop advanced electrode processing technologies with the potential to significantly reduce production cost or increase battery performance.	• New competitively selected awards will significantly improve electrochemical performance, and scale up of new materials from laboratory quantities (grams) to batch quantities (10s of kilograms). The goal is to build cells with SOA materials that have the potential to leapfrog existing energy densities and lifetime performance statistics.

Vehicle Technologies
Electric Drive Technologies R&D

Description

In support of the EV Everywhere Grand Challenge ($39 million), the Electric Drive Technologies R&D subprogram addresses the research and development of affordable, reliable, highly efficient power electronics and electric motors necessary for the widespread adoption of electric vehicles by developing components and systems to reduce the modeled high-volume cost of 55kW electric drive systems from $12/kW ($660/system) in 2015 to $8/kW ($440/system) by 2022, a 33 percent cost reduction.[1]

The Electric Drive Technologies R&D subprogram funds programs with partners in academia, National Laboratories, and industry. The subprogram emphasizes material, device, and component innovations to significantly reduce the cost, weight, and volume of electric drive systems. The subprogram supports material and process innovations to achieve significant cost reduction in power electronics, electric motors, and integrated electric drive systems by supporting two areas: Electric Drive Technologies Research and Electric Drive Technologies Development.

In FY 2017, the subprogram will continue to develop Wide Bandgap (WBG) power electronics and non-rare earth motors, with an emphasis on increasing power density while reducing costs at both the component and system level. An Electric Drive Technologies Development FOA topic is planned in FY 2017 to develop electric drive systems that can achieve performance and cost targets with improved reliability and power density. This can dramatically affect how future electric drive vehicles will be constructed by integrating improvements to designs and subcomponents at a system level. In addition, an Electric Drive Technologies Research FOA topic in FY 2017 will develop advanced materials and technologies for WBG packages and power module designs to accelerate power electronics innovation and commercialization. Electric Drive Technologies Research will also continue to fund National Laboratory activities to strengthen and accelerate advancements in WBG power electronics and non-rare earth motors for electric drive systems. Focus areas include novel, high-temperature WBG die attachments, interfaces, and substrates for advanced packaging technologies; rapid prototyping of innovative topologies and designs to enable and accelerate use of WBG technologies; and modeling and simulation to optimize designs and technologies to balance the trade-offs of performance improvements, heat removal, and improved efficiency based on cost-effective materials, processes, and manufacturing technologies.

[1] Key additional details include:
- Lower cost electric drive systems must meet the vehicle performance, efficiency, and reliability requirements.
- Component weight and volume reductions are necessary to meet requirements and targets.
- Cost target is based on electric drive system production volume of 100,000 per year.

Electric Drive Technologies R&D
Activities and Explanation of Changes

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
Batteries and Electric Drive $141,100,000	**$0**	**-$141,100,000**
Electric Drive Technologies R&D $0	**$39,000,000**	**+$39,000,000**
• Support projects at the National Laboratories to conduct research of high temperature materials, devices, and components including interfaces and interconnects that enable innovative power electronics designs; and 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 to accelerate commercialization. • Initiate three to four new projects through a FOA for Electric Drive Technologies Development to focus on advances in low cost vehicle motors. These projects will develop and demonstrate advanced electric machine designs, technologies, materials, and production pathways to significantly lower cost. Of particular interest are projects that emphasize materials-based developments, which can enable meeting performance targets for specific power, power density, and cost.	• Continue to support National Laboratory activities emphasizing innovative Wide Bandgap (WBG) power electronics, non-rare earth electric motors, and electric drive systems to meet electric vehicle targets and requirements. Research focuses on novel, high temperature WBG die attachments, interfaces and substrates for advanced packaging technologies to improve high-temperature capabilities and reduce processing and manufacturing costs. • Initiate modeling and simulation at the National Laboratories with a focus on optimization of designs and technologies to balance the trade-offs of performance improvements, heat removal, and improved efficiency based on cost-effective materials, processes, and manufacturing technologies. • Initiate at least two new projects through an Electric Drive Technologies Research FOA topic in FY 2017 to develop advanced materials and technologies for WBG packages and power module designs to accelerate power electronics innovation and commercialization. • An Electric Drive Technologies Development FOA topic is planned in FY 2017 to initiate at least two projects developing integrated electric drive systems that can achieve the 2022 performance and cost target of $8/kWh. Specific improvements are sought at the subcomponent and system level for both	• Continue National Laboratory research efforts to develop and validate innovative materials and designs for high-temperature electric drive components and system applications. Increased emphasis on innovations to increase power density while maintaining focus on cost reduction and reliability. Efforts will focus on demonstration of the most promising substrates and interface materials in WBG power modules and innovative packaging designs. • Increase focus on modeling and simulations at the National Laboratories to confirm research progress and identify remaining gaps and challenges to achieving 2022 EV Everywhere electric drive system targets and goals. • An Electric Drive Technologies Research FOA topic in FY 2017 will develop advanced materials and technologies for Wide Bandgap (WBG) packages and power module designs to accelerate power electronics innovation and commercialization. Competitively awarded efforts with teams from industry, universities, and National Laboratories will focus on overcoming barriers and gaps to commercializing WBG power electronics for vehicle electric drive systems. • New competitively selected FOA projects for Electric Drive Technologies Development will target drive system development, integrating power electronics and motor innovations into

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
	power electronics and motors, affecting how future electric drive vehicles will be constructed through the integration of these systems.	a single vehicle traction drive system. These advancements will significantly increase the current electric drive system performance and efficiency while achieving further cost reduction. Funding levels will allow for multiple project selections, which will enable greater participation from U.S. industry and partners while reducing technical risk through diverse solutions and project approaches.

Vehicle Technologies
Vehicle Systems

Description

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 following:

- 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 these technologies;
- Component and vehicle evaluations in both laboratory and on-road environments to validate modeling tools, prove long-term reliability and benefits of advanced technologies, and identify critical R&D to improve these technologies;
- Development of critical codes and standards to support the EV Everywhere Grand Challenge ($48.2 million) 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, improved aerodynamics, and low rolling resistance technologies.

Vehicle Systems continues to support the DOE Grid Modernization Initiative ($18 million) in the FY 2017 Budget Request. In Devices and Integrated System Testing, Vehicle Systems will work on developing power electronics, standards for interoperability, and integrated system testing. In Sensing and Measurement, Vehicle Systems will focus on the development of low-cost sensors for electric vehicles and charging equipment. In System Operations, Control, and Power Flow, Vehicle Systems will quantify the multiple value streams electric vehicles can provide to the grid fully integrated with distributed solar generation, building energy management systems, and other smart grid technologies. In Institutional Support, Vehicle Systems will engage with utilities and other stakeholders to identify what valuable services PEVs may provide to the electric grid. In Design and Planning Tools, Vehicle Systems will work on tools that help utilities and other stakeholders understand the impact of electric vehicles on the grid. Finally, Vehicle Systems will support broader demonstration projects that will co-optimize across multiple grid attributes including affordability, security, resilience, reliability, and integration of clean technologies.

Vehicle Systems will expand its connected and autonomous vehicles work with the Transportation as a System (TAS) initiative ($20 million). Transportation as a System seeks to explore opportunities for energy efficiency above the Vehicle Technologies Program's traditional vehicle-level focus, at the system level. Transportation as a System will evaluate how transportation assets, travelers, and the transportation system interact and influence each other using multi-scale, multi-system models, with the longer-term goal of optimizing the transportation system. Vehicle Systems continues to support SuperTruck II ($21 million); focus areas may include aerodynamic improvements, hybridization, connectivity and automation, controls improvement, logistics efficiency concepts, climate control and accessory load optimizations, and other systems-level opportunities.

Vehicle Systems
Activities and Explanation of Changes

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
Vehicle Systems $30,600,000	**$90,000,000**	**+$59,400,000**
• Provide a vehicle systems context in support of Vehicle Technologies' component-level R&D activities. Enhance advanced vehicle models and simulation capabilities by developing and validating higher-fidelity models based on test data from the Advanced Powertrain Research Facility.	• Continue developing software modeling tools and use them to analyze the performance and efficiency benefits of component technologies integrated into vehicle systems at the National Laboratories. • Continue to conduct simulation studies at the National Laboratories to evaluate the benefits of technologies currently in development, and assess the potential fuel efficiency impacts of novel advanced vehicle concepts in the early development stage.	• Vehicle Systems continues to support National Laboratory work in FY 2017; model-based systems engineering tools accelerate the development and reduce the cost of bringing advanced vehicle technology to market.
• In coordination with industry partners, support National Laboratory project to conduct laboratory and field testing of two new emerging advanced electric-drive vehicle models by incorporating them into the Advanced Vehicle Testing & Evaluation (AVTE) fleet, and disseminate data regarding their performance and fuel consumption benefits. This inter-laboratory collaborative research activity is focused on conducting repeatable, structured experiments of advanced vehicles, vehicle systems, and component technologies to create an unbiased database of performance, efficiency, and system response.	• In coordination with industry partners, continue to conduct detailed closed-track and on-road evaluations of five new emerging and near-market ready advanced technology vehicles, and test infrastructure to fully characterize vehicle, systems, and component operations.	• Support continues for closed-track and on-road evaluations. This activity is critical to DOE's efforts to quantify the real-world performance, efficiency, reliability, and cost characteristics of emerging vehicle technologies, including connected and automated vehicles. It is also an essential source of real-world data to support the EV Everywhere Solutions Center.
• Provide technical support for PEV standards development, and promote international harmonization of vehicle codes and standards through participation in key standards development organizations.	• Provide technical expertise and leadership to support development of standards related to PEVs and grid connectivity and development of standards related to communications and directional power transfer protocols.	• Continue support of National Laboratory efforts in ensuring that codes and standards are in place for PEV technology.
• Complete final SuperTruck I projects and initiate up to four new SuperTruck II projects	• Continue support of FY 2016 SuperTruck II awards. Vehicle Systems work in the	• SuperTruck II continues from FY 2016.

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
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 and cost-effectiveness of these technologies to heavy-duty Class 8 regional-haul vehicles.	SuperTruck II project may focus on aerodynamic improvements, hybridization, connectivity and automation, controls improvements, logistics efficiency concepts, climate control and accessory load optimizations, and other systems-level opportunities.	
• Continue vehicle/grid integration R&D efforts by supporting three vehicle-specific projects and additional foundational work proposed through the Grid Modernization Laboratory Consortium, coordinated with other EERE and DOE offices to ensure synergy and optimal integrated impact.	• Through a combination of National Laboratory work and competitively selected awards, Vehicle Systems supports the Grid Modernization initiative through 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, as well as analyze the scope of cybersecurity issues relevant to vehicle/grid integration.	• Vehicle Systems significantly expands its support of the Grid Modernization initiative by increasing funding available for competitively selected awards. The Grid Modernization initiative focuses its efforts in FY 2017 on devices and integrated system testing; sensing and measurements; systems operations; institutional support; and design and planning tools.
• Support the development of enabling technologies, including thermal management of vehicle powertrains and cabin loads, aerodynamic drag reduction designs, and advanced high-power wireless charging systems.	• Initiate National Laboratory efforts to optimize vehicle powertrains through thermal control technologies and electrification opportunities in the medium-and heavy-duty sector.	• In FY 2017, Vehicle Systems will initiate one to two National Laboratory projects to investigate optimization opportunities through the entire vehicle powertrain in the medium- and heavy-duty vehicle segment, leveraging initial results from the Co-Optimization of Fuels and Engines effort.

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
	• Transportation as a System identifies and explores energy efficiencies beyond the traditional vehicle-level focus to accelerate sustainable transportation at the system level. This effort combines broad expertise from National Laboratories, industry, and other government agencies in an integrated framework, leveraging existing models and tools to build a highly effective virtual test bed system for advanced vehicle technologies and alternative fuels and infrastructure. Research topics include Mobility Decision Science; Connectivity and Automation; Multi-Modal Combinations; Urban Science; and Vehicle and Infrastructure Systems.	• In FY 2017, Transportation as a System R&D will transition from Analysis within Outreach, Deployment, and Analysis to Vehicle Systems. As new paradigms emerge in transportation and information technology, new opportunities are created to better understand and leverage the human role in transportation as well as the higher degree of integration between physical systems in the modern built environment.

Vehicle Technologies
Advanced Combustion Engine R&D

Description

The Advanced Combustion Engine R&D subprogram develops cutting-edge technologies that 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 GHG 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] Prior successful DOE investments in combustion research have yielded a 70:1 return on investment in fuel savings and associated health benefits.[2]

The subprogram supports research to accelerate the development of high-efficiency advanced combustion engines while reducing emissions, and develops enabling technologies, such as waste energy recovery 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 percent and diesel vehicle fuel economy by 50 percent compared to 2009 gasoline vehicles; and
- In 2020, increase commercial vehicle engine efficiency by 30 percent compared to a 2009 baseline.

Advanced Combustion Engine R&D will competitively award cost-shared projects with industry to develop cost-competitive engine and powertrain systems for light-duty passenger vehicles capable of attaining at least a 35 percent fuel economy improvement for gasoline-fueled vehicles and at least 50 percent fuel economy improvement for diesel-fueled vehicles, while meeting future EPA emissions standards. The subprogram will continue supporting SuperTruck II ($25.8 million) by funding industry teams 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. The subprogram will improve the thermal efficiency of passenger and commercial vehicle engines by investigating emerging and innovative combustion processes for high-efficiency 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. The subprogram will also conduct research and development of innovative emission control strategies to enable successful development of low-cost, high-efficiency engines that meet EPA Tier 3 standards.

Support will also continue at the National Laboratories for the Co-Optimization of Fuels and Engines effort ($4.5 million), collaboration with the Fuel and Lubricant Technologies subprogram and Bioenergy Technologies Program. The Co-Optimization of Fuels and Engines effort investigates the impact of fuel properties on engine performance and how they can be optimized to achieve higher efficiency and lower emissions.

The subprogram will support competitively awarded, cost-shared 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 emissions.

[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.

Advanced Combustion Engine R&D
Activities and Explanation of Changes

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
Advanced Combustion Engine R&D $37,141,000	**$74,800,000**	**+$37,659,000**
• Develop computer simulations of combustion and emission control processes that utilize the high performance computing capabilities at the National Laboratories. • Support laser- and X-Ray-based National Laboratory research of advanced combustion concepts and fuel injection systems to improve engine efficiency. • Continue to develop chemical kinetic models of fuels at the National Laboratories to optimize combustion and reduce emissions. • Support National Laboratory 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.	• Continue support for 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 with further refinement from experimental and high performance computing facilities at the National Laboratories. • Continue National Laboratory projects supporting fundamental combustion research in optically accessible engines with in-cylinder optical and laser diagnostics, and X-Ray- and neutron-based fuel injection spray visualization. National Laboratory work continues in FY 2017 to support fundamental catalyst and particulate filtration research having low-cost and energy penalty to enable market introduction of more efficient combustion technologies.	• The FY 2017 Budget Request continues support of fundamental research to increase engine efficiency resulting in fuel economy improvements of 35 percent for light-duty and 30 percent for heavy-duty vehicles by 2020. • Increase funding for National Laboratory combustion research portfolio that supports Computational Fluid Dynamic (CFD), fuel spray, and chemical kinetics modeling along with supporting experiments, and combustion systems development.
• Continue to develop emission control systems at the National Laboratories to reduce NOx from lean-burn gasoline and other advanced engines that have low exhaust temperatures. • Develop and validate performance of gasoline particulate filters at the National Laboratories to enable efficient direct-injection engines to meet future particulate standards. • Initiate up to three 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.	• Continue support for research at the National Laboratories in areas including low-cost base metal catalysts for lean-burn gasoline and other advanced engines (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.	• Increase funding for National Laboratory support for fundamental catalyst and particulate filtration research to reduce NOx and particulates for meeting future EPA standards with low-cost and energy Support development of multi-functional emission control system to reduce volume.

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
• Initiate up to four 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 and cost-effectiveness of these technologies to heavy-duty Class 8 regional-haul vehicles.	• Continue supporting FY 2016 SuperTruck II awards. Advanced Combustion Engine R&D will focus on development of energy efficient powertrain technologies that will improve commercial vehicle engine efficiency by 30 percent compared to a 2009 baseline.	• SuperTruck II continues from FY 2016.
• 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 Co-Optimization of Fuels and Engines effort.	• Continue National Laboratory projects focused on the co-optimization of fuels and engines to remove barriers to higher-efficiency and reduced carbon intensity. Research will focus on advanced conventional and kinetically controlled engine technologies with fuels that enable maximum engine performance. Engine and fuels research will increase fuel economy up to an additional 15-20 percent and reduce petroleum consumption by 30 percent compared to the business-as-usual case in 2030.	• The FY 2017 Budget Request increases support for Co-Optimization of Fuels and Engines to investigate the influence of various fuels on engine efficiency and emissions.
	• Initiate up to six competitively awarded projects with universities that will complement research at the National Laboratories for fundamental research to improve combustion efficiency and increase the effectiveness of catalyst to reduce emissions. Research will include modeling of fuel sprays, and other combustion processes, development of kinetic mechanisms for fuels and combustion, and characterization of catalyst for emissions reduction at low temperatures.	• Initiate support for unique fundamental combustion and emission control research at universities that complements National Laboratory capabilities to develop predictive models for high performance computing along with experimental validation.

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
	• Initiate up to three competitively awarded cost-shared projects with industry to support the development of cost-competitive engine and powertrain systems for light-duty passenger vehicles capable of increasing fuel economy by at least 35 percent for gasoline-fueled vehicles and at least 50 percent for diesel-fueled vehicles by 2020 (compared to a 2009 baseline gasoline vehicle) while meeting future emissions standards.	• Initiate up to three new competitively awarded cost-shared R&D projects with industry.

Description

The Materials Technology subprogram supports vehicle lightweighting and improved propulsion (powertrain) efficiency through the discovery, development, and use of materials and enabling technologies for light- and heavy-duty vehicles. The Materials Technology subprogram accomplishes its technical objectives through research programs with academia, National Laboratories, and industry.

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

- By 2022, enable a 30 percent weight reduction for light-duty vehicles including body, chassis, and interior against a 2012 baseline;
- By 2017, validate a 25 percent improvement in component strength relative to components made with 2010 baseline cast Al alloys (A319 or A356) for improved efficiency light-duty engines; and
- By 2018, validate a 25 percent improvement in component strength relative to components made with 2010 baseline A842 (Cast Iron) for improved efficiency heavy-duty engines.

Lightweight Materials Technology ($71.5 million)

The FY 2017 Budget Request supports 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. Address materials and manufacturing challenges spanning from extraction to assembly with an emphasis on establishing tools, capabilities, and material standards for light- and heavy-duty vehicles. These efforts in advanced materials R&D support the Administration's Materials Genome Initiative and Advanced Manufacturing Partnership 2.0. Support of SuperTruck II ($6 million) continues from FY 2016.

Materials Technology supports the Advanced Materials Crosscut ($39.3 million) by supporting planned competitive awards in developing computational tools and techniques to predict optimized polymeric precursors and processing for low-cost carbon fiber designed specifically to meet the mechanical and cost requirements for high-volume automotive applications. The National Laboratories, through a Lightweight Materials Consortia established under the Energy Materials Network (EMN), will provide expertise in carbon fiber characterization and scale-up. Taken together, the outcome of the joint effort with industry and the National Laboratories will be a set of validated computational tools to rapidly design and predict properties and processing for optimized low-cost carbon fiber precursors.

Propulsion Materials Technology ($11.2 million)

This activity supports developing and demonstrating materials for vehicle powertrains with greatly improved properties compared to the state-of-the-art. In FY 2017, the Propulsion Materials activity will support SuperTruck II ($7.2 million) 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. The activity will develop improved integrated Computational Materials Engineering tools to accelerate the development of advanced engine alloys for high efficiency engines.

Materials Technology
Activities and Explanation of Changes

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
Materials Technology $26,959,000	**$82,700,000**	**+$55,741,000**
Lightweight Materials Technology $21,636,000	**$71,500,000**	**+$49,864,000**
• National Laboratory work supports vehicle weight reduction across all vehicle classes through development of precursors and processes for low-cost carbon fiber composites.	National Laboratory support of vehicle weight reduction across all vehicle classes through development of low-cost carbon fiber, targeted cost analysis, crosscutting materials R&D, and expert materials support continues in FY 2017.	• National Laboratory efforts in vehicle weight reduction continue from FY 2016.
• Support up to four 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.	• Continue to support FY 2016 SuperTruck II awards. Support development and demonstration of materials technologies that can contribute to the 100 percent freight efficiency improvement goal for SuperTruck II, co-funded with Vehicle Systems and Advanced Combustion Engine R&D.	• SuperTruck II continues from FY 2016.
• Initiate up to five competitively awarded projects for 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 Advanced Materials Crosscut 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.	• Initiate up to three new competitively selected awards to develop tools to predict optimized polymeric precursor for low-cost carbon fiber designed specifically to meet the mechanical and cost requirements for high volume automotive applications. Advanced Materials Crosscut support will provide characterization and scale-up of the carbon fiber candidates. • Support advanced materials manufacturing R&D at the National Laboratories via the Lightweight Materials Consortium under the EMN, which includes the use of high-performance computing and high-throughput materials experimentation, to capture the effects of processing and end use and dramatically accelerate the development of novel lightweight material systems.	• The FY 2017 Budget Request reflects a shift of focus from Mg Sheet to low-cost carbon fiber. Better predictive tools for carbon fiber precursors will enable accelerated development of precursors for low-cost carbon fiber for vehicle applications. This shift reflects the subprogram's plan to focus significant and sufficient resources to develop tools for different lightweight materials/areas each year while fully funding all awards. The Advanced Materials Crosscut will provide necessary expertise in carbon fiber characterization and scale-up to support competitively selected efforts to achieve these goals.

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
• National Laboratory work will focus on dissimilar material joining and assembly technologies that enable the use of various lightweight materials as best suited for particular applications. • Initiate up to five new competitively awarded projects to address specific challenges in assembly and galvanic corrosion of multi-material joints.	• Initiate up to six new competitively selected awards to support vehicle weight reduction across all vehicle classes through development of light metal alloys and processing technologies. • Initiate up to four new competitively selected awards to support vehicle weight reduction across all vehicle classes through demonstration of multi-material joining techniques and tools.	• New FOA topic area in FY 2017 supports novel technologies and new program participants in light metal alloys and processing. • New FOA topic area in FY 2017 focuses on modeling and simulation of multi-material joints and processes.
Propulsion Materials Technologies $5,323,000	**$11,200,000**	**+$5,877,000**
• Develop materials and manufacturing processes for up to four new competitively awarded SuperTruck II projects, targeting cost-effective freight efficiency improvements via materials enabled powertrain efficiency increases and weight reductions through increased power density. • Conduct National Laboratory research in High Temperature Engine Materials, with a focus to operate in regimes necessary for the commercialization of engines with increased efficiencies.	• Support development and demonstration of materials technologies that can contribute to the 100 percent freight efficiency improvement goal for the SuperTruck II FY 2016 awards, co-funded with Vehicle Systems and Advanced Combustion Engine R&D. • Continue National Laboratory research in High Temperature Engine Materials. • Develop improved Integrated Computational Materials Engineering tools to accelerate the development of advanced engine alloys for high efficiency engines.	• SuperTruck II continues from FY 2016. • High Temperature Engine Material research at the National Laboratories is increased in FY 2017. • Develop improved Integrated Computational Materials Engineering tools to accelerate the development of advanced engine alloys for high efficiency engines.

Vehicle Technologies
Fuel and Lubricant Technologies

Description

Fuel and Lubricant Technologies 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 fuel properties to improve efficiency; and, (3) lubricant technologies that can reduce friction losses in new and legacy vehicles to improve fuel economy.

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; and
- 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 2017, the subprogram will continue to fund fuel properties R&D for the Co-Optimization of Fuels and Engines effort ($10.5 million), in coordination with EERE's Bioenergy Technologies Program and the Vehicle Technologies Advanced Combustion Engine R&D (ACE) subprogram. The ultimate goal of the effort is cost-effective, lower-carbon fuels for high-performance efficient engines. These systems will deliver up to 30 percent lower GHG emissions than conventional engines using conventional fuel on a lifecycle basis. 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. In addition, the subprogram will develop advanced lubricants that are compatible with future and legacy vehicles to reduce friction loss in engines, transmissions, and axles.

The Fuel and Lubricant Technologies subprogram continues to develop technologies that reduce petroleum consumption by displacing it with alternative fuels and by enabling vehicle powertrain efficiency improvements. The two to six percent fuel economy improvement that advanced lubricants can potentially provide should be immediately applicable to the more than 240 million light-duty vehicles and two million heavy-duty vehicles on the road today. Achieving a four percent fuel economy improvement in all light-duty vehicles by 2020 could save about five billion gallons of petroleum per year – the equivalent to taking nearly 10 million light-duty vehicles off the road in 2020. This is a significant addition to the petroleum reductions achieved through new technology adoption. Additional heavy-duty fleet savings could be realized.

Fuel and Lubricant Technologies
Activities and Explanation of Changes

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
Fuel and Lubricant Technologies $22,500,000	**$20,500,000**	**-$2,000,000**
• In collaboration with the Bioenergy Technologies Program and Vehicle Technologies Advanced Combustion Engine R&D subprogram, and building on prior-year activities, support the Co-Optimization of Fuels and Engines effort, with a focus on cost-effective, bio-derived, high-octane fuels for high-performance, efficient engines, as well as fuel quality metrics.	• National Laboratory work on the Co-Optimization of Fuels and Engines effort continues from FY 2016 to co-optimize fuels and engines and remove barriers to higher-efficiency and reduced carbon intensity. Research led by a multi-National Laboratory consortium will focus on advanced conventional and kinetically controlled engine technologies with fuels that enable maximum engine performance.	• The FY 2017 Budget Request reflects continued funding for the Co-Optimization of Fuels and Engines effort.
• Design prototype system of drivetrain lubricants capable of cost-effectively delivering a three percent fuel economy benefit relative to SAE 10W-20 engine oil in vehicle testing.	• National Laboratory work in advanced lubrication continues to develop methodologies to improve correlations between benchtop testing and in-use lubricant performance.	• Advanced lubrication systems work at the National Laboratories continues in FY 2017.
• Conduct RD&D supporting direct injection engines using propane or liquefied petroleum gas.		• RD&D of direct injection engines using propane or liquefied petroleum gas is not supported in the FY 2017 Budget Request.

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 following activities:

- Vehicle Technologies Deployment: 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. 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.
- Advanced Vehicle Competitions: Provides unique hands-on training to university student engineers — helping to address the need for more highly skilled engineers in advanced vehicle technologies to overcome barriers in the marketplace.
- Legislative and Rulemaking: 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.
- Analysis: Supports the planning, execution, and communication of technology, societal, economic, and interdisciplinary analyses to inform overall Vehicle Technologies program's portfolio planning as well as key technology investment decisions.

Outreach, Deployment, and Analysis
Activities and Explanation of Changes

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
Outreach, Deployment, and Analysis $48,400,000	**$31,500,000**	**-$16,900,000**
Vehicle Technologies Deployment $34,000,000	**$23,000,000**	**-$11,000,000**
• Document petroleum reduction impact of Clean Cities' activities of at least 1.15 billion gallons per year. • Expand technical and problem solving assistance to key stakeholders to help in overcoming specific market and technical barriers. • Plan, execute, and communicate technology, societal, economic, and interdisciplinary analyses to inform program planning and technology investment decisions. • 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 two projects will be awarded with Federal funding leveraged by a minimum 50 percent cost share from private sector partners.	• National Laboratory funding continues to support technical and problem solving assistance to key stakeholders in overcoming specific market and technical barriers. • Competitively award electric drive, alternative fuel, and advanced vehicle deployment projects to remove market barriers, facilitate infrastructure development, and accelerate market transformation and commercialization efforts.	• Eliminate funding for Alternative Fuel Vehicle Community Partner Projects. • Reduced funding for National Laboratory technical and problem solving assistance.
Advanced Vehicle Competitions $2,500,000	**$2,500,000**	**$0**
• Year two of a four-year collegiate engineering competition, EcoCAR 3. In year two, teams integrate their powertrains into vehicles, which must pass a comprehensive safety and technical inspection, and perform an on-road safety evaluation, which tests a baseline level of functionality from all powertrain components.	• Year three of a four-year collegiate engineering competition, EcoCAR 3. In year three, the competition vehicles will be evaluated to full-vehicle functionality in all states and modes, and vehicles are tested rigorously in a variety of dynamic events that test vehicle performance, ride and handling, drive quality, and emissions and energy consumption.	• Advanced Vehicle Competitions will continue the four-year collegiate engineering competition (2014-2018), 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.

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
Legislative and Rulemaking $1,500,000	**$1,500,000**	**+$0**
• Review and process petitions to designate new alternative fuels under EPAct 2005. Implement legislative changes to the EPAct 2005 fleet activities, as needed.	• National Laboratory work continues to review and process petitions to designate new alternative fuels under EPAct 2005 and to implement changes to the EPAct 2005 fleet activities, as needed.	• Legislative and Rulemaking activities continue in FY 2017.
Analysis $10,400,000	**$4,500,000**	**-$5,900,000**
• 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. FY 2016 Analysis activities also support foundational exploratory and prioritization analyses for Transportation as a System (TAS).	• National Laboratory work, in cooperation with university partners, continues to support the planning, execution, and communication of technology, societal, economic, and interdisciplinary analyses to inform program planning and technology investment decisions.	• The FY 2017 Budget Request reflects a funding decrease as Transportation as a System moves from Analysis to Vehicle Systems, which is consistent with program evolution from foundational exploratory and prioritization analyses to applied vehicle systems modeling and simulation.

Vehicle Technologies
NREL Site-Wide Facility Support

Description

In FY 2017, EERE will continue to directly fund National Renewable Energy Laboratory (NREL) Site-Wide Facility Support costs rather than fund those costs as laboratory overhead.

EERE proposes to eliminate the NREL Site-Wide Facility Support subprograms in its individual technology programs, and consolidate NREL Site-Wide Facility Support funding in the Facilities and Infrastructure program. Locating this funding in the Facilities and Infrastructure Program will provide clarity and transparency in communicating EERE's stewardship for NREL, and will simplify planning and execution of EERE's annual budget. This consolidation into a single program allows for better integration and coordination of operations and investments.

NREL Site-Wide Facility Support
Activities and Explanation of Changes

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
NREL Site-Wide Facility Support $3,300,000	**$0**	**-$3,300,0000**
• 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 funding requested within the Vehicle Technologies Budget Request.	• Requested reduction is offset by a corresponding increase in the Facilities and Infrastructure Budget Request. Funding is consolidated in EERE's NREL Site-Wide Facility Support.

Vehicle Technologies
Performance Measure

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 2015	FY 2016	FY 2017
Performance Goal (Measure)	**Batteries -** Reduce the modeled cost of energy storage for Electric Vehicles (EVs). ($/kWh) 2014: Measure for modeled production cost of a high power battery for a Plug-In Electric Vehicle.		
Target	275	250	225
Result	Met - 269	N/A	N/A
Endpoint Target	$125/kWh by 2022		

Bioenergy Technologies

Overview

The Bioenergy Technologies Program focuses on accelerating the development and commercialization of cost-competitive technologies to convert the Nation's abundant domestic, renewable biomass resources into advanced biofuels and bio-based products. DOE is investing in cutting-edge technologies designed to produce "drop-in" biofuels, including renewable gasoline, diesel, and jet fuels, from non-food sources of biomass,[1] such as wastes and agricultural residues, energy crops like switchgrass, and algae. The program is also focused on converting biomass into high-value chemicals and products historically derived from petroleum that can simultaneously enhance the economics of biofuel production.

Displacing petroleum-based fuels and products with alternatives derived from domestically produced renewable biomass offers a tremendous opportunity to reduce American dependence on petroleum, lower greenhouse gas emissions (GHG) from the transportation sector, and create new economic opportunities throughout the U.S. By statute, "Advanced Biofuels" must reduce GHG emissions by at least 50 percent compared to petroleum fuels. Recent DOE studies confirmed that by 2030, the U.S. has the resource potential to sustainably produce 1 billion dry tons of non-food biomass resources without disrupting agricultural markets for food and animal feed.[2] This could produce approximately 50 billion gallons of biofuels, displacing a quarter of petroleum-derived transportation fuels, while also producing high-value chemicals and products, and generating over 100 billion KWh of electricity.[3]

Highlights of the FY 2017 Budget Request

- The Conversion Technologies subprogram will support development of a Synthetic Biology Foundry[4], which will leverage the tools of synthetic biology (ways of redesigning biological processes and systems) to enable the biotechnology industry to achieve substantial improvements in conversion efficiencies and the scale-up of biological processes with lower development costs and lead-times. These new technical innovations will be easily transferrable to industrial applications and significantly enhance industry efforts to commercialize advanced bioenergy technologies.
- The Conversion Technologies subprogram will bring together National Laboratory and industry partners, in support of the Administration's Materials Genome Initiative (MGI) and Advanced Manufacturing Partnership 2.0, to use high throughput screening of catalysts, advanced computational tools, and characterization approaches to accelerate discovery and development of new types of catalysts for conversion processes and reduce costs in ways that will be necessary to produce price competitive biofuels for America. This effort will be supported through the establishment of a National Lab-led consortia focused on development of advanced catalysts under the Energy Materials Network (EMN); and competitive funding opportunities for universities, private-sector partners and others to work collaboratively with the National Lab-led consortia to address specific challenges to catalyst development.
- The Feedstock Supply and Logistics subprogram will support an Advanced Feedstock Supply Systems funding opportunity announcement (FOA) to develop preprocessing technologies to reduce feedstock costs and variability. The FOA will reduce the cost for processing and transporting feedstocks to the biorefinery, which will be an essential part of creating a national bioeconomy.
- The Demonstration and Market Transformation subprogram will support Phase II of the drop-in hydrocarbon fuel integrated biorefinery (IBR) program initiated in FY 2016, down-selecting one demonstration-scale and one pilot-scale projects. The program's investment in pilot- and demonstration- scale biorefineries will be critical to reducing technical

[1] As recommended in the Quadrennial Energy Review: Energy Transmission, Storage, and Distribution Infrastructure, April 2015.

[2] U.S. Billion Ton Update http://www1.eere.energy.gov/bioenergy/pdfs/billion_ton_update.pdf .

[3] Biomass R&D Board. Billion Ton Bioeconomy Analysis. Unpublished Report, Interagency Analysis Working Group. (In Review).

[4] The term "foundry" is used to emphasize that a standardized set of tools, parts, and chassis organisms (e.g. analogous to a set of production molds) can be combined with a set of interchangeable genomic parts to churn out, at very high-throughput, a large variety of different fuel and chemical products. Reusing the base set of chassis for each new product minimizes the amount of the process that needs to be designed from scratch. The term "foundry" as used here has a distinctly different meaning than a purpose-built facility such as a steel foundry.

and investor risks for the construction of first-of-a-kind commercial facilities needed to meet national goals on bioenergy.

To realize these benefits, the program is engaged in public-private partnerships to invest in the research and development (R&D) of new technologies that reduce costs along each step of the bioenergy supply chain. Feedstock logistics projects will enable the use of a broad variety of feedstocks in many different geographic regions and research efforts targeting multiple conversion pathways and end products will lower conversion costs and enable the development of the most viable and cost-effective routes to the commercial sector. Larger pilot- and demonstration-scale integrated biorefinery projects are cost-shared with industry to help de-risk first-of-a-kind technologies and prove out integrated processes at scale. Once successfully demonstrated, private capital markets are expected to replicate these facilities at commercial scale and expand production throughout the U.S. The program will use about 51 percent of its FY 2017 appropriations to support critical R&D priorities at eight DOE National Laboratories. In addition, the Bioenergy Technologies Program creates competitive funding opportunities to engage universities, the private sector, and other entities to focus research efforts on key technical barriers, which if successfully overcome, would have broad-reaching benefits for the industry. Sustainability is a core focus of programmatic efforts. At every step, DOE is working to ensure that the commercial application of these technologies yield the promised environmental and social benefits of reduced GHG emissions, neutral impacts on agricultural markets for food/feed, and the sustainable use of land and water resources.

Bioenergy is an important component of the President's clean energy strategy and a key technology for realizing the Administration's energy security and climate goals to reduce oil imports by 50 percent by 2020 (from a 2008 baseline) and cut GHG emissions by at least 26-28 percent by 2025 below the 2005 baseline and dramatically below these levels by mid-century. Significant public-sector investment is also necessary to achieve the targets established by Congress under the Renewable Fuel Standard (RFS), as defined by the bipartisan Energy Independence and Security Act of 2007.

Bioenergy R&D activities across all of government are coordinated through the Biomass Research and Development Board (BRD), which allows DOE to leverage the resources of the U.S. Department of Agriculture, the U.S. Environmental Protection Agency, and many other agencies, in a collaborative effort to fully develop the bioeconomy and to ensure all efforts are synergistic and non-overlapping.[1]

As part of the DOE Energy-Water Nexus (EWN) Initiative ($4 million), the program will support a variety of activities that will help improve water quality and use. The conversion subprogram's waste-to-energy research will help to improve water quality by exploring ways to use wastewater in the production of bioproducts and biofuels. Critical National Laboratory research with the Strategic Analysis and Cross-Cutting Sustainability subprogram will focus on addressing and improving water quality and quantity issues associated with bioenergy. The Strategic Analysis and Cross-Cutting Sustainability subprogram will also support the development of tools, such as Argonne National Laboratory's publically available Water Analysis Tool for Energy Resources (WATER), which evaluates the use and quality of water in the production of biofuels and will ultimately help improve efforts to use water more efficiently.

FY 2017 Crosscuts ($K)

	EWN	**Total**
Bioenergy Technologies	4,000	**4,000**

[1] "Bioeconomy" is defined as "the industrial transition to sustainably utilizing renewable aquatic and terrestrial biomass resources for production of energy, intermediate, and final products with economic, environmental, social, and national security benefits," by the Operations Committee of the Biomass Research and Development Board.

Bioenergy Technologies
Funding ($K)

	FY 2015 Enacted	FY 2015 Current[1]	FY 2016 Enacted	FY 2017 Request	FY 2017 vs FY 2016
Bioenergy Technologies					
Feedstocks	32,000	31,109	46,500	0	-46,500
Feedstocks Supply and Logistics*	0	0	0	22,000	+22,000
Advanced Algal Systems**	0	0	0	30,000	+30,000
Conversion Technologies	95,800	92,903	85,500	140,900	+55,400
Demonstration and Market Transformation	79,700	34,700	75,100	75,000	-100
Strategic Analysis and Cross-Cutting Sustainability	11,000	10,703	11,000	11,000	0
NREL Site-Wide Facility Support	6,500	6,500	6,900	0	-6,900
Total, Bioenergy Technologies	**225,000**	**175,915**	**225,000**	**278,900**	**+53,900**

*In prior years, the Feedstock Supply and Logistics subprogram included the Algae and Advanced Feedstock activity. The FY 2016 Enacted Budget for just the Feedstock Supply and Logistics subprogram was $16.5 million. This is therefore an increase of $5.5 million in a comparable budget structure.

**In prior years, the Advanced Algal - Systems subprogram was the Algae and Advanced Feedstock activity within the Feedstock Supply and Logistics subprogram. The FY 2016 Enacted Budget for just the Algae and Advanced Feedstock subprogram was $30 million, resulting in no change in a comparable structure.

SBIR/STTR:

- FY 2015 Transferred: SBIR $3,590,000; STTR $495,000
- FY 2016 Projected: SBIR $3,761,000; STTR $564,000
- FY 2017 Request: SBIR $4,132,000; STTR $581,000

[1] Funding reflects the transfer to DPA Title III and SBIR/STTR to the Office of Science.

Budget Crosswalk ($K)

FY 2016 Budget Structure	Proposed FY 2017 Budget Structure					
	Feedstock Supply and Logistics	Advanced Algal Systems	Conversion Technologies	Demonstration and Market Transformation	Strategic Analysis and Cross-cutting Sustainability	Total
Bioenergy Technologies						
Feedstocks	22,000	30,000	-	-	-	**52,000**
Conversion Technologies	-	-	140,900	-	-	**140,900**
Demonstration and Market Transformation	-	-	-	75,000	-	**75,000**
Strategic Analysis and Cross-cutting Sustainability	-	-	-	-	11,000	**11,000**
NREL Site Wide Facility Support (Moved to F&I)	-	-	-	-	-	**-**
Total, Bioenergy Technologies	**22,000**	**30,000**	**140,900**	**75,000**	**11,000**	**278,900**

Bioenergy Technologies
Explanation of Major Changes ($K)

	FY 2017 vs FY 2016 Enacted
Bioenergy Technologies	
Feedstocks: To better align with program management, Algae and Advanced Feedstocks are reflected as their own distinct subprograms (both are former activities under the Feedstocks subprogram), which results in this subprogram reflecting a reduction in funding compared to prior-year requests.	**-46,500**
Feedstocks Supply and Logistics: The major change in the Budget reflects an increase of $5.5 million to include the release of the Advanced Feedstock Supply Systems FOA.	**+22,000**
Advanced Algal Systems: The increase in funding appears because in prior year requests, this subprogram was an activity within the Feedstock Supply and Logistics subprogram. The change will clarify the budget and objectives of the algal biofuel R&D activities in the Bioenergy Technologies Program. In a comparable budget structure, $21 million was requested for this activity in FY 2016.	**+30,000**
Conversion Technologies: The increased funding in the subprogram budget reflects an increased investment of $35 million for the Synthetic Biology Foundry, which will remove barriers to rapid and cost-effective development and scale-up of novel organisms for the production of biofuels and chemicals. Funding will also support the continuation of core R&D conversion activities, as well as alternate selections from the FY 2016 MEGABIO FOA, and increased funding for activities for advanced materials R&D to develop new types of catalysts for conversion in support of the Administration's Materials Genome Initiative (MGI) and Advanced Manufacturing Partnership 2.0.	**+55,400**
Demonstration and Market Transformation: The decrease in funding to Demonstration and Market Transformation reflects the completion of DOE's contribution to the interagency Defense Production Act (DPA) initiative being offset by an increase to the Integrated Biorefinery FOA. Subprogram funding from FY 2017 will be used to down select (from the initial FY 2016 IBR FOA) one pilot-scale and one demonstration-scale biofuel manufacturing facilities to enter into Phase 2 for construction and operation.	**-100**
Strategic Analysis and Cross-Cutting Sustainability: No changes to this subprogram.	**0**
NREL Site-Wide Facility Support: In FY 2017, EERE proposes to move funding for the NREL Site-Wide Facility Support subprogram from individual technology programs to the Facilities and Infrastructure Program.	**-6,900**
Total, Bioenergy Technologies	**+53,900**

Bioenergy Technologies
Feedstock Supply and Logistics

Description

The primary goal of the Feedstock Supply and Logistics subprogram is to develop strategies, technologies, and systems that can provide consistent-quality feedstock to the biorefinery at a total average cost of $80/dry ton by FY 2017[1] (from $130/dry ton in FY 2014 in 2011 dollars). Past accomplishments for this program include publishing the 2016 *U.S. Billion-Ton Update*,[2] disseminating yield data for energy crops from the Regional Feedstock Partnership, [3] and reducing logistics costs through high-tonnage feedstock logistics projects, the results of which are publicly available on the Bioenergy Knowledge Discovery Framework.[4] In FY 2016, the program initiated two new projects from the Advanced Logistics II FOA to build upon the success of the 2009 FOA by lowering the delivered cost of short rotation woody crops and to study how blending feedstocks at industrial scale could play a role in increasing the amount of available feedstock within a given delivery radius.

Partners at DOE National Laboratories have continued to make substantial progress toward the subprogram's cost targets. Researchers at Idaho National Laboratory (INL) have achieved $10/dry ton modeled cost reduction in feedstock preprocessing costs through improvements in size reduction, densification, and drying, thus putting the subprogram on the trajectory of meeting the 2017 goal of $80/dry ton. INL's Biomass Feedstock National User Facility (BFNUF) continues to be the premier facility in the U.S. for scientific and technical investigation of biomass feedstock processing for energy applications. 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 ways to deliver high-quality, easily convertible biomass to the biorefinery and address technical and logistical risks for the national supply chain. The BFNUF will continue to receive base funding support in FY 2017, as it continues work in the scale-up and integration of preprocessing systems, and positions partner companies to validate design concepts that are being built into modern biorefineries. The INL Resources Library will also expand its available feedstock information and publicly share results in alignment with the Presidential Open Data Initiative.

The Advanced Feedstock Supply Systems FOA (up to $10 million) will be a key subprogram activity in FY 2017. This FOA will be designed to begin to verify cost and quality improvement of preprocessing technologies and to begin integration of preprocessing unit operations.[5] Without more advanced supply systems, only a fraction of the potential 1 billion tons of available feedstock is expected to meet the $80/dry ton target under conventional systems. Substantial efficiencies are gained by moving preprocessing activities into distributed depot facilities that are located closer to the site of biomass production and necessary for scaling of available feedstocks. In FY 2017, the program will incorporate feedstock trial results obtained from the Sustainable Landscape Design FOA project into core resource assessment efforts and use them to evaluate progress. In FY 2017, the subprogram will also continue its increased focus on the blending of sorted, dried municipal solid waste with other feedstocks as it seeks to identify high-volume, low-cost sources of biomass while increasing the diversity and reducing the supply risk for national bioenergy feedstocks.

[1] Validated in 2017. Demonstrated with 285 million dry tons in 2022 at multiple biorefineries.
[2] http://www1.eere.energy.gov/bioenergy/pdfs/billion_ton_update.pdf; http://energy.gov/eere/bioenergy/downloads/webinar-changing-market-biofuels-and-bioproducts.
[3] Nationwide Crop Suitability Modeling of Biomass Feedstocks. Michael Halbleib, Chris Daly, David Hannaway. 2012 Sun Grant National Conference. http://sungrant.tennessee.edu/NR/rdonlyres/8CF2F183-8B72-4E48-9E2F-BCAB4E421C7A/3630/46Halbleib_Mike.pdf
[4] http://www.bioenergykdf.net.
[5] Scale (≥ 1 ton/day throughput; time on stream greater than 200 hours). These projects may leverage or borrow existing equipment, may run in "batch" rather than fully integrated continuous mode, and process steps might be spatially and temporally separated between various institutional facilities.

Feedstocks Supply and Logistics (formerly Feedstocks)
Activities and Explanation of Changes

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
Feedstocks $46,500,000	**$0**	**-$46,500,000**
Feedstocks Supply and Logistics $0	**$22,000,000**	**+$22,000,000**
• Update to the *U.S. Billion Ton Study* (last published in FY 2011). A 5-year resource analysis effort in collaboration with the Regional Feedstock Partnership will be used to update yield projections. • 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.	• Continue R&D: Labs will continue work on feedstock supply characterization, resource assessment, logistics and handling tasks. • A new priority area for FY 2017 will be the start of the Advanced Feedstock Supply Systems FOA. Funds will be used to support one to two projects that will aim to verify preprocessing technologies at scale and begin integration towards a distributed (not vertically integrated) model.	• The reduction in funding appears because in prior requests, this subprogram included the Algae and Advanced Feedstocks activity that is now being requested as a separate subprogram in FY 2017. The FY 2016 Enacted Budget for just the Feedstock Supply and Logistics subprogram was $16.5 million. Therefore, in a comparable budget structure, the FY 2017 request represents a net increase of $5.5 million over the FY 2016 Enacted level for Feedstock Supply and Logistics activities. • The net increase in funding for the Feedstock Supply and Logistics subprogram will support the Advanced Feedstock Supply Systems FOA.

Bioenergy Technologies
Advanced Algal Systems

Description

The Advanced Algal Systems subprogram funds R&D of algal biomass[1] production and logistics systems for cost-competitive, advanced biofuels. The broadly recognized advantages of algal biomass include its ability to grow quickly, use waste resources, and produce fuel precursors. Algal biofuels could potentially contribute up to 5 billion gallons per year — about 25 percent of the current jet fuel market — to the U.S. domestic production of liquid transportation fuels by 2030.[2] In recent years, the subprogram has achieved technological advancements that can 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 high-throughputs; and the ability to extract and convert more algal biomass components into fuels.[3]

In FY 2016, the Advanced Algal Systems subprogram issued a FOA focused on improving biomass productivity, yield, and other logistical considerations. In FY 2017, the subprogram plans to select up to three additional projects from this FOA. Additional projects will provide a diversity of technology approaches to achieve programmatic goals. In FY 2017, as directed by the period of performance in the 2012 Advancements in Sustainable Algal Production Funding Opportunity Announcement (DE-FOA00000615) and because all original funds will be expended, the subprogram expects to conclude longstanding awards for the Algae Testbed Public-Private Partnership (located in Arizona, Hawaii, California, Georgia, and Florida) and the Regional Algal Feedstock Testbeds (located in Arizona, Texas, New Mexico, and Washington). These testbeds are validating algal strain improvements and cultivation technologies and are providing stakeholders from universities, industry, and National Laboratories with an outdoor environment to test innovative algal biofuel technologies. Without these testbeds, many researchers would not have had access to appropriate testing facilities, and would not have been able to compete for future funding opportunities. These projects (awarded in FY 2012, $23 million total) have made significant contributions to understanding the performance of outdoor algae cultivation, helped create a new workforce of algae experts, and set a solid foundation for further innovation. The subprogram is working with the Algae Testbed Public-Private Partnership on their plans to continue the utilization of their facilities as testbeds for the industry after the project's period of performance officially ends. DOE's role in this development and maintenance is being considered.

In addition, in FY 2017, the subprogram will continue to invest in critical National Laboratory capabilities that align with specific algal biofuel R&D barriers, as well as the development and validation of models for techno-economics, life-cycle GHG emissions, advanced engineering practices, and new research into innovative cultivation strategies. A major focus for the National Laboratories in FY 2017 will be meeting BETO's Multi-Year Program Plan[4] milestone of modeling a 2022 sustainable supply of 1 million metric tons of algal biomass (translating to 150 million gallons gasoline equivalent per year at $4.35 per gallon) leveraging current relevant R&D project data. The annual state-of-technology reports issued by the National Renewable Energy Laboratory and the Pacific Northwest National Laboratory will capture continued innovations.

[1] The term algae refers to microalgae, cyanobacteria (often referred to as "blue-green algae"), and macroalgae (or seaweed).

[2] Ryan Davis, Daniel Fishman, Edward Frank, et al., "Renewable Diesel from Algal Lipids: An Integrated Baseline for Cost, Emissions, and Resource Potential from a Harmonized Model," Argonne National Laboratory, ANL/ESDA/12-4 (2012), http://greet.es.anl.gov/publication-algae-harmonization-2012.

[3] Algal innovations across the supply chain cited here can be found in the 2015 BETO Peer Review presentations, at http://www.energy.gov/eere/bioenergy/downloads/2015-peer-review-presentations-algal-feedstocks.

[4] Bioenergy Technologies Program Multi-year Program Plan, March 2015. http://energy.gov/sites/prod/files/2015/04/f22/mypp_beto_march2015.pdf.

Advanced Algal Systems
Activities and Explanation of Changes

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
Advanced Algal Systems $0	**$30,000,000**	**+$30,000,000**
• The Advanced Algal Systems subprogram will fund competitive R&D project work to achieve programmatic targets for productivity and yield (up to 3 projects focused on pre-pilot integration of production and pre-processing). • Targeted R&D along the algal biofuels supply and logistics chain will continue through the National Laboratories.	• The Advanced Algal Systems subprogram will select additional projects from the FY 2016 Advancements in Algal Biomass Yield Phase 2 FOA to achieve programmatic targets for productivity and yield at a minimum scale needed to verify progress. • Targeted R&D along the algal biofuels supply and logistics chain will continue through the National Laboratories. • Funding will be used to address the high level of stakeholder interest in developing earlier TRL research to work on enabling tools for systems biology, genetic engineering, and organism development.	• The increase in funding appears because in prior requests, this subprogram was an activity within the Feedstock Supply and Logistics subprogram. In a comparable budget structure, $30 million was enacted for this activity in FY 2016 — representing no net change in the funding level for advanced algal activities.

Bioenergy Technologies
Conversion Technologies

Description

The Conversion Technologies subprogram develops technologies for converting biomass feedstocks into commercially viable liquid transportation fuels and related bioproducts that enable biofuels. Conversion R&D includes both biological (using biological organisms) and thermochemical (using heat and chemical processes) routes to convert biomass into "drop-in" hydrocarbon fuels, and fuel components, called "intermediates," such as sugars, bio-oils, and gases. The diversity of biomass resources across the Nation necessitates the development of multiple conversion technologies that can efficiently use a broad range of feedstock material. In addition, different conversion routes have the potential to produce different types of products, such as renewable gasoline, diesel, jet fuel, and a variety of chemicals and biobased products. Because each of these pathways are at different levels of technical maturity, the subprogram focuses its R&D on multiple candidate technologies that can potentially meet the cost goal of $3 per gallon of gasoline equivalent (GGE) by reducing technical risk along a pipeline of innovative technologies. In FY 2017, core R&D will continue to focus on the development of catalysts (a substance that increases the rate of a chemical reaction) and biological organisms needed to convert intermediates into hydrocarbon fuels and related bioproducts. Significant experimental activities on two conversion pathways will develop data that analysis and modeling efforts will use to verify the potential to meet performance goals of $3/GGE.

The development of a Synthetic Biology Foundry, a key subprogram activity in 2017, will leverage recently developed synthetic biology tools (ways of redesigning biological processes and systems) to improve efficiencies in the conversion of biomass to fuels and related products that enable biofuels. Currently, the industrial biotechnology sector scales up processes on a case-by-case basis, without tools that can be extrapolated to multiple host organisms, pathways, and applications. The Synthetic Biology Foundry will connect distributed capabilities across multiple National Laboratories and other partners with biofuel and biochemical manufacturers to develop processes for predictable scale-up, improved systems capability, and standards, by establishing a robust biomanufacturing set of principles, which would use standardized DNA elements and commercially relevant and optimized host organisms. These tools would dramatically reduce design, construction, lead-time, and cost for developing biological systems. The Foundry will produce a set of tools and organism development packages that would be easily transferred to the biotechnology industry, enabling the scaling of multiple, high-impact chemicals in multiple industrially-relevant host organisms. The Foundry will function as a multi-lab effort leveraging both existing and newly acquired world-class resources within the national laboratories while working with external stakeholders through competitive grant awards, cooperative agreements, and work for others, enabling partners to leverage the effort's synthetic biology tools and expertise, ultimately expediting industrial adoption of the technology.

R&D focused on co-production of biofuels and related bioproducts that enable biofuels will continue to be a focus for FY 2017. High-value chemicals and bioproducts, which would otherwise be made from petroleum, can significantly improve the economics of biofuel production and reduce risks associated with investments in pioneer-scale biorefineries. Projects selected under the Multi-Products for Enabling Generalized Approaches to the Bioeconomy (MEGA-BIO) FOA in FY 2016 will enable integrated development of deconstruction, separation, and upgrading technologies (separate steps in the conversion process) for both petrochemical and fuel replacements. The subprogram expects to make additional selections from the FY 2016 MEGA-BIO in FY 2017. This will be a collaborative effort requiring diverse expertise and likely partnerships between National Laboratories, academia, and industry.

In FY 2017, the subprogram will integrate existing and new capabilities to create a National Lab led catalysis consortium under the Energy Materials Network (EMN) model in support of the Administration's Materials Genome Initiative (MGI) and Advanced Manufacturing Partnership 2.0. This network will focus on improving catalyst materials by using high-throughput screening capabilities, computational modeling, and cutting-edge characterization tools developed by the Office of Science. This network will advance research objectives with the goal of creating techniques that will enable rapid identification (>100x more efficient catalyst screening) of new robust catalytic materials. The network will invest in establishing and expanding unique expertise and capabilities within the Catalysis consortium, as well as issue competitive funding opportunities for universities, private-sector partners and others to collaborate on advanced materials R&D activities with the consortium on specific challenges and opportunities related to the development of advanced catalysts. More advanced catalysts will increase conversion efficiencies, make more robust catalysts, and ultimately make biofuels more cost competitive.

In FY 2017, critical conversion research activities will continue in a variety of other areas. The subprogram will continue to overcome the remaining R&D hurdles for the integration of bio-oils and other intermediates into existing petroleum refineries and petrochemical plants. This effort should enable biofuels to leverage the existing petroleum infrastructure by inserting biofuel intermediate directly into existing refineries, rather than creating separate production and distribution channels for biofuels. Remaining activities will include sub-refinery-scale testing, improved stabilization processes, and the finalization of broadly applicable and accepted analysis and characterization methods.

Critical R&D will also continue supporting research for the conversion of lignin to fuels and products. Lignin makes up almost a third of biomass by mass but due to its chemical complexity, it is generally burned for heat and power rather than being converted into a valuable fuel or coproducts. R&D on producing higher-value products or "valorizing" (creating value from) lignin is essential to improve the economics of fuel production. Other subprogram research activities will include continued development of technologies that accelerate the economic and innovative conversion of wet waste feedstocks, including biosolids, to biofuels and bioproducts. In FY 2016, the subprogram built off a waste-to-energy workshop series from FY 2015 to produce a waste-to-energy roadmap, which will inform R&D directions in FY 2017.

R&D in a number of enabling technology areas will also continue in FY 2017, including advanced modeling in support of reaction design, systems biology, design, and discovery of novel catalyst systems, and advanced separation concepts.

Conversion Technologies
Activities and Explanation of Changes

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
Conversion Technologies $85,500,000	**$140,900,000**	**+$55,400,000**
• Finalize facility modification for conversion pathways validation in FY 2017. Possible modifications are for pyrolysis and upgrading, biological upgrading or indirect liquefaction. • Continue to advance the integration of bio-oils into petroleum refineries (a conversion topic in the FY 2015 Demonstration and Market Transformation FOA that builds on the FY 2013 BOSC FOA), clean sugar production, and other issues identified in FY 2014 workshops. • 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). • 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. • Initiate R&D in a diverse set of pathways (MEGA-BIO FOA) that produce renewable chemicals derived from biomass that enable more competitive biofuels and support the DOE Clean Energy Manufacturing Initiative.	• Support new Synthetic Biology R&D effort. This effort was seeded in FY 2016 and, with industry partners, will develop and apply synthetic biology tools to biological organism engineering, scale-up, and process development with the goal of reducing cost and time to market. • The advanced materials R&D activities will integrate existing and new capabilities at the National Laboratories with industry partners under the Energy Materials Network (EMN) for development of next generation chemical catalysts and enzymes. The efforts are expected to accelerate the rate of catalyst discovery as well as explore the ability to proactively design for a specific target fuel or intermediate molecule via chemical catalytic or enzymatic routes. • Select an additional project(s) from the FY 2016 MEGA-BIO FOA to develop additional co-product strategies and technologies for converting biomass to fuels and chemicals. • Continue R&D for technologies that allow for the conversion of wet waste and other biomass feedstocks to biofuels and renewable chemicals.	• Increased funding for this subprogram will be used primarily to connect capabilities across various National Laboratories with biofuel manufacturers in order to more quickly and cost effectively bring new technologies to market. • Additional funding will also be used to make alternate selections from the FY 2016 MEGA-BIO FOA. • Increase funding for advanced materials R&D activities in the area of next generation catalysts and enzymes in support of the Administration's Materials Genome Initiative (MGI) and Advanced Manufacturing Partnership 2.0.

Bioenergy Technologies
Demonstration and Market Transformation

Description

The Demonstration and Market Transformation (DMT) subprogram drives commercial integration of many of the other technologies in the program portfolio. The subprogram supports the commercial production of advanced biofuels and bioproducts by reducing technology and investor risks through the validation of Integrated Biorefinery (IBR) designs and processes at the pilot, demonstration, and pioneer scales. Validating these technologies at smaller scales is essential for building and sustaining private sector investments in the bioenergy industry. Once performance has been validated at the demonstration scale, companies will be more likely to secure project finance mechanisms, such as equity investment or traditional debt financing, to support replication and expansion of their facilities.

Each scale in the development of IBR projects have its own distinct role, defined as follows:

- Pilot-scale facilities verify the integrated technical performance of the given suite of technologies and provide the initial detailed financial data to scale the facility.
- Demonstration-scale facilities validate the performance of technology at larger scales and provide the process and equipment specifications required to design a pioneer or "first-of-a-kind" commercial-scale facility.
- Pioneer-scale biorefineries prove integrated technical operation and economical production at commercial volumes on a continuous basis.

In FY 2015, the program managed a portfolio of 28 projects, including 3 at pioneer scale, 6 at demonstration scale, 12 at pilot scale, and 4 additional projects selected under the Innovative Pilot FOA. The subprogram also co-managed 3 additional pioneer-scale projects, as part of the interagency Defense Production Act (DPA) initiative. The portfolio included projects focused on 13 biochemical pathways, 10 thermochemical pathways, and 5 algal pathways, with 13 projects intending to produce cellulosic ethanol, 14 focused on renewable hydrocarbons, and 1 focused on renewable chemicals. However, the American Recovery and Reinvestment Act (ARRA) funded the majority of these projects, and most concluded by the end of FY 2015. With only one IBR FOA since 2009, only eight projects were still active in FY 2016: 2 at the pioneer scale producing cellulosic ethanol at commercial quantities, 3 DPA projects producing renewable diesel and jet fuel, and 3 small pilot-scale projects producing renewable hydrocarbons. Several of the projects that concluded in FY 2015 have the potential to advance to the next scale to demonstration- or pioneer-scale facilities, and numerous technologies funded at the R&D scale are ready to move to piloting.

To address this concern, in FY 2016, the DMT subprogram issued a new IBR FOA with the goal of enabling future pioneer-scale biorefineries through new pilots and demonstration projects. The FY 2016 FOA sought participation from successful projects with previous awards from the Bioenergy Technologies Program, projects that could leverage other previous capital investments, and other qualified applicants not previously included in the Bioenergy Technologies Program portfolio. The program structured the FOA into two phases: 1) a design and due diligence phase followed by 2) a construction and operation phase. The Bioenergy Technologies Program will review and validate projects following the design phase based on technical, financial, and other success factors, and down-select projects that will advance to the construction and operation phase. The program will fund Phase 1 of the first FOA prior to FY 2017. The Bioenergy Technologies Program plans to use FY 2017 funds to enable the construction and operation of one demonstration-scale facility and one pilot-scale facility, ultimately expected to lead to at least one successful pioneer-scale biorefinery facility (financed and constructed without financial assistance from the Bioenergy Technology Program).

The DMT subprogram must successfully address numerous barriers to bring emerging technologies to the commercial market and expand the production of advanced biofuels and bioproducts. These barriers include developing secure, sustainable, and cost-effective feedstock supply chains at commercial quantities, ensuring efficient operation of integrated end-to-end systems, reducing capital and operating costs, testing product qualifications, increasing reliability of operations and on-stream performance, enabling off-take agreements, securing investments, and encouraging commercial financing. Financial barriers are the most challenging hurdle for technology deployment. To ensure the best possible use of public funds, the subprogram uses well-defined stage gates and annual comprehensive project reviews to actively manage all of its projects. If projects fail to meet specific technological and financial criteria to advance to the next phase of development, the program will stop funding those projects. This review process ensures active control of projects within the portfolio and

has led to a number of project terminations that mitigate against large losses in public funding. Finally, the DMT subprogram has executed a Lessons Learned/Best Practices campaign to inform and educate financial stakeholders on the role of public-private partnerships in achieving measurable reduction in technological and financial risks, thus facilitating increased participation from the private sector in developing profitable commercial-scale biorefinery projects.[1]

Another key initiative in FY 2017 will be continued collaborations with the Vehicle Technologies Program to support the Fuels and Vehicle Systems Co-Optimization of Fuels and Engines project ($15 million), which was established in FY 2016. The Co-Optimization of Fuels and Engines project will develop new fuels and engines that are co-optimized, which means they are designed in tandem to maximize performance and carbon efficiency. The effort will leverage biofuel's potential high-octane levels and other unique fuel properties to enable higher efficiency engines and reduce GHG emissions. The overall objective of the Co-Optimization of Fuels and Engines project is to achieve a 30 percent reduction in per-vehicle petroleum consumption beyond 2030 business-as-usual evolutionary improvements.

[1] Public presentations of this information were delivered at the 2012 AIChE National Meeting, the 2013 and 2014 BioPacific Rim Conferences, and the Biomass 2014 and Bioenergy 2015 annual conferences.

Demonstration and Market Transformation
Activities and Explanation of Changes

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
Demonstration and Market Transformation $75,100,000	**$75,000,000**	**-$100,000**
• The program will fund Phase 1 of the new IBR FOA for up to ten biofuel manufacturing pilot scale facilities and up to four new demonstration scale facilities from the pool of projects that are validated and ready for construction through public and private partnerships.[1] • Continue managing commercial biofuel manufacturing facilities under the DPA interagency effort with DOE, the U.S. Department of Agriculture, and U.S. Department of Defense. • 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, for impacts on engine efficiency and tailpipe emissions, and for the development of various codes and standards for certification.	• $60 million in funding from FY 2017 will be used to down-select one pilot-scale and one demonstration-scale IBRs to enter into Phase 2 for construction and operation, ultimately leading to one pioneer-scale biorefinery facility (financed and constructed without financial assistance from the Bioenergy Technology Program). • $15 million for collaboration with the Vehicle Technologies Program on the Fuel and Vehicle Systems Co-Optimization of Fuels and Engines Project.	• Decreased funding is due to completion of Bioenergy Technologies role in funding the DPA initiative.

[1] Note: The subprogram's plans for FY 2016 have changed since the initial request was submitted. Rather than completely fund these projects in FY 2016, the subprogram's approach will be to break up this FOA into Phase I (FY 2016) and Phase II (FY 2017). In Phase I, BETO will fund up to 10 pilot-scale and 4 demonstration-scale biorefineries for validation, design, and due diligence. In Phase II, funding will be used to down-select up to 3 pilot-scale and 1 demonstration-scale projects for construction and operation.

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 that are instrumental in setting the entire biofuel value chain on an environmentally, socially, and economically viable course. The maintenance and enhancement of key models and tools for internal and external use ensures that BETO has the ability to advance the understanding of bioenergy and its related economic and environmental impacts. The subprogram also works with EERE's Strategic Program to ensure the coordination of analyses within the Sustainable Transportation Sector of EERE and alignment with DOE-wide and government-wide goals.

Strategic Analysis activities provide quantified analysis, context, and justification for decisions regarding the future direction and scope of the program's research, development, and demonstration (RD&D) work. Activities include techno-economic, resource, market, life-cycle GHG, and impact assessments that provide the analytical basis for planning and assessing progress. System-level analyses identify the key drivers and hurdles to industry growth and help identify areas where process improvements could have the greatest impact. Decision support, data management, and analytical tools allow the program to better articulate its vision, identify and validate performance goals, and measure progress toward these goals. FY 2017 activities will focus on assessing and enhancing the environmental, socio-economic, and industry impacts of a growing bioenergy economy.

Cross-cutting Sustainability activities enable the development of more sustainable practices regarding GHG emissions, air quality, land use, water quality, water consumption, soil quality, biodiversity, and socio-economic factors. The subprogram 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 and disseminated through publications, interagency interactions, and online databases such as the Bioenergy Knowledge Discovery Framework (KDF). 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 2017, Cross-cutting Sustainability activities will identify best practices for reducing air emissions, water use, and wastewater associated with advanced bioenergy pathways as well as publicly deploy Web-based tools that enable users to visualize and improve the sustainability performance of bioenergy systems.

Key accomplishments of the Strategic Analysis and Cross-cutting Sustainability subprogram include the creation of transparent tools for evaluating economic, social, and environmental sustainability. Models developed with the subprogram include the GHG, Regulated Emissions, and Energy Use in Transportation Model (GREET), the Biomass Scenario Model (BSM), the Water Assessment Tool for Energy Resources (WATER), and the Landscape Environmental Assessment Framework (LEAF). In FY 2017, Cross-cutting Sustainability and Strategic Analysis activities will continue to identify conditions under which at least one technology pathway for hydrocarbon biofuel production, verified at a mature modeled price of $3/GGE, reduces GHG emissions by 50 percent or more compared to petroleum fuel and meets Federal water quality and air emissions regulations. The subprogram will also document the sustainability requirements for the *Billion-Ton Update* biomass resource assessment and publish an annual market assessment that details the state of the industry.

Strategic Analysis and Cross-cutting Sustainability
Activities and Explanation of Changes

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
Strategic Analysis and Cross-cutting Sustainability $11,000,000	**$11,000,000**	**$0**
• Maintain and enhance key models and tools for internal and external use (including GREET, Biomass Scenario Model (BSM), WATER footprint tool, and LEAF). • Assess environmental, socioeconomic, and industry impacts of a significantly larger bioeconomy concept. • 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.	• Make improvements to critical models and tools (including GREET, BSM, WATER, and LEAF) and apply models to conduct high-priority analyses. • Use the BSM to complete cross-supply chain analyses that consider the impact of BETO's RD&D investment on the growth of the bioenergy industry. • Identify conditions under which at least one technology pathway for hydrocarbon biofuel production will meet BETO's GHG emissions performance goals.	• No changes.

Bioenergy Technologies
NREL Site-Wide Facility Support

Description

In FY 2017, EERE will continue to directly fund National Renewable Energy Laboratory (NREL) Site-Wide Facility Support costs rather than fund those costs as laboratory overhead.

EERE proposes to eliminate the NREL Site-Wide Facility Support subprograms in its individual technology programs, and consolidate NREL Site-Wide Facility Support funding in the Facilities and Infrastructure Program. Locating this funding in the Facilities and Infrastructure Program will provide clarity and transparency in communicating EERE's stewardship for NREL, and will simplify planning and execution of EERE's annual budget. This consolidation into a single program allows for better integration and coordination of operations and investments.

NREL Site-Wide Facility Support
Activities and Explanation of Changes

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
NREL Site-Wide Facility Support $6,900,000	**$0**	**-$6,900,000**
• 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 funding requested within the Bioenergy Technologies Budget Request.	• Reduction in the Request is offset by a corresponding increase in the Facilities and Infrastructure Budget Request. Funding is consolidated in EERE's NREL Site-Wide Facility Support.

Bioenergy Technologies
Performance Measure

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 2015	FY 2016	FY 2017
Performance Goal (Measure)	**Thermochemical Conversion -** Reduce modeled thermochemical conversion cost of a combined gasoline and diesel production ($/gallons of gasoline equivalent).		
Target	$3.70	$3.00	$2.47
Result	Met - $3.69	N/A	N/A
Endpoint Target	$$2.47/GGE by 2017[1]		

[1] Once the endpoint target of $2.47/GGE for thermochemical conversion costs is attained, BETO will seek to bring other pathways to similar cost targets.

Hydrogen and Fuel Cell Technologies

Overview

Hydrogen and fuel cells have the potential to improve energy security and reduce emissions of greenhouse gases (GHG), criteria pollutants, and net oil imports by improving energy efficiency, enabling alternative fuel sources, and spurring domestic production of clean energy technologies. Analysis indicates that meeting the goals of the Hydrogen and Fuel Cell Technologies Program and subsequent market penetration, could reduce national oil consumption by 2-4 million barrels per day and GHG emissions by 200–450 million metric tons per year by 2050.[1] The fuel cell industry is poised for significant expansion — investing heavily in early product development with 880 patents issued in 2014.[2] Global shipments were recorded at 50,000 units worldwide in 2014 with an annual growth of roughly 30 percent *every year* since 2010 and for the first time, revenues have exceeded ($2 billion).[3] Although the U.S. has been the world leader in fuel cells, global advances in both research and early-stage deployment underscore the market potential for these technologies and the need for continued investment to enable a competitive domestic industry.

The program's focus is primarily on transportation applications, but its efforts concurrently benefit stationary fuel cells, a strong first-adopter market that will benefit from advances in transportation research areas such as catalyst and membrane development. The successful development of early stationary markets – such as backup power or small-scale co-generation of heat and power using polymer electrolyte membrane (PEM) fuel cell systems – as well as other early markets (e.g., forklifts and airport/delivery trucks) will help drive down cost, develop a supply base, provide a strategic pathway to higher volumes and establish 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 and heat in fuel cell-mode. These technologies align with the program's hydrogen production activities, regardless of fuel cell technology or temperature, and focus on reducing life-cycle emissions. The scope is technology-neutral emphasizing 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). The program coordinates efforts with the Office of Fossil Energy (FE), which focuses on solid oxide fuel cells while EERE focuses on research and development (R&D) on PEMs and other fuel cell technologies.

Highlights of the FY 2017 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 assemblies (MEAs); fuel cell performance and durability (including R&D to address mass transport and degradation issues), systems, and system integration; balance of plant (BOP) components; testing; technical analysis; and high-throughput combinatorial approaches coupled with high-performance modeling to develop non-platinum group metal (PGM) catalysts and electrodes. 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).

The Hydrogen Fuel R&D subprogram's efforts will include emphasis on materials and process development to enable hydrogen production from diverse renewable resources and storage in higher density form. In FY 2017, these efforts will continue to balance approaches between nearer-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 employ a two-pronged approach: (1) enabling nearer-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 meet the technical and cost targets 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

[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.

[2] Source: http://www.cepgi.com/2015/04/2014-year-end.html.

[3] Source: DOE Fuel Cell Technologies Market Report based on data from Navigant; 4th Energy Wave; and E4tech.

and static seals; and low-cost station and vehicle storage. The Hydrogen Fuel R&D subprogram's onboard hydrogen storage efforts will also continue a two-pronged strategy, of lowering the cost of high-pressure carbon fiber composite tanks systems for the near-term while also developing advanced storage technologies offering high-energy density at lower pressures for the longer-term.

The Program directly addresses its goals, market needs and opportunities through its portfolio focus 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, reducing the life-cycle vehicle costs from about 32 cents per mile in 2013 to 12.6 cents per mile by 2020 and 7.6 cents per mile by 2030. Depending on gasoline price, comparable components (fuel, tank, and engine) of the gasoline internal combustion engine (ICE) cars on the road today average a levelized cost per mile of $0.095 to $0.14 cents. 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.

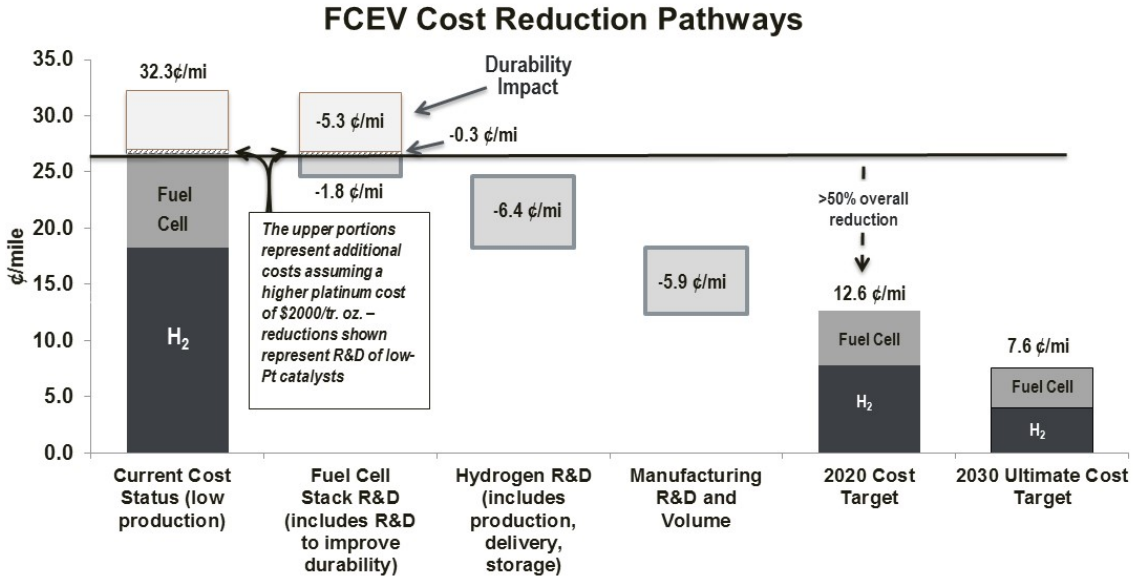


Figure 1. The program's goals for reducing FCEV cost are driven by an overarching goal to reduce the hydrogen and fuel cell portion of the life-cycle cost of the vehicle to 12.6¢/mile by 2020, with an ultimate goal of 7.6¢/mile.

The program supports the Department's Clean Energy Manufacturing Initiative through 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.

The program will collaborate on advanced materials R&D, focused on non-PGM catalysts, electrodes, and interfaces. This approach will use public-private partnerships supported through a National Lab-led electrocatalysis consortium under the Energy Materials Network and competitively selected collaborative projects 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 performance to dramatically accelerate the development of these materials from the point of discovery through qualification and deployment. These efforts support both the Administration's Materials Genome Initiative and Advanced Manufacturing Partnership 2.0.

As part of the DOE Grid Modernization crosscut, the Hydrogen and Fuel Cell Technologies Program will focus its efforts in each of the six technical areas detailed in the Grid Modernization's Multi-Year Program Plan (MYPP). In Devices and Integrated System Testing, the Program will determine how reversible fuel cells and electrolyzers can provide flexibility to the grid. In Sensing and Measurement, the Program will determine requirements for low-cost sensors to provide visibility to grid

operators on what services reversible fuel cells and electrolyzers can provide to the grid. In System Operations, Control, and Power Flow, the Program will develop 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. In Institutional Support, the Program will provide information to utilities and regulators regarding the impact of fuel cells and electrolyzers deployed on the grid. In Design and Planning Tools, the Program will investigate how electrolyzers and 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. Finally, the Program will support broader demonstration projects that will co-optimize across multiple grid attributes including affordability, security, resilience, reliability, and integration of clean technologies.

FY 2017 Crosscuts ($K)

	Grid	Total
Hydrogen and Fuel Cell Technologies	**5,000**	**5,000**

Hydrogen and Fuel Cell Technologies
Funding ($K)

	FY 2015 Enacted	FY 2015 Current[1]	FY 2016 Enacted	FY 2017 Request	FY 2017 vs FY 2016
Hydrogen and Fuel Cell Technologies					
Fuel Cell R&D	33,000	32,063	35,000	35,000	0
Hydrogen Fuel R&D	35,200	34,155	41,050	44,500	+3,450
Manufacturing R&D	3,000	2,911	3,000	0	-3,000
Systems Analysis	3,000	3,000	3,000	3,000	0
Technology Validation	11,000	11,000	7,000	0	-7,000
Safety, Codes and Standards	7,000	6,901	7,000	10,000	+3,000
Market Transformation	3,000	3,000	3,000	0	-3,000
Technology Acceleration	0	0	0	13,000	+13,000
NREL Site-Wide Facility Support	1,800	1,800	1,900	0	-1,900
Total, Hydrogen and Fuel Cell Technologies	**97,000**	**94,830**	**100,950**	**105,500**	**+4,550**

SBIR/STTR:

- FY 2015 Transferred: SBIR $1,907,000; STTR $263,000
- FY 2016 Projected: SBIR $2,149,000; STTR $322,000
- FY 2017 Request: SBIR $2,427,000; STTR $341,000

Budget Structure Crosswalk ($K)

FY 2016 Budget Structure	Proposed FY 2017 Budget Structure					
	Fuel Cell R&D	Hydrogen Fuel R&D	Systems Analysis	Safety, Codes and Standards	Technology Acceleration	Total
Hydrogen and Fuel Cell Technologies						
Fuel Cell R&D	35,000	0	0	0	0	**35,000**
Hydrogen Fuel R&D	0	44,500	0	0	0	**44,500**
Manufacturing R&D	0	0	0	0	3,000	**3,000**
Systems Analysis	0	0	3,000	0	0	**3,000**
Technology Validation	0	0	0	0	7,000	**7,000**
Safety, Codes and Standards	0	0	0	10,000	0	**10,000**
Market Transformation	0	0	0	0	3,000	**3,000**
NREL Site-Wide Facility Support (Moved to F&I)	0	0	0	0	0	**0**
Total, Hydrogen and Fuel Cell Technologies	**35,000**	**44,500**	**3,000**	**10,000**	**13,000**	**105,500**

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

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

	FY 2017 Request vs FY 2016 Enacted
Hydrogen and Fuel Cell Technologies	
Fuel Cell R&D: No funding change.	**0**
Hydrogen Fuel R&D: The funding increase will advance long-term R&D in hydrogen production from renewable resources including efforts in high temperature water-splitting as well as other pathways, the development of novel hydrogen delivery methodologies, and cutting-edge, high energy-density hydrogen storage technologies. FY 2017 funding will expand upon renewable hydrogen pathways not funded in FY 2016 since renewable hydrogen production is critical to achieving carbon reduction goals.	**+3,450**
Systems Analysis: No funding change.	**0**
Safety, Codes and Standards: The funding will accelerate research for hydrogen compatibility with metallic and non-metallic materials and will expand the outreach for training of code officials to support the expanding hydrogen infrastructure. As FCEVs enter the market, expanding and then sustaining a safe hydrogen infrastructure becomes critical.	**+3,000**
Technology Acceleration: Consolidated three sub-programs – Manufacturing R&D, Technology Validation, and Market Transformation – into a new sub-program.	**0**
NREL Site-Wide Facility Support: In FY 2017, EERE proposes to move funding for the NREL Site-Wide Facility Support subprogram from individual technology programs to the Facilities and Infrastructure Program. Locating this funding in the Facilities and Infrastructure Program will provide clarity and transparency in communicating EERE's stewardship of NREL, and will simplify planning and execution of EERE's annual budget. This consolidation into a single program allows for better integration and coordination of operations and investments.	**-1,900**
Total, Hydrogen and Fuel Cell Technologies	**+4,550**

Hydrogen and Fuel Cell Technologies
Fuel Cell R&D

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. Key goals include reducing the modeled high-volume 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 (2014 status) 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. However, the current low-volume cost is estimated at roughly $280/kW, significantly higher than the projected $55/kW, illustrating the need for continued technology advances. To be consistent with the volumes used for battery technology in electric vehicles (100,000 units/year manufacturing rates), updated fuel cell analysis shows a modeled cost of $60/kW for fuel cells based on the latest technology developments through 2015 and projected for manufacturing volumes of 100,000 units per year.

The subprogram will focus on 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 that 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.[1] Advances in fuel cell component and balance of system technologies can provide a range of benefits for all applications. The portfolio covers a range of fuel cell technologies, including PEM fuel cells, alkaline membrane fuel cells, direct methanol fuel cells, and medium-temperature fuel cells such as phosphoric acid fuel cells. For example, high temperature or alkaline membrane advances in these applications could benefit the performance and durability of automotive fuel cell systems, contributing to the use of different catalysts or subsystems and thus leading to overall cost reduction.

In FY 2017, the Fuel Cell R&D subprogram ($35 million) will continue R&D in the following key areas: cell stack component R&D including catalysts, membranes, MEAs, and addressing next generation technologies such as alkaline exchange membranes ($8 million); fuel cell performance and durability including R&D through a lab-led public-private partnership (consortium) to address mass transport, degradation issues, the integration of new materials, and development of new structures for enhanced performance and durability ($11 million); and work on subsystems (such as fuel processing), systems and system integration, BOP components, testing, and technical analysis ($6 million). In addition, the subprogram will further pursue an advanced materials manufacturing R&D effort as part of the EMN ($10 million), focused on using high-performance computing and high-throughput combinatorial approaches through a lab-led consortium focusing on the development, processing, component integration, qualification and end-use of non-PGM catalysts and electrodes into MEAs. These approaches will capture the effects of materials processing and end-use performance and will accelerate advanced materials development and implementation. Discovery and development of non-PGM catalysts could dramatically reduce fuel cells stack cost by approximately 40 percent. 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).

The Fuel Cell R&D subprogram improved the catalyst specific power of fuel cells to 6.5 kW per gram (g) of PGM in 2015, 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

[1] Record #16002, "Environmental and Energy Security Benefits for APUs in Transportation Applications, https://www.hydrogen.energy.gov/program_records.html.

than 80 percent reduction in total platinum content in fuel cells since 2005. In FY 2017, the subprogram plans to increase the catalyst power density to 7.2 kW per gram of PGM, to help reduce the high-volume, modeled levelized cost per mile from the current cost of $0.32 per mile, toward the 2020 goal of close to $0.13 per mile. Depending on gasoline price, comparable components (fuel, tank, and engine) of the gasoline internal combustion engine 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 subprogram reallocated funding over the past several years to prioritize and emphasize R&D that addressed 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 subprogram implements a portfolio approach to address specific R&D needs based on the status of the technology compared to application-driven targets, such as fuel cleanup for fuel-flexible fuel cells.

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 and evaluation of operation strategies — with the aim of enhancing performance and reducing degradation. 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).

[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 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
Fuel Cell R&D $35,000,000	**$35,000,000**	**$0**
• Develop innovative catalyst and electrode technologies and integrate state-of-the-art components in advanced MEAs to achieve 6.9 kW/g PGM.	• Develop innovative catalyst and electrode technologies and integrate state-of-the-art components in advanced MEAs to achieve 7.2kW/g PGM.	• FY 2017 efforts will focus on achieving higher MEA specific power output per gram PGM to 7.2 kW/g PGM from the FY 2016 target of 6.9 kW/g PGM.
• 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.	• Establish high-functioning team through a consortium approach through FOAs and competitive lab solicitation to bring together expertise from National Laboratories, industry, and universities to accelerate non-PGM catalyst, electrode, and MEA development. High-throughput combinatorial experimental and advanced modeling tools will be implemented and coupled to baseline non-PGM catalyst R&D. Effort will enable meeting 2020 and ultimate fuel cell cost targets of $40/kW and $30/kW.	• Efforts will evolve from high-throughput combinatorial experimental and advanced modeling tool development to implementation with immediate application to accelerate non-PGM catalyst, electrode, and MEA development.
• 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.	• Continue both low and high-temperature PEM fuel cell stack component development, with a focus on better understanding both performance and durability.	• Effort will continue to shift more towards transportation applications instead of focusing on achieving the 50,000-hour durability target for stationary applications.
• 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.	• Couple 5 to 10 industry/university led projects with core National Laboratory capabilities via the established lab-led consortium focusing on fuel cell performance and durability. Coordinated approach will streamline effort to achieve targeted 2020 cost ($40/kW) through fuel cell performance improvement and 2020 durability (5,000 hours) by mitigating fuel cell degradation.	• Introducing industry/university/National Laboratory partners to the lab-led consortium core team will provide a synergistic approach that benefits the fuel cell community in its effort to: understand and mitigate fuel cell degradation; improve performance through modeling; and accelerate material development, leading to achieving fuel cell cost in the targeted timeframe.

Hydrogen and Fuel Cell Technologies
Hydrogen Fuel R&D

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 (at high volumes), by 2020. This cost represents the threshold at which hydrogen for FCEVs will be competitive on a cent-per-mile basis with conventional vehicles.[1] To enable the use of hydrogen produced from highly efficient centralized facilities, technologies must 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 subprogram 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 (at high volumes).[2] Techno-economic and life-cycle analyses will continue to provide important guidance on cost and GHG emissions reduction potentials. In addition, analysis efforts will determine a baseline cost for low volume hydrogen production and delivery, as well as cost targets to enable a commercially viable early market penetration for low hydrogen-demand scenarios.

The Hydrogen Fuel R&D subprogram ($44.5 million) 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 energy density and 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 recently started to lease and sell vehicles that achieve about 300 miles with 700 bar compressed hydrogen, vehicles will need advanced storage approaches to achieve this driving range across all platforms without compromising passenger and cargo space or performance, and at a cost that will be commercially successful without incentives. The Hydrogen Fuel R&D subprogram has established onboard automotive storage density goals for 2020 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 $10/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 production component ($16.9 million) of the Hydrogen Fuel subprogram will address materials, process and systems-level R&D to enable cost-competitive and low-GHG-emissions hydrogen production from sustainable/renewable sources. The efforts will focus on advances in hydrogen production through innovative approaches in bio-feedstocks conversion (including microbial conversion approaches), advanced technologies for renewable water-splitting (including direct solar water-splitting), and other innovative approaches. As part of the Energy Materials Network (EMN), the R&D portfolio will include advanced high throughput/combinatorial approaches to enable rapid identification and development of promising materials and processes for renewable hydrogen production, including the advanced water-splitting approaches; and will leverage collaborations with other offices and agencies.

The Hydrogen Fuel R&D subprogram's hydrogen delivery component ($12 million) 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

[1] https://www.hydrogen.energy.gov/pdfs/11007_h2_threshold_costs.pdf.
[2] https://www.hydrogen.energy.gov/pdfs/12001_h2_pd_cost_apportionment.pdf.

compressors; durable, high-pressure dynamic and static seals; and low-cost station storage. In addition, the subprogram will explore synergies between hydrogen and other infrastructures (e.g., natural gas, biogas, transmission and distribution, station technologies and components for compression and storage and dispensing) and identify specific leveraging opportunities.

The hydrogen storage component ($15.6 million) 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 relevant to compressed natural gas vehicles. In FY 2017, the Hydrogen Fuel R&D subprogram will employ accelerated materials R&D approaches through the Energy Materials Network, integrating theory, advanced computation, and high throughput experimentation to develop advanced hydrogen storage technologies that exceed the energy density possible with 700 bar compressed hydrogen.

Hydrogen Fuel R&D
Activities and Explanation of Changes

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
Hydrogen Fuel R&D $41,050,000	**$44,500,000**	**+$3,450,000**
• Continue support for approximately nine direct-funded National Laboratory projects and plan to initiate approximately 13 new projects (TRL level 2 to 5) to achieve the outcomes below. • Relative to the 2011 baseline of $8.00/gge, reduce the hydrogen cost (dispensed and untaxed) to $6.70/gge. [1]	• Support coordinated efforts across at least 15 National Laboratory, industry, and university projects (TRL level 2 to 5) to address key hydrogen fuel challenges and to achieve the outcomes below. • Demonstrate technologies enabling early-market costs of 80 percent of the 2016 baseline for hydrogen dispensed at forecourt refueling stations. • Develop low cost renewable hydrogen production technology with potential to achieve 10 percent reduction in GHG emissions compared to the 2016 baseline.	• In FY 2016, the National Laboratory efforts for the development of advanced materials-based hydrogen storage efforts were organized into a collaborative effort. In FY 2017, these efforts will be expanded by including new industry and university led projects that will benefit from close collaboration with the National Laboratories. • While emphasis will continue on demonstrating technological advances toward meeting the ultimate high-volume hydrogen cost target of <$4/gge (dispensed and untaxed), FY 2017 will place additional emphasis on establishing methodologies for validating early-market costs of hydrogen dispensed at refueling stations along with demonstration of technology innovations. FY 2017 will also emphasize establishing methodologies for validating the life-cycle GHG emissions of renewable hydrogen production pathways along with demonstration of technology innovations that minimize these emissions.
• 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.	• Demonstrate optimized hydrogen forecourt dispensing technologies that enable refueling with less than 4 percent error. • Demonstrate the potential of hydrogen liquefaction using magnetocaloric materials to be at least 20 percent more efficient than conventional liquefaction, while comparable in capital cost.	• FY 2017 will focus on advanced materials, components, & technologies for forecourt storage e.g., tube trailer consolidation; dispensing/metering; and for low-cost delivery.

[1] This cost target is based on high-volume manufacturing; baselines for low-volume costs and for life-cycle GHG emissions are also being developed in FY 2016.

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
• Demonstrate > 500 hours of H_2 production from bio-derived liquids with in-situ CO_2 capture and >90 percent pure H_2.	• Demonstrate reformer/purifier technology that is compatible with gaseous bio-feedstocks and can produce hydrogen at 100 kg/day with CO2 emissions that are 40 percent lower than steam methane reforming of natural gas.	• In FY 2017, projects on bio-feedstock conversion selected in a FY 2014 FOA will near completion, including a semi-central bio-gas reforming approach demonstrated at a 100 kg-H2/day laboratory scale, and a distributed bio-derived liquid approach demonstrated at a 2 kg-H2/day laboratory scale. Another emphasis will continue the support of projects on microbial conversion of bio-feedstocks selected in a FY 2015 FOA.
• 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. • 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.	• Continue support of the renewable hydrogen production consortium established under the Energy Materials Network on advanced water-splitting technologies, including enhancement of core capabilities in accelerated materials-, device- and system-level development for advancing TRL in technologies including photoelectrochemical and solar-thermochemical water splitting. Competitively select at least 2 new consortium-associated projects in advanced water-splitting including industry, academia, and/or laboratory participants.	• In FY 2017, projects on advanced water-splitting technologies selected in a FY 2014 FOA will near completion, including photoelectrochemical and solar-thermochemical projects demonstrating solar-hydrogen water-splitting at the laboratory-scale over 8 hours with a cumulative production of > 3 standard liters of H_2. An expanded emphasis will be the continuation of applied R&D of advanced water-splitting through the consortium, including incorporation of lessons-learned from previous projects and expansion through selection of additional associated FOA projects. Accelerated materials development approaches (both theoretical and experimental) will be employed.
• 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. • 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.	• Continue evaluation of high-strength glass fiber composites as an alternative to carbon fiber composites in 700 bar compressed hydrogen storage systems and its potential impact on reducing system costs towards $10/kWh by 2020.	• In FY 2017, technologies that have potential to further reduce the costs of compressed hydrogen storage towards the 2020 target of $10/kWh will continue to be evaluated. With demonstration of the pilot scale production of high strength glass fibers, emphasis will shift to evaluation of suitability for use of composites with the high strength glass fibers in compressed hydrogen 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, 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 subprogram assesses the requirements of potential end-users to determine metrics for components, subsystems, and systems. Results also support annual updates to key planning documents that provide direction and milestones for the program.

The Systems Analysis subprogram ($3 million) will continue to develop, refine, and use analytical models and tools; assess business cases and investment strategies for hydrogen infrastructure build-out scenarios for fuel cell electric vehicle (FCEV) rollout strategies such as those in support of H2USA; and program milestones and technology readiness goals, including risk and environmental analyses, and financial evaluations. In FY 2017, the subprogram will also initiate sustainability analysis and develop a framework for incorporating metrics (such as GHG emissions, ecological footprint, economic/societal impact, etc.) into hydrogen production and infrastructure assessments and identify research and technology gaps to guide investments and enable targeted R&D that will help achieve the fuel cell portion of levelized cost of $0.13 per mile by 2020 (and these gaps will also be assessed for other applications, such as material handling and stationary power/CHP systems).

The Systems Analysis subprogram will continue to support program-wide activities such as underlying technical analysis for technology-related go/no-go decisions and modeling and analysis of synergies between hydrogen and fuel cells with other emerging technologies, fuels such as biogas, 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.

Also in FY 2017, the subprogram will continue to assess the market impacts of DOE R&D funding. For example, as of 2015:

- The program's funding has led to about 40 commercial technologies, 65 emerging technologies (expected to be commercial within three years) and more than 515 patents.

Systems Analysis
Activities and Explanation of Changes

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
Systems Analysis $3,000,000	**$3,000,000**	**$0**
• Continue to assess the market impacts of DOE R&D funding in advancing fuel cell and hydrogen technologies that will be used to assess the program's progress and technology advances.	• Continue to determine the market impacts of DOE R&D funding in advancing fuel cell and hydrogen technologies to determine the program's progress and technology advances.	• No change in this annual measure of Hydrogen and Fuel Cell Technologies Program performance.
• 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.	• Assess sensitivity of components on fuel cell performance and life cycle cost for FCEVs in support of continued fuel cell R&D.	• Continue annual analysis to identify R&D needs.
• Assess program milestones and technology readiness goals, including risk and environmental analyses, and financial evaluations.	• Assess life cycle GHG, petroleum use, costs, and sustainability for future hydrogen/FCEV pathways with renewable hydrogen production to identify areas requiring continued R&D.	• In FY 2017, analysis projects will focus on quantifying the cost and GHG emission and petroleum use reduction for future hydrogen production pathways with renewable resources for FCEVs.
• 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.	• Conduct regional life cycle analysis of water use based on at least two hydrogen production pathways, with emphasis on future renewable approaches.	• Identify regional requirements/limitations on water use.
	• Assess business cases for hydrogen infrastructure financing and investment strategies and employment impact, particularly with respect to the U.S. veteran community for growing hydrogen and fuel cell industries.	• FY 2017 will expand existing business analyses to identify impact of growing hydrogen infrastructure.
• Continue to support approximately six direct-funded National Laboratory project to achieve these outcomes.	• Continue to support approximately six direct-funded National Laboratory projects to achieve these outcomes.	• No change.
• Assess natural gas and hydrogen infrastructures to determine potential synergies and opportunities to reduce cost through economies of scale applicable to hydrogen.		• Project completed in FY 2016.

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 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. A key activity also involves developing information resources and best practices for the safe use of hydrogen. The subprogram uses extensive external stakeholder input from 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 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 ($10 million) implements research to understand the impact of fuel quality and risk associated with infrastructure, and continues to develop critical outreach tools to guide the deployment of hydrogen infrastructure. In FY 2017, the subprogram will investigate metering technologies and fuel dispensing requirements to allow accurate measurement of hydrogen and quantify the impact of fuel contaminants on fuel cell system performance to help achieve the hydrogen and fuel cell portion of the FCEV life-cycle cost of about $0.13 per mile by 2020. The Safety, Codes and Standards subprogram will collaborate with Department of Transportation (DOT), the Environmental Protection Agency (EPA), National Institute of Standards and Technology (NIST), and other 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 2017, the subprogram will continue research on mechanism-based models for hydrogen behavior in materials covering liquid hydrogen and optimize test methods to reduce the time required to qualify materials, components, and systems. In addition, expanded activities on materials compatibility of non-metallic materials and safety outreach will support the deployment and public acceptance respectively of hydrogen infrastructure.

Safety, Codes and Standards
Activities and Explanation of Changes

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
Safety, Codes and Standards $7,000,000	**$10,000,000**	**+$3,000,000**
• Continue to 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. • Develop the initial liquid hydrogen release models to inform the risk assessment for separation distances that will be used for revising the current codes. • Implement quantitative risk assessment models to address restricted structures such as tunnels, parking garages (e.g.-semi-enclosed), maintenance repair facilities, bridges, and limited access highways.	• Continue to support approximately six direct funded National Laboratory projects and competitively select via a FOA and/or lab solicitation 1 to 2 projects to achieve these outcomes. • Evaluate metallic materials that could potentially be used in hydrogen service to reduce cost by at least 10 percent without sacrificing safety. • Develop better understanding of hydrogen effects in non-metallic materials for hydrogen infrastructure, on-board vehicle storage, and balance of plant. Initiate the development of a publicly available technical reference for non-metallic material behavior in the presence of hydrogen and testing of high priority materials from the coupon to system level.	• In FY 2017, additional funding will support the new competitively selected projects while maintaining the base funding level for the direct funded National Laboratory projects. • Greater emphasis on understanding non-metallic material behavior in a high-pressure hydrogen environment. These materials could provide lighter-weight and lower cost and more flexible manufacturing options for use in hydrogen service. (TRL 4 to 5). Focus is on developing a science-based approach for gaseous and liquid hydrogen to allow more flexibility on siting and location of hydrogen refueling stations. (TRL 6 to 7).
• Train at least 150 first responders and code officials regarding hydrogen and fuel technologies in the Northeast U.S. corridor. • Support coordination of state rollouts and public-private partnerships (e.g. H2USA) to leverage deployment of hydrogen infrastructure. .	• Continue R&D and initiate support for the development of a domestic supply chain of safety, codes and standards-related hydrogen and fuel cell components, including a testing and standard committee providing input for critical components (e.g. nozzles, metering, and sensors). • Expand existing outreach, education, and training activities and train at least 1,000 first responders and code officials to support the public acceptance of hydrogen and fuel cell technologies through H2USA, state and industry initiatives.	• Increased efforts on R&D related to infrastructure components (e.g. safety sensors, meters, etc.). TRL (4 to 5) Continued effort in outreach and training tools, critical for market acceptance of hydrogen and fuel cells. Outreach efforts will include state-level engagement to support deployment of hydrogen infrastructure and fuel cell electric vehicles and key stakeholders such as Authorities Having Jurisdiction (AHJs) and emergency responders. (TRL 6 to 7).

Hydrogen and Fuel Cell Technologies
Technology Acceleration

Description

The primary goal of the Technology Acceleration subprogram is to accelerate the transition from R&D to commercial viability and market acceptance. Specific objectives are to: develop advanced fabrication technologies and processes to meet the cost targets of hydrogen and fuel cell technologies; test and evaluate advanced hydrogen and fuel cell technologies under real-world conditions — providing valuable feedback to R&D efforts while validating the performance of pre-commercial technologies; and operate near-commercial technologies evaluating various fuel cell applications in user environments. These efforts will enable informed decisions for public and private investment in continued R&D and/or commercial deployment. Another key goal is to increase penetration of hydrogen and fuel cell technologies in key early markets by demonstrating both technical viability and business cases in emerging commercial applications. In FY 2017, the subprogram plans to develop diagnostics for defect detection on roll-to-roll manufacturing of membrane electrode assembly (MEA) materials (e.g. MEA, membranes, etc.) and to model effects of MEA defects on fuel cell performance. The Technology Acceleration subprogram will provide critical data to predict whether FCEVs and hydrogen refueling stations 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 high-volume hydrogen fuel costs of less than $4/gge. Specifically, through field demonstration projects the subprogram aims to verify an increase in FCEV durability from 2,521 hours in 2012 to 5,000 hours by 2020 and expand hydrogen station data collection as more stations are brought online. Additionally, Technology Acceleration addresses hydrogen energy storage systems and their ability to support the grid. In FY 2017, the subprogram will test and operate near-commercial ready equipment such as fiber reinforced pipeline and advanced on-board energy storage (e.g. cryo-compressed tanks) under real world conditions.

The Technology Acceleration subprogram ($13 million) is comprised of three main thrusts: Manufacturing R&D ($3 million), Technology Validation ($7 million) and Market Transformation ($3 million). The Manufacturing R&D activity supports research efforts to develop advanced fabrication technologies and processes to meet the cost targets outlined in the hydrogen and fuel cell subprograms. In FY 2017, efforts 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. The subprogram will validate and extend models to predict the effect of manufacturing variations on MEA performance and durability of MEAs. Activities will analyze various approaches to develop a domestic supply chain for hydrogen and fuel cell components and systems. A nimble supply chain can help reduce cycle time in production and ensure a constant flow of raw materials. In FY 2017, the subprogram will conclude 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 efforts that have the greatest impact on cost reduction and on supporting domestic hydrogen and fuel cell manufacturing. Manufacturing R&D activities are coordinated with DOE's Clean Energy Manufacturing Initiative, the Advanced Manufacturing Program, the Department of Defense (DOD), and the Department of Commerce (National Institute of Standards and Technology) to leverage other activities.

The Technology Validation area will assess current technology and provide feedback to hydrogen and fuel cell R&D activities to help achieve an FCEV life-cycle cost of $0.13 per mile by 2020. 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. The effort will install various hydrogen contaminant detectors at hydrogen stations to evaluate their performance, cost, and operation and maintenance needs. The subprogram will collect data from advanced FCEVs, hydrogen-refueling stations, and other vehicles such as fuel cell–powered transit buses (in collaboration with 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.

The final thrust within the Technology Acceleration subprogram is Market Transformation, which includes collaboration with other agencies (Federal and state) to facilitate the deployment of hydrogen and fuel cells in key applications such as fleet vehicles, early markets (e.g. range extenders, power generation, etc.) as a pathway to enabling widespread deployment, and renewable hydrogen production (including the use of hydrogen for energy storage). This activity also provides technical assistance to regional, state, and local planners by evaluating fleet operations, infrastructure configurations, and costs for specific deployments in strategic locations. The subprogram strives to achieve sufficient industry commitment to result in self-sustaining markets. In FY 2017, the activity will focus on refueling to demonstrate affordable hydrogen fuel for fuel cell road vehicles leveraging strategies to reduce costs such as: identifying property in strategic locations such as Federal sites, using dual use approaches, and testing the operation of mobile refuelers and near commercial ready equipment such as fiber reinforced pipelines and advanced storage (e.g. cryo-compressed) refueling systems.

Technology Acceleration
Activities and Explanation of Changes

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
Technology Acceleration $13,000,000	**$13,000,000**	**+$0**
• Support at least three direct-funded National Laboratory projects and about five projects awarded from a solicitation to:	• Support about 7 direct funded National Laboratory projects and about 13 new and continuing projects awarded from solicitations to:	
▪ Demonstrate continuous in-line quality control methods for detecting pinholes in fuel cell membranes <150 micrometers in diameter.	▪ Develop real-time quality control devices that are readily implementable in a roll-to-roll production line for the manufacture of MEA component materials that can detect anode and cathode defects as small as 0.5 cm^2.	• Defer manufacturing and supply chain efforts to prioritize technology validation and market transformation activities, primarily related to enabling a robust, low cost hydrogen infrastructure.
▪ Report on development of outreach activities that facilitate the development of a robust domestic hydrogen and fuel cell supply chain.		• No change.
▪ Identify supply chain gaps and strategies to overcome these gaps and reduce supply chain costs.	▪ Collating input from industry and National Laboratory projects, determine the cost of materials and manufacturing infrastructure components (e.g., dispensers, nozzles, hoses, etc.); identify opportunities for U.S. manufacturing, cost reduction, and standardization.	• In FY 2017, more detail will be generated on specific component cost and manufacturing requirements since more hydrogen stations will be in use based on state and industry funding.
• 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: ▪ The current industry structure both domestically and internationally to benchmark markets;		• Global manufacturing competitiveness analysis project is scheduled to be completed in FY 2017.

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
▪ The value stream from raw materials (or component parts where more relevant) to consumer products; ▪ Areas where the U.S. has (or may have) viable manufacturing opportunities and identify potential vulnerabilities to U.S. competitiveness; and ▪ Segments identified as having particularly well suited to U.S. strengths (e.g., requiring a highly skilled, innovative workforce).		
• 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.	• Through a combination of a competitive FOA and National Lab call, conduct the world's first-of-its-kind in situ demonstration to verify the goal of reducing hydrogen distribution pipeline cost by 20 percent from conventional welded steel pipelines.	• Activities will transition from development to demonstration.
• Demonstrate a medium-duty fuel cell hybrid electric parcel delivery truck with a projected driving range of 120 miles on a single hydrogen fill.	• Using data from field demonstrations, validate doubling of the driving range of electric parcel delivery truck, the performance, and fuel cost for mobile refueler trucks and hydrogen refueling stations in novel demand response programs to support the grid.	• No change, project in process.
• Demonstrate 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. • 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.		• Focus on assessment of renewable hydrogen stations and increase emphasis on component reliability data and lessons learned from early market applications.

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
• 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.	• Using data from field demonstrations, validate targets e.g. 5kg H2 in <3 min performance, maintenance and operations, at multiple stations as well as early market technologies such as buses.	• Projects will include data from new hydrogen stations in CA and the North East as they are commissioned.
• 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).	• Initiate field testing and gather and analyzed data to validate lower fuel cost with respect to advanced hydrogen compression, storage, or dispensing equipment.	• No change. Various fuel cell applications are validated as technology advances are made.
• 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.	• Demonstrate novel refueling infrastructure systems such as home/workplace refueling and gather data from these systems to validate a lower cost relative to the current, low volume status of around $14/gge.	• U.S. Maritime Administration project is concluding and focus shifts to new approaches to reduce fuel costs.
• Complete the development and deployment of refrigerated truck auxiliary power technology and document the petroleum savings and business value propositions.	• Complete field testing and analyze data gathered during the demonstration to validate diesel fuel savings using auxiliary power units for refrigerated trucks.	• Field-testing is scheduled to be completed. Focus will be on analysis and documentation demonstrating technical and economic viability/gaps.
• 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.	• Continue collaboration with other Federal agencies and state fleets on the pilot program by collecting preliminary data and conducting technical – economic analyses.	• No change.
• 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.	• Collect and analyze technical and economic data from a fuel cell hybrid utility van field demonstration to validate a 2X increase in battery electric vehicle range.	• No change.

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
	• Evaluate education needs of key stakeholders and develop education/outreach materials and implementation strategies.	

Hydrogen and Fuel Cell Technologies
NREL Site-Wide Facility Support

Description

In FY 2017, EERE will continue to directly fund National Renewable Energy Laboratory (NREL) Site-Wide Facility Support costs rather than fund those costs as laboratory overhead.

EERE proposes to eliminate the NREL Site-Wide Facility Support subprograms in its individual technology programs, and consolidate NREL Site-Wide Facility Support funding in the Facilities and Infrastructure program. Locating this funding in the Facilities and Infrastructure Program will provide clarity and transparency in communicating EERE's stewardship for NREL, and will simplify planning and execution of EERE's annual budget. This consolidation into a single program allows for better integration and coordination of operations and investments.

NREL Site-Wide Facility Support
Activities and Explanation of Changes

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
NREL Site-Wide Facility Support $1,900,000	**$0**	**-$1,900,000**
• 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 funding requested within the Hydrogen and Fuel Cell Technologies Budget Request.	• Reduction in the Request is offset by a corresponding increase in the Facilities and Infrastructure Budget Request. Funding is consolidated in EERE's NREL Site-Wide Facility Support.

Hydrogen and Fuel Cell Technologies
Performance Measure

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 2015	FY 2016	FY 2017
Performance Goal (Measure)	**Fuel Cell Power -** Improve the catalyst specific power of fuel cells (kW per gram of platinum group metal)		
Target	6.5	6.9	7.2
Result	Met - 6.6	N/A	N/A
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 solar thermal energy to electricity and usable thermal power. These approaches and objectives will help re-establish American technological and market leadership in solar energy, diversify the Nation's electricity supply, reduce adverse environmental and climate-related impacts of electricity generation, strengthen U.S. manufacturing competitiveness, and catalyze domestic economic growth.

EERE's Solar Energy Program supports the DOE SunShot Initiative's mission, which requires 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. The Solar Energy Program has similar aggressive targets for residential and commercial market segments. By the end of 2014, reductions of 56 percent, 52 percent, and 54 percent were achieved for U.S. photovoltaics system costs at the utility, commercial, and residential scales respectively, relative to 2010. These achievements have the Solar Energy Program on target to achieve the 75 percent cost-reduction goal by 2020.

Despite these gains, cost reduction trends have leveled off in several sub-categories and the remainder of the decade will be used to access harder-to-reach cost reduction paths with innovations in products, more scalable national soft cost reduction approaches, and grid integration at high solar penetration challenges. In addition to the 2020 goals, the program seeks to lower the cost of solar electricity beyond $0.06/kWh, to enable higher integration approaches.

Deployment of PV across the U.S. has been growing at a rapid rate, with an anticipated record 8 GW or more deployed in 2015 — a roughly 20-fold increase from the 2009 level.[1] By 2016, close to 30 GW (3 percent of U.S. generation capacity) of solar power may be installed across the U.S., which also represents significant job growth. By the end of 2014, approximately 174,000 people in the U.S. were employed in the solar sector, a 21.8 percent job growth rate over the prior year.[2] Rapid declines in systems and hardware costs have made these market and job growth increases possible. Nevertheless, significant work remains before solar achieves unsubsidized cost-competitiveness with conventional energy resources and realizes its full potential throughout the country. Market barriers and grid integration challenges also continue to hinder greater deployment. Non-hardware solar "soft costs" — such as permitting, financing, and customer acquisition —constitute up to 64 percent of the cost of a residential system.[3] With this in mind, the Solar Energy Program is 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.

Highlights of the FY 2017 Budget Request

The Solar Energy Program will launch significant efforts in the following major areas in FY 2017:

- With solar already close to 2 percent of the Nation's electricity generating capacity—and with a clear pathway to 10 percent — the challenges of even higher levels of grid integration need to be researched today for cost-effective solutions in the future. The Solar Energy Program therefore 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 Initiative. The program supports industry through development of test and evaluation standards, and by developing technologies and tools for meeting grid requirements. The Solar Energy

[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.

Program develops advanced technologies and engages 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, the Solar Energy Program's new efforts will focus on strategic partnerships with utilities to reduce barriers for increased deployment of solar across the Nation. A new training program 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 and "Utility/Grid Modernization Laboratory Consortium (GMLC) Partnership on Future Business Models" will allow utilities to explore solar ownership and operation integration
- Leveraging promising component-level concentrating solar power research that developed sub-systems from prior-year support, 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. The program will use FY 2017 funds to further systems integration work beyond the topics, or at a scale above that in the FY 2016 FOA. 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 1 GW of CSP plants that came online in the U.S. in FY 2014.
- Next Generation PV Modules fills an important research gap by focusing on the non-cell module components and module design, which comprise 40 percent of typical module cost and have the potential to significantly impact PV performance as well as installation cost. The Bridging Research Interactions through Cooperative Development Grants in Energy (BRIDGE) FOA will build relationships with basic science researchers to understand degradation modes that limit PV reliability and to develop new PV characterization techniques. These topics will continue to support U.S. leadership in PV innovation, which has led to more than 50 percent of the world records in solar power conversion efficiency over the past 35 years. This research drives toward a "Beyond SunShot" cost target of 2-3 cents/kWh by 2030, to enable PV plus storage to reach grid parity (with concurrent advances in storage technology).
- Solar Manufacturing Technologies PV, the fifth round of a successful manufacturing research and development (R&D) FOA, started in FY 2012, will continue to support innovative manufacturing technologies, and advanced materials that could give U.S. manufacturing companies a competitive edge over subsidized foreign competitors. The scope of the program includes all components in the solar value chain. Continued DOE support will focus on technological advances and innovative solutions to further drive down costs towards the DOE SunShot Initiative 2020 targets. By eliminating the perceived cost advantage of overseas manufacturing (e.g., low cost labor, low cost capital) with automation and high throughput/low capex production techniques, U.S. companies can competitively produce products in the U.S. In 2014-2015, 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. Also in support of greater solar technology ecosystem, and industry advancements, the Solar Energy Program is planning to issue a Solar Consortium FOA to close the gap in the research done by universities and industry.

Through the DOE SunShot Initiative, the Solar Energy Program 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. The DOE SunShot Initiative's postdoctoral research fellowship program funds emerging research leaders in the field who will pursue breakthrough solar energy technologies. The Concentrating Solar Power (CSP), Photovoltaic Research and Development (PV R&D), and Systems Integration (SI) subprograms invest in these 2-year awards to 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.

As part of the DOE Grid Modernization Initiative, the Solar Energy Program will focus its efforts in each of the six technical areas detailed in the Grid Modernization Multi-Year Program Plan (MYPP). The Devices and Integrated System Testing technical area will work on developing power electronics, interoperability, interconnection, and integrated system testing. The Sensing and Measurement technical area will focus on developing new sensing technologies that provide visibility of the impact of solar technologies on the grid as well as the development of new solar forecasting tools. The System Operations, Control, and Power Flow technical area will work on developing advanced communications and control systems to support PV integration. The Institutional Support technical area will provide information to utilities and regulators regarding the impact of solar technologies deployed on the grid. The Design and Planning Tools technical area will work on tools that help utilities and other stakeholders understand the impact of solar technologies on the system. Finally, the Solar

Energy Program will support broader demonstration projects that will co-optimize across multiple grid attributes including affordability, security, resilience, reliability, and integration of clean technologies. A Thermal Desalination R&D FOA will explore using thermal energy systems for cost-effective water purification and desalination strategies, in support of the larger DOE Energy-Water Nexus (EWN) Crosscut.

FY 2017 Crosscuts ($K)

	Grid	EWN	Total
Solar Energy	**93,000**	**15,000**	**108,000**

Solar Energy
Funding ($K)

	FY 2015 Enacted	FY 2015 Current[1]	FY 2016 Enacted	FY 2017 Request	FY 2017 vs FY 2016
Solar Energy					
Concentrating Solar Power	46,400	45,285	48,400	43,000	-5,400
Photovoltaic R&D	35,300	34,810	53,152	64,000	+10,848
Systems Integration	43,700	43,337	52,447	83,000	+30,553
Balance of Systems Soft Cost Reduction	40,700	40,468	34,913	23,100	-11,813
Innovations in Manufacturing Competitiveness	57,800	57,800	43,488	62,000	+18,512
Next Generation Renewable Fuels and Chemicals R&D	0	0	0	10,000	+10,000
NREL Site-Wide Facility Support	9,100	9,100	9,200	0	-9,200
Total, Solar Energy	**233,000**	**230,800**	**241,600**	**285,100**	**43,500**

SBIR/STTR:

- FY 2015 Transferred: SBIR $1,933,000; STTR $267,000
- FY 2016 Projected: SBIR $1,774,000; STTR $266,000
- FY 2017 Request: SBIR $3,392,000; STTR 477,000

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

Solar Energy
Explanation of Major Changes ($K)

	FY 2017 vs FY 2016 Enacted
Concentrating Solar Power: A small decrease in the CSP sub-program reflects the changing nature of system designs and needed R&D. CSP will focus on integrating novel system components into workable systems, extending beyond those already deployed in the field.	**-5,400**
Photovoltaic R&D: The increase supports innovative Next Generation PV Modules R&D focusing on non-cell module components and design as well as the BRIDGE FOA to build relationships with basic science researchers to understand degradation modes that limit PV reliability and develop new PV characterization techniques.	**+10,848**
Systems Integration: A substantial increase in Systems Integration is partly matched by participation in the department's Grid Modernization Crosscut and complements the strong industry emphasis on solar grid integration. This increase reflects the need to address solar integration issues now to inform the foreseeable ramp-up in deployments.	**+30,553**
Balance of Systems Soft Cost Reduction: BOS will support very focused and targeted programs in partnership with utilities and other stakeholders. The activities across the program will be more limited in FY 2017, enabling the assessment of the market environment, while resources and effort are focused on the new programs in utility engagement and training, and reflecting the strong investment in this area made in FY 2016.	**-11,813**
Innovations in Manufacturing Competitiveness: The focus remains on cutting-edge innovation in the private sector from small-business early stage concepts to competitive R&D in manufacturing processes. The Solar Energy Program pivots towards more exploratory approaches (such as low-capex concepts).	**+18,512**
Next Generation Renewable Fuels and Chemicals R&D: This new subprogram builds on earlier efforts on thermochemical storage from the CSP subprogram, including the ELEMENTS FOA, which worked to develop energy storage reaction cycles based on ammonia, metal hydrides, metal oxides, and metal carbonates.	**+10,000**
NREL Site-Wide Facility Support: In FY 2017, EERE proposes to move funding for the NREL Site-Wide Facility Support subprogram from individual technology programs to the Facilities and Infrastructure program. Locating this funding in the Facilities and Infrastructure Program will provide clarity and transparency in communicating EERE's stewardship of NREL, and will simplify planning and execution of EERE's annual budget. This consolidation into a single program allows for better integration and coordination of operations and investments.	**-9,200**
Total, Solar Energy	**+43,500**

Solar Energy
Concentrating Solar Power

Description

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

The goal of the CSP subprogram is to reduce the levelized cost of CSP energy at utility scale to $0.06/kWh by 2020, which is cost competitive with traditional electricity sources, from a baseline of $0.21/kWh in FY 2010. [1] The CSP subprogram seeks to accomplish these technical objectives through competitively funded research programs with industry, the National Laboratories, and academia.

Leveraging promising component-level CSP research that developed sub-systems in prior fiscal years, CSP Systems Integration in FY 2017 will integrate best-in-class sub-system technologies to demonstrate technologies at the 1-10 MW scale. Going to smaller-scale plants will enable a reduction in the time to construction and the corresponding cost of capital. The effort will refine and optimize subcomponent technologies that are currently under development in the major CSP focus areas (i.e., solar collection, receivers and heat transfer fluids, power conversion, and thermal energy storage) toward an integrated solution. Moreover, significant challenges exist in integrating the subcomponent technologies of the solar field, thermal receivers, thermal storage, and power block

The CSP subprogram also funds the DOE National Laboratories in R&D topics beyond commercial technologies that are also focused on the technical targets and goals of the DOE SunShot Initiative. The FY 2017 request continues the efforts at the National Laboratories in the areas of solar field cost reduction, high-temperature receiver development, R&D of thermal energy storage (TES) that allows turbine operation beyond the daytime hours, advanced power cycles, and systems integration that are in line with the major CSP focus areas detailed previously. 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.

Finally, the CSP subprogram will also support the Energy-Water Nexus Crosscut with a FOA targeting desalination R&D using solar thermal processes ($15 million). The desalination effort will focus on improvements in cost and performance of the heat transfer technologies used in thermal desalination and on systems integration challenges.

[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.

Concentrating Solar Power
Activities and Explanation of Changes

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
Concentrating Solar Power $48,400,000	**$43,000,000**	**-$5,400,000**
• Continue the efforts at the National Laboratories in the areas of solar field cost reduction, high temperature receiver development, advanced R&D 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.	• Continue the efforts at the National Laboratories in the areas of solar field cost reduction, high temperature receiver development, advanced R&D of thermal energy storage, advanced power cycles, and systems integration.	• No Significant Change.
• 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.	• Systems integration remains a focus topic, to integrate component solutions developed in prior years. The FY 2017 request contains a CSP Integration FOA.	• No Significant Change.
• 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.	• No FY17 funds provided; work continues on projects awarded in FY16.	• No Significant Change.
	• Desalination R&D FOA will support the DOE Energy-Water Nexus Crosscut by funding 8 to 12 competitively selected projects focused on advanced thermal desalination techniques.	• Desalination R&D FOA is a new activity within the Energy-Water Nexus Crosscut. CSP subprogram is uniquely positioned to support it with its expertise and network. The total small decrement in CSP sub-program reflects the changing nature of systems architectures and R&D needs.

Solar Energy
Photovoltaic R&D

Description

The focus of the Photovoltaic (PV) R&D subprogram is to reduce the cost of PV electricity by reducing manufacturing costs and improving efficiency and reliability of the PV module and system. The subprogram supports aggressive development of low-cost, high-performance photovoltaic technologies, through the DOE SunShot Initiative, to make solar electricity cost-competitive with other sources of energy by 2020. This near-term goal is unsubsidized, utility-scale PV energy at $0.06/kWh. Longer term, as PV reaches greater levels of grid penetration, there will likely be additional system costs to accommodate the intermittency of the solar resource, such as for energy storage and demand-side management. To enable PV to be cost-competitive while accounting for these additional costs, the levelized cost of energy of PV systems may need to be significantly lower than the established SunShot 2020 goals. Accordingly, the PV R&D subprogram is now targeting new and advanced technologies that can provide PV electricity at a cost of $0.02-0.03/kWh by 2030

The PV R&D subprogram advances state-of-the-art PV, by taking a technology-agnostic approach to competitively funding R&D across the technology type and readiness spectrum with industry, academic, and National Laboratory partners. Specifically, the subprogram seeds research to advance materials processes, and device design approaches that enable higher PV performance, and reduced cost, as well as better predictability and understanding of long-term reliability. The PV R&D portfolio spans work from early stage solar cell research, up to the point of commercialization. For example, projects include advanced silicon processes to reduce the cost of high-efficiency devices, III-V multi-junction solar cells that push efficiency limits, the study of outdoor soiling impacts on PV performance, and model systems for Cadmium-Telluride solar cells to probe fundamental efficiency limits.

In FY 2017, the PV R&D subprogram will support ongoing R&D at the National Renewable Energy Laboratory (NREL) and Sandia National Laboratories, as well as two funding opportunity solicitations. The PV R&D subprogram supports ongoing merit-reviewed research activities at the National Laboratories, focused at the National Center for PV (NCPV) at NREL as well as Sandia. This work covers foundational research on applied problems, advancement of existing and emerging technologies, module reliability, improved performance prediction, and development of new measurement and characterization techniques. It also funds the Regional Test Centers (RTCs) located in Denver, Colorado; Albuquerque, New Mexico; Las Vegas, Nevada; Orlando, Florida; and Williston, Vermont. The primary mission of the RTCs is to validate the performance and operation of PV modules and systems. The RTCs serve as test beds for systems of varying size and provide independent validation of PV performance and reliability. In FY 2016, the RTCs began a transition to a funding model requiring at least 50 percent cost share from industry users.

In FY 2017, the subprogram will issue two solicitations. The first focuses on the full PV module, which includes the PV cell plus packaging and associated electronics. Next-Generation PV Modules fills an important research gap by focusing on the full module design and the non-cell module components that comprise 40 percent of typical module cost. The second solicitation, Bridging Research Interactions through Cooperative Development Grants in Energy (BRIDGE) II, expands on a successful FY 2012 program that built collaborations with DOE User Facilities researchers to develop new deposition and characterization techniques that advanced the understanding of defects and performance in PV devices. BRIDGE II will facilitate and encourage collaboration between PV researchers and experts in other fields, including basic science researchers, to tackle some of the most challenging problems in PV.

Photovoltaic R&D
Activities and Explanation of Changes

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
Photovoltaic R&D $53,152,000	**$64,000,000**	**+$10,848,000**
• 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).	• Continue approximately 25 merit-reviewed research projects at the National Laboratories (NREL and Sandia). This work advances existing and emerging photovoltaic technologies, develops new measurement and characterization techniques, and improves module reliability and performance. NREL and Sandia work in collaboration with industry and academia.	• No Significant change.
• 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.	• Issue Next Generation Modules solicitation and competitively select approximately 10 projects focusing on novel module design and packaging components. This fills a gap in the portfolio left by the prior focus on only one component of the module: the PV cell.	• Expands research topic areas to include modules.
• 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.	• No FY17 funds provided; work continues on projects awarded in FY 2016.	• No Significant Change.
• Fund 4 to 6 emerging research leaders through SunShot Postdoctoral Research Awards who will pursue breakthrough PV technologies and publish impactful peer-reviewed articles.	• No FY17 funds provided; work continues on projects awarded in FY 2016.	• No Significant Change.
	• Issue Bridging Research Interactions through Cooperative Development Grants in Energy (BRIDGE) II solicitation and competitively award 5-	• This is the second round of BRIDGE. The previous round began in FY 2012.

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
	10 projects that use partnerships between PV and outside researchers to tackle technological challenges where progress has been limited to date.	

Solar Energy
Systems Integration

Description

The Systems Integration (SI) subprogram supports the development of transformative solutions that will create seamless integration of 100s of GW of solar energy into the electricity grid in a safe, reliable, and cost-effective manner. As the deployment of photovoltaic systems in electric distribution systems has aggressively accelerated over the past few years, utilities, regulatory agencies, and developers face 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 two-way power flows. Regulatory agencies are concerned with grid stability, while the developers are concerned with the time it takes to interconnect systems, with increasing amount of solar penetration.

The anticipated proliferation of solar power at centralized and distributed scales underscores the need for timely and cost-effective interconnection procedures, accurate prediction of solar resources, as well as monitoring and control of solar power. Moreover, the impact of solar energy on the performance and reliability of transmission and distribution power systems is becoming a larger challenge. The SI subprogram will address these technical and regulatory 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 2017, the SI subprogram will support four focus areas — Grid Performance and Reliability, Dispatchability, Power Electronics and Communications — towards their associated metrics, as illustrated in Figure 1 and described below. The broader Grid Modernization MYPP encompasses each of these four focus areas. For example, Grid Performance and Reliability is encompassed within the Design and Planning Tools technical area, Dispatchability is covered within the System Operations, Control, and Power Flow technical area, Power Electronics falls under the Devices and Integrated Systems technical area, and Communication falls under Sensing and Measurement. As solar approaches 2 percent of the Nation's electricity generation capacity, the critical systems integration challenges outlined below need to be addressed and solar technology needs to be comprehensively integrated with other generation, distribution, and load assets on the grid.

- 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.
- Focused research on Dispatchability will ensure that solar power plants based on PV and CSP technologies at both utility and distributed scales are capable of being dispatched in a fashion that is comparable to or better than conventional power plants.
- Focused research in Power Electronics will develop intelligent devices that can maximize the power output from PV arrays on the one side and serve as the interface to the electric grid (or end-use circuits) on the other, while ensuring overall system safety, reliability, and controllability. A core technical challenge for power electronics is optimizing the three design drivers of performance, reliability, and cost.
- Focused research in Communications technologies will effectively inform grid operations with high penetration levels of solar. 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).

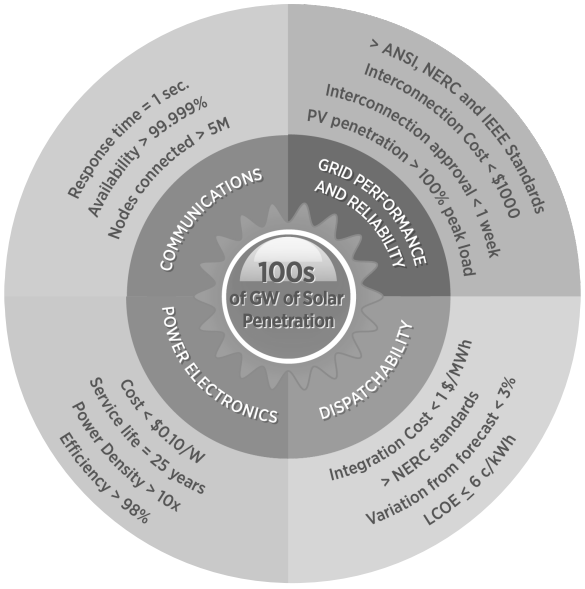


Figure 1

Systems Integration
Activities and Explanation of Changes

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
Systems Integration $52,447,000	**$83,000,000**	**+$30,553,000**
• 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.	• Coordinate expertise among a number of the National Laboratories through the SunShot National Laboratories Multiyear Partnership initiative, SuNLaMP with industry (utilities as well as equipment and service providers) to more rapidly address systems integration challenges. Continue support for selected projects as part of the OE-EERE Grid Modernization Laboratory Consortium initiative. • 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.	• No significant change.
• Issue Solar Dispatchability solicitation and competitively select 5 to 10 projects focused on technologies that will enable utilities to integrate high levels (>100 percent 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	• No new worked planned in this area in FY 2017.	• In FY 2016, SHINES and ENERGISE will have addressed dispatchability.

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
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.		
• 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 percent 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 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.	• Issue "Advanced Power Electronics Solutions for Distributed PV" solicitation and competitively select about 10 projects focused on transformative power electronics technologies to enhance solar power conversion and energy flow in the transmission and distribution grids and on customer premises. The SPEED funding is anticipated to generate outcomes in the form of new technologies, devices, protocols, and standards that will have broad-based impact in enabling high penetration of solar into the Nation's grid, particularly on the distribution grid. • This effort will build off the developments from the HiPen and SEGIS-AC funding programs that were completed in FY 2015, and bridge the gap between the outcomes of the programs and the SunShot Systems Integration targets. • R&D in the area of power electronics will be pursued through the Solar Power Electronics for Electricity Delivery (SPEED) funding opportunity, to position the industry for transformative future growth. • The objective of the SPEED funding opportunity will be to develop solutions that leverage transformative power electronics technologies—including wide band gap semiconductors, advanced magnetics, thin film capacitors, and advanced system design and packaging—to enhance solar power conversion and energy flow in the transmission and distribution grids and on	• No Significant Change.

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
	customer premises. The SPEED funding is anticipated to generate outcomes in the form of new technologies, devices, protocols, and standards that will have broad-based impact in enabling high penetration of solar into the Nation's grid, particularly on the distribution grid. • The objectives and the targeted metrics for the solutions envisioned in SPEED are quite challenging and the proposed funding opportunity will engage a broad range of stakeholders including industries, academia, utilities, and National Laboratories, to develop and demonstrate integrated, scalable and cost-effective power electronics technologies for solar that address SunShot Systems Integration goals. • The SPEED solutions must demonstrate all of the following target metrics: conversion efficiency > 98 percent; service lifetime and reliability > 25 years; power density > 100 W/in3; system cost < $0.10/W (utility scale), < $0.15/W (residential scale); provide grid support functions compliant with IEEE, NERC, and ANSI standards; and be interoperable compliant with open standards.	
• Fund 2 to 3 emerging research leaders through the DOE SunShot Initiative Postdoctoral Research Awards who will pursue breakthrough solar integration technologies.	• No FY 2017 funds provided; work continues on projects awarded in FY16.	• No Significant Change.
	• Issue Solar Forecasting solicitation. This effort will build off prior efforts on Solar Forecasting, the National Laboratories R&D, and SUNRISE funding programs, to bridge the gap between the outcomes of these completed or to-be-completed in FY 2016 programs and the SunShot Systems Integration targets. R&D in Solar Forecasting will significantly improve the accuracy and availability	• A new cycle of Forecasting research and power electronics research will begin with the refined targets.

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
	of forecasting at a range of temporal and spatial scales. At distributed scale, accurate forecasts will need to be integrated with individual PV systems or a cluster of systems for optimal asset use such as optimizing battery performance. At large system scale, accurate forecasts of solar plant generation and ramp rate will need to be integrated with utility and ISO operations to ensure grid reliability and efficient energy markets. Achieving the target accuracy needed under high penetration scenarios at fine spatial (< 0. 5km) and temporal (< 5 min) scale, with coverage of the entire U.S., is a challenging goal. To this end, the FOA will develop solutions that improve the modeling physics of aerosol and cloud descriptions, radiative transport, multiscale, multiphysics integration; significantly advance sensing and measurement of cloud and aerosol data at fine spatial and temporal resolutions; develop advanced data assimilation methods; and provide detailed model validation and efficient encapsulation of the physical models into tools that seamlessly integrate and operate with utility and grid planning and operation systems. Coordinate with the DOE Grid Modernization Initiative to issue a solicitation on a grid demonstration program to competitively select awards that demonstrate solutions towards the SunShot Systems Integration vision and its metrics in the area of grid performance and reliability, dispatchability, power electronics and communications. The Solar Energy Program will also contribute to a grid demonstration program, focusing on advances in the controls and associated system architectures needed to manage a diverse set of resources and grid assets,	

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
	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. The Solar Energy 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.	

Solar Energy
Balance of Systems Soft Cost Reduction

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, small, and large commercial PV systems.

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 2016, the U.S. saw a rapid 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 strategically. 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 2017, the BOS subprogram will support the following focus areas to support reductions in soft costs and promote uniform access to solar.

In FY 2017 the BOS subprogram will release the Business Models FOA with two topics (Topic 1: Solar Market Pathways and Topic 2: Utility Challenge). The first topic will focus on increasing access and will build upon the successful "Solar Market Pathways" program, first launched in 2014. The first "Solar Market Pathways" program supports 15 SunShot projects that are developing new solar business and finance models and solutions. Developing new business models, such as community solar models, programs that enable universities to expand solar energy on campuses, and programs for non-profits and low-income communities is critical to the continued growth of the solar industry. Without innovation in the business arena, access to solar electricity is limited to early adopters and consumers in mature solar markets. These projects take a variety of approaches to develop actionable strategic plans to expand solar electricity use for residential, community, and commercial properties. Awardees use a wide range of tools, including special financing mechanisms like commercial property assessed clean energy, and the integration of solar energy generation in local emergency response plans. Ultimately, the case studies and lessons learned from the Solar Market Pathways projects will provide examples that can be replicated — an important step towards increasing access to solar electricity and making solar deployment faster, easier, and cheaper across the country, which is a major goal of the SunShot Initiative.

The second topic in the Solar Market Pathways FOA includes the new Utility solar challenge. This program aims to aid utilities in developing and implementing new solar programs that increase utility supported and/or partnership programs and projects. As the U.S. electricity sector continues to evolve, utilities face not just technical, but also business related challenges in integrating solar into their generation portfolios. This program aims to develop tools, share best practices among utilities and connect them to a network of peers who have successfully grown their solar capacity. Due to the wide variety of utility business models (IOU, coops, munis, regulated, power markets, etc.) a "one-size-fits-all" approach is not feasible. Nevertheless, developing tools that help utilities to implement and administer solar programs is an important step in meeting SunShot goals. The kinds of tools and programs developed under this challenge may include decision support tools, new consumer portals, programs designed to expand solar access to businesses or underserved communities or resources for scenario planning that enable utilities to increase their stake in regional solar projects while simultaneously maximizing economic and technical benefits to the grid. These solutions could be tested and scaled or implemented by many utilities once successful models have been developed.

In FY 2017, the National Laboratories will conduct new and ongoing research and analysis to reduce the balance of systems costs, 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. The National Laboratories will also continue provide technical assistance to state and local governments in development of programs to improve solar market access and market conditions such as utility administered solar programs, reduced permitting times. Environmental impacts, including wildlife, of both large scale CSP and PV plants are also studied in order to reduce permitting barriers.

Balance of Systems Soft Cost Reduction
Activities and Explanation of Changes

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
Balance of Systems Soft Cost Reduction $34,913,000	**$23,100,000**	**-$11,813,000**
• 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.	• National Laboratory funding is maintained at a steady state to support the portfolio of merit-reviewed projects selected in FY 2015 to ensure that research continues as planned for the FY 2016-2019 three-year cycle.	• National Laboratory funding is maintained at a steady state to ensure that research continues as planned for the FY 2016-2019 three-year cycle.
• 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.	• No new worked planned in this area.	• Work fully funded in FY 2016.
• 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.	• No new worked planned in this area.	• Work fully funded in FY 2016.
• Installation, Quality Assurance and Utility/Manufacturing Standards Effort will comprehensively address best practices for products and installation to reduce costs and ensure consumer protection.	• No new worked planned in this area.	• Work fully funded in FY 2016.
• 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.	• No new worked planned in this area.	• Work fully funded in FY 2016.

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
	• Issue and select project under the Business Models FOA: ▪ A second round of the Solar Market Pathways topic area will support 6 to 10 new awards that will develop, pilot and/or scale new business and financial models that increase access to solar electricity, create new markets for solar and decrease the soft costs of solar deployment for a broad range of consumers and communities.	• This new funding opportunity will focus on reducing soft costs of solar deployment.
	▪ A Utility Challenge topic area will support 10 to 15 projects focused on the obstacles for utilities to empower IOUs, COOPs, and MUNIs, to embrace the changing landscape of delivering solar electricity to consumers. The obstacles for utilities are grounded in the organizational ability to innovate new business models and the agility to adopt compatible information/decision-support and knowledge systems. This program is designed to help utilities address a number of challenges in this rapidly changing marketplace.	• NewFOA topic intended to reduce the barriers for utility engagement.

Solar Energy
Innovations in Manufacturing Competitiveness

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 solar technology 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.

Despite U.S. technological leadership over the last 35 years, 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. The IM subprogram focuses its efforts to ensure that technologies developed in the U.S. can compete in the global marketplace. This also includes investigating segments of the value chain where America has defensible, long-term competitive advantages.

The Solar Energy Program has a well-developed and integrated technology-to-market strategy that supports U.S.-based business along a spectrum of development activities. In 2014-2015, the U.S. solar manufacturing industry expanded for the second year in a row. Several new manufacturing facilities, including what will be the largest solar manufacturing facility in the western hemisphere, with direct DOE technology development linkage, began construction to address U.S., as well as growing global, markets. Several foreign companies have announced their intention to start manufacturing in the U.S. The DOE strategy to invest in manufacturing technology innovation that could provide U.S. companies the competitive advantage, such as high-performance products, in an un-level global marketplace helps strengthens the U.S. innovation ecosystem that has the highest innovative output in this space, including National Laboratories. In FY 2017, the IM subprogram will fund two focus areas to support the achievement of the SunShot Initiative:—Technology to Market and Manufacturing Technologies.

Focused research in the Technology to Market portfolio supports 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 tenth round. The DOE SunShot Initiative Incubator Program supports businesses seeking to commercialize innovations in hardware installation, grid conversion technologies, and novel business models as well as software platforms for reducing soft costs. 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 annual solicitation is open to a wide range of topics. 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 2017, the DOE SunShot Initiative Incubator will continue its twelfth round of providing early-stage assistance to help small businesses cross technological barriers to commercialization while encouraging private sector investment. The project payments are made upon completion and verification of aggressive project deliverables.

The Solar Manufacturing Technologies (SolarMAT) Program 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 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 of the private sector to achieve U.S. -based cost-effective manufacturing. In FY 2017 SolarMAT will continue to fund R&D in manufacturing, including advanced materials processing, automation, and materials substitution for lowering costs.

In support of greater solar technology ecosystem, and industry advancements, the Solar Energy Program will also issue a Solar Consortium FOA in FY 2017 to close the gap in the research done by universities and industry. The Program will also focus on advanced materials R&D ($10 million) in support of the Administration's Materials Genome Initiative (MGI) and Advanced Manufacturing Partnership 2.0. Building upon the findings and lessons learned through investments in durable materials, the program will establish a National Lab-led consortium with unique expertise and capabilities under the Energy Materials Network (EMN) that will use an accelerated R&D approach to discovering and developing durable coatings and packaging materials for photovoltaic modules including advanced anti-reflective coatings, encapsulants, flexible packaging and glass alternatives. The program will also competitively select projects with universities, and private-sector and other partners to conduct collaborative R&D with the Lab-Led consortium on topics related to durable materials for new and existing PV form factors. Developing high-performance materials that are designed for durability is of particular importance since these layers must be able to withstand decades of harsh conditions (UV, H_2O, freeze/thaw, and/or physical abrasion) while maintaining properties such as transmission, index matching, adhesion, anti-soiling, and/or low H_2O/O_2 permeability. The National Laboratory-led consortium will drive innovation across computation, data informatics, and high-throughput experimentation through integration of national labs, academic institutions, and the PV industry in order to achieve its goals. Through this consortium, SETO will support the development of an infrastructure that can predict and use high-throughput techniques to discover advanced coatings and module materials to lower the levelized cost of PV electricity.

The IM program also funds technology cost analysis and competitiveness analysis at the National Laboratories to inform strategic funding directions for technology development within the program and to assess higher-leverage opportunities for U.S.-based supply chain development.

Innovations in Manufacturing Competitiveness
Activities and Explanation of Changes

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
Innovations in Manufacturing Competitiveness $43,488,000	**$62,000,000**	**+$18,512,000**
• 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 to reduce the trade imbalance in the solar industry.	• Issue SolarMAT V solicitation and competitively select 10-20 projects focused on developing solar manufacturing technologies with the greatest potential to reduce cost in manufacturing and supply chain to reduce the trade imbalance in the solar industry.	• Increasing the number of awards in SolarMAT to address the focus on solar technologies beyond modules (racking, systems integration commercialization etc.)
• Implement Incubator round 11 to provide early stage assistance to help 10 to 20 small businesses commercialize innovative solar technologies.	• Implement Incubator round 12 to provide early stage assistance to help 20-30 small businesses commercialize innovative solar technologies.	• Increasing the number of awards in Incubator to address the focus on solar technologies beyond modules (racking, systems integration commercialization etc.)
• Initiate the durable materials lab call 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 percent in time.	• The Solar Consortium lab component will build upon the findings and lessons learned through the FY 2016 investments in durable materials, and will use a materials genome approach to discovering and developing durable coatings and packaging materials for photovoltaic modules including advanced anti-reflective coatings, encapsulants, flexible packaging, and glass alternatives.	• This increase will enable the program to explore a materials genome approach to discovering and developing durable coatings and packaging materials for photovoltaic modules.
	• The Solar Consortium FOA component will work to close the gap in the research done by universities and industry.	• New activity in support of greater solar technology ecosystem, and industry advancements.

Solar Energy
Next Generation Renewable Fuels and Chemicals R&D

Description

Next Generation Renewable Fuels and Chemicals R&D subprogram mission is to support the transition to a clean energy economy through innovative approaches of converting and storing solar power into usable fuels. With the anticipated proliferation of solar power at the centralized and distributed scales, there is an opportunity to store excess solar energy by producing low-cost fuels generated using variable renewable energy. While electrochemical batteries costs continue to decrease, fuels will still be needed in specific cases where high energy density is required. The goal of this subprogram is to produce hydrocarbon fuel from carbon dioxide, at scale, and at a cost lower than $50 barrel of oil equivalent (<$2/gallon gasoline). As electricity is the major cost component of producing synthetic fuels, the ultra-low cost of solar electricity that we can expect in the future can make a difference; for $2/ gallon gasoline equivalent, electricity cost must be $0.02/kWh.

In FY 2017, the subprogram will issue a competitive funding opportunity announcement to solicit initial projects focused on feedstocks and conversion pathways ($10 million). Feedstock inputs of interest include partially or fully oxidized forms of carbon, hydrogen, sulfur, and nitrogen. Conversion pathways of interest will include thermochemical, electrochemical, photoelectrochemical, biological, and processes to generate products including hydrogen, hydrocarbons, ammonia, and other energy dense fuels and industrial chemicals. The initiative will address the system integration challenges of coupling electrocatalysis cycles with photovoltaic energy generation. The funding will offer opportunity to leverage basis research funded historically by BES (Joint Center for Artificial Photosynthesis for example) toward applied research and development of commercially relevant systems.

This work builds on earlier efforts on thermochemical storage from the CSP subprogram, including the ELEMENTS FOA, which worked to develop energy storage reaction cycles based on ammonia, metal hydrides, metal oxides, and metal carbonates. Thermal and electrochemical methods could also be used to increase the energy density of conventional fuels like methane (natural gas) through solar powered conversion into syngas (hydrogen/carbon monoxide mixture) or other energy dense fuels. Additionally, this work could be leveraged to offset energy intensive industrial production of chemicals such as fertilizers (ammonia).

Next Generation Renewable Fuels and Chemicals R&D
Activities and Explanation of Changes

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
Next Generation Renewable Fuels and Chemicals R&D $0	**$10,000,000**	**+$10,000,000**
• No funding requested within the Solar Energy Technologies Budget Request.	• Issue a FOA and select 4 to 6 initial projects focused on feedstocks and conversion pathways for producing fuels from variable renewable solar power.	• New activity to diversify SETO's storage portfolio.

Solar Energy
NREL Site-Wide Facility Support

Description

In FY 2017, EERE will continue to directly fund National Renewable Energy Laboratory (NREL) Site-Wide Facility Support costs rather than fund those costs as laboratory overhead.

EERE proposes to eliminate the NREL Site-Wide Facility Support subprograms in its individual technology programs, and consolidate NREL Site-Wide Facility Support funding in the Facilities and Infrastructure Program. Locating this funding in the Facilities and Infrastructure Program will provide clarity and transparency in communicating EERE's stewardship for NREL, and will simplify planning and execution of EERE's annual budget. This consolidation into a single program allows for better integration and coordination of operations and investments.

NREL Site-Wide Facility Support
Activities and Explanation of Changes

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
NREL Site-Wide Facility Support $9,200,000	**$0**	**-$9,200,000**
• 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 funding requested within the Solar Energy Technologies Budget Request.	• Reduction in the Request is offset by a corresponding increase in the Facilities and Infrastructure Budget Request. Funding is consolidated in EERE's NREL Site-Wide Facility Support.

Solar Energy
Performance Measure

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 2015	FY 2016	FY 2017
Performance Goal (Measure)	**Photovoltaics (PV) -** Cost of solar power from photovoltaics (cents/kWh)		
Target	10	9	8
Result	Met - 10	N/A	N/A
Endpoint Target	6 cents/kWh by 2020, cost competitive with traditional electricity sources		

Wind Energy

Overview

The U.S. has abundant natural wind resources, both over land and offshore and across all 50 States and wind power has confirmed its credibility as a scalable, reliable, and environmentally sound, domestic energy technology. Wind power also has very low life-cycle greenhouse gas (GHG) emissions, criteria pollutant (NO_x, SO_x, and $PM_{2.5}$) emissions, and water use; therefore making wind a valuable component in the U.S. electricity generation portfolio of domestic, low-carbon, low-pollutant power generation solutions. Wind power has rapidly become a mainstream power source in the U.S. electricity portfolio, with nearly 66 gigawatts (GW) of installed capacity in 39 states, supplying 4.9 percent of the Nation's electricity end-use demand in 2014, and wind power costs have declined by more than one third from 2008-2014. The U.S. wind industry has robust domestic manufacturing capacity and supported 73,000 U.S. jobs in installation, manufacturing, and operations in 2014, with more than 500 U.S. wind-manufacturing facilities in 43 states. Strong market demand coupled with the size of wind turbine components has enabled this robust domestic manufacturing sector.

Technology innovations provide an opportunity for further, significant cost reduction and expansion of U.S. wind power. A 2015 analysis of U.S. wind energy potential was performed by a collaboration of DOE with over 250 experts from industry, electric power system operators, environmental stewardship organizations, state and Federal Governmental agencies, research institutions and laboratories, and siting and permitting stakeholder groups. The collaboration analyzed and wrote a new report entitled "*Wind Vision, A New Era for Wind Power in the United States*" published by DOE in March 2015. This report concluded that a scenario in which wind power supplies 10 percent of national end-use electricity demand by 2020, 20 percent by 2030, and 35 percent by 2050, is technically feasible, generates long-term savings, and provides substantial environmental and local community benefits.

The Wind Energy Program focuses on enabling and accelerating widespread U.S. deployment of clean, affordable, reliable, and domestic wind power to promote national security, economic growth, and environmental quality through a balanced program of technology research and development (R&D), testing and demonstration, and deployment efforts. Land-based wind technology in high-wind speed locations is cost competitive today, in locations with access to transmission capacity. Wind Energy Program activities therefore target lowering U.S. wind power costs for the remaining balance of land, offshore, and distributed wind opportunities to also be directly cost-competitive (without subsidy) with traditional electricity sources across the Nation. High-wind speed sites will also benefit from program efforts by increasing energy capture and decreasing loads, thereby improving reliability. Program RDD&D on taller towers, larger rotors, and increased energy capture aims to broaden the number of available sites for economic wind deployment. Several specific core challenges for wind power, include wind turbine design, reliability, wind plant optimization, cost reduction, and mitigation of environmental impacts and deployment barriers, including grid integration.

Highlights of the FY 2017 Budget Request

In FY 2017, through its Atmosphere to electrons (A2e) initiative the program will fund R&D to improve the performance and reliability of next-generation "smart wind" plants by investigating systems-level interactions influenced by atmospheric conditions, variable terrain, and machine-to-machine wake interactions. The program will conduct field experiments to validate the performance improvements from innovative wake controls in realistic atmospheric operating conditions.

The Wind Energy Program will issue a "Tall Wind" (hub heights of 140m or greater) competitive solicitation to access higher altitude wind resources with topic areas in turbine components, such as blades and towers, to support the design, manufacturing and demonstration of full-scale technologies that mitigate U.S. transportation and logistics constraints. Domestic technology innovation is needed to reduce the costs of manufacturing and deploying taller turbines in the U.S. to leverage our vast resources at higher elevations above the ground.

A competitive solicitation to establish an Offshore Wind R&D Consortium will be issued. This Joint Industry Project (JIP) will focus on technical challenges of special significance to the U.S. offshore wind industry. Research areas will address cost reduction for deep-water floating foundations and moorings, new approaches to installation that are compliant with existing maritime law, design standard development for the extreme marine conditions unique to U.S. waters, and other key industry research priorities for cost reduction. It will also include technologies to address turbine-turbine wake interaction and enhanced reliability, thereby reducing operations and maintenance (O&M) costs for offshore wind farms by requiring less frequent scheduled maintenance.

The program will provide funds for the sixth year of a program previously competed through the FY 2012 Offshore Wind Advanced Technology Demonstration Project Funding Opportunity Announcement (FOA), to support the establishment of a competitive U.S. offshore wind industry through offshore system development and demonstration. These projects are currently active.

To help enable effective co-existence of wind energy and wildlife, a competitive solicitation will be issued to develop or improve eagle risk assessment, compensatory mitigation tools, and refinement of curtailment approaches for significant reductions in bat mortality. These efforts will complement and build-upon projects funded over the past two years, to provide a robust set of tools for assessing, minimizing, and compensating for impacts of wind energy development on wildlife.

As part of the DOE Grid Modernization Initiative, the Wind Energy Program will focus its efforts in each of the six technical areas detailed in the Grid Modernization Multi-Year Program Plan (MYPP). In Devices and Integrated System Testing, the Program will work on the integration of distributed wind technologies, power electronics, device controls enhancing system stability, and hybrid energy-storage systems. In Sensing and Measurement, the Program will focus on the development of new wind forecasting tools. In System Operations, Control, and Power Flow, Wind Energy will work on developing control algorithms to manage congestion and provide system support to the grid. In Institutional Support, Wind Energy will work in partnership with utilities and regulators to provide information on the deployment of wind. The Design and Planning Tools technical area will work on tools and develop planning studies that help utilities and other stakeholders understand the impact of wind technologies on the system. Finally, Wind Energy will support broader demonstration projects that will co-optimize across multiple grid attributes including affordability, security, resilience, reliability, and integration of clean technologies.

FY 2017 Crosscuts ($K)

	Grid	Total
Wind Energy	**12,730**	**12,730**

Wind Energy
Funding ($K)

	FY 2015 Enacted	FY 2015 Current[1]	FY 2016 Enacted	FY 2017 Request	FY 2017 vs FY 2016
Wind Energy					
Technology Research, Development & Testing (RD&T) and Resource Characterization (Land, Offshore, Distributed)	34,658	33,594	24,789	87,500	+62,711
Technology Validation and Market Transformation	46,250	46,250	47,650	30,200	-17,450
Mitigate Market Barriers	11,207	11,207	12,395	34,000	+21,605
Modeling and Analysis	10,185	10,185	8,166	4,300	-3,866
NREL Site-Wide Facility Support	4,700	4,700	2,450	0	-2,450
Total, Wind Energy	**107,000**	**105,936**	**95,450**	**156,000**	**+60,550**

SBIR/STTR:

- FY 2015 Transferred: SBIR $935,000; STTR $129,000
- FY 2016 Projected: SBIR $652,000; STTR $98,000
- FY 2017 Request: SBIR $1,621,000; STTR $228,000

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

Wind Energy
Explanation of Major Changes ($K)

	FY 2017 vs FY 2016 Enacted
Wind Energy	
Technology RD&T and Resource Characterization (Land, Offshore, Distributed): Increased funding due to launch of the competitive Offshore Wind R&D Consortium to accelerate fundamental offshore-specific R&D activities and a "Tall Wind" competitive solicitation for accessing higher altitude wind resources through innovations in turbine components, such as taller towers and larger rotors, which also address U.S. transportation and logistics constraints.	**+62,711**
Technology Validation and Market Transformation: Decreased funding will continue to support the offshore wind demonstration projects and also reflects a reallocation of some resources to support complementary fundamental offshore wind R&D under the Technology RD&T and Resource Characterization (Land, Offshore, and Distributed) subprogram. The demonstration projects timeline have been extended an additional year, allowing the remaining balance of the mortgage to be split between FY 2017 and FY 2018.	**-17,450**
Mitigate Market Barriers: Increased funding due to the proposed solicitation on wind-wildlife impact reduction, and work with interagency partners to demonstrate novel, radar-interference mitigation measures, including software approaches to filter wind turbine interference from radar signals.	**+21,605**
Modeling and Analysis: Decreased funding due to change in accounting for programmatic activities including development and execution of annual operating plans and programmatic strategic plans; strategic support for National Laboratories and technology partners, and other communications needs and requirements. This funding is now pro-rated across the subprograms; the scope of work is unchanged.	**-3,866**
N**REL Site-Wide Facility Support**: In FY 2017, EERE proposes to move funding for the NREL Site-Wide Facility Support subprogram from individual technology programs to the Facilities and Infrastructure Program. Locating this funding in the Facilities and Infrastructure program will provide clarity and transparency in communicating EERE's stewardship of NREL, and will simplify planning and execution of EERE's annual budget. This consolidation into a single program allows for better integration and coordination of operations and investments.	**-2,450**
Total, Wind Energy	**+60,550**

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

Description

The primary objective of the Technology Research, Development and Testing (RD&T) and Resource Characterization (Land, Offshore, Distributed) subprogram is to reduce the U.S. wind power levelized cost of energy (LCOE) for land, offshore and distributed wind systems to be directly cost-competitive with traditional electricity sources across the nation. The subprogram's strategy for cost reduction is to optimize the cost and performance of the wind plant as an integrated system, rather than focusing solely on components, because LCOE is determined at the wind-plant system level. To address key cost drivers — capital costs, O&M costs, annual energy production (AEP), and financing rates — and improve the performance and reliability of the wind plant overall, the subprogram invests in a range of parallel and complementary activities. These activities inform wind turbine technology innovations–including those that enable higher hub heights, larger rotors, and improved energy capture–to provide the opportunity for significant expansion of U.S. wind power deployment through 2030 and beyond.

The Program's applied research portfolio ($37 million) takes an integrated approach to wind plant cost of energy reduction through complex aerodynamics R&D, advanced component manufacturing and development, wind plant reliability improvement, resource characterization and wind-specific test facilities that will reduce wind plant LCOE through increased annual energy capture and lower cost, more reliable turbines. Atmosphere to Electrons (A2e) is a major component of the subprogram examining the performance of an entire wind plant comprised of an array of turbines. This complete system approach enables the design and deployment of low-cost "smart" wind power plants by improving current predictive capability of wind plant flow and performance. A2e is conducting R&D for next-generation wind plants to reduce wind plant underperformance (20-30 percent observed in current operational wind plants), and operations and maintenance (O&M) costs. The goal is to improve wind plant reliability over 20-25 year lifetimes, demonstrating a "smart" wind plant through real-time plant-flow control strategies capable of increased energy capture and mitigating stress loading in both existing and next-generation wind plants, and to lower the integrated plant systems LCOE by 20 percent.

Other long-term objectives also include developing, using, and maintaining testing facilities to support research and certification of wind turbine technologies at the component, turbine, and wind plant levels for land, offshore and distributed wind systems. Technology R&D in the wind manufacturing and supply chain helps U.S. manufacturers develop advanced blade designs, improve fabrication techniques, and automation processes; and encourages collaboration with wind technology suppliers to increase reliability while lowering production costs, and promotes an industry that can meet all domestic demands while competing in the global market. All non-federal facilities (a.k.a. user-facilities) will move toward a more sustainable business model based on user fees as opposed to Federal support.

In FY 2017, the A2e initiative will build upon the Wind Forecasting Improvement Project phase 2 (WFIP 2) field campaign and conduct research to improve the wind forecasting models and disseminate them to the industry. The initiative will include comprehensive field experiments to develop and validate high-fidelity wind inflow and wake models, and to develop and demonstrate innovative wind-plant flow control strategies for land and offshore wind applications. It will also leverage DOE high-performance computing (HPC) assets at the National Laboratories, and simulation toolsets to develop wind application-focused, high-fidelity, and computational simulations capable of modeling the relevant physical processes critical to predicting wind plant performance and turbine loads. In partnership with wind turbine OEMs, wind plant owner/operators, and the wind consulting industry, A2e will conduct a detailed wind plant energy production benchmarking exercise to understand the underlying cause for differences between pre-production estimates and the actual power production observed in operational wind plants.

Funding in FY 2017 will continue to support operation and enhancement of DOE's world-class testing infrastructure, including the National Wind Technology Center (NWTC) in Colorado and the Scaled Wind Farm Test Facility (SWiFT) in Texas, as well as collaborations with the Massachusetts Blade Test Facility and Clemson Drive Train Facility in South Carolina. The testing infrastructure 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 field conditions wind turbines are likely to experience.

In collaboration with the Office of Science National Laboratories (e.g. Argonne, Oak Ridge) High Fidelity Model (HFM) development efforts, the subprogram will begin to examine the most appropriate methods for incorporating future exa-scale computing capability for a coupled atmosphere to turbine integrated analysis capability that resolves the atmosphere/wind plant coupled interactions. This effort represents a significant first step in providing an integrated analysis method to assess new wind-plant technology options and predict actual installation cost and performance with a high degree of certainty, using a virtual digital environment.

In FY 2017, the subprogram will support development of transformative component technologies and manufacturing methods to enable domestic manufacturing through a competitive solicitation ($22.5 million) enabling taller wind turbines ("Tall Wind"), thereby improving access to higher altitude wind resources. The objective is to demonstrate the design, manufacturability and testing of full-scale technologies that address the technical challenges and have the cost performance needed to reach wind turbine hub heights between 110 m and 140 m economically. For context, current U.S. turbines average just over 80m hub heights. The subprogram will also investigate challenges in the areas of lightning damage to blades, and electrical collector systems and power electronics failures.

In FY 2017, the subprogram will issue a competitive solicitation to establish an Offshore Wind R&D Consortium ($25 million) to accelerate fundamental R&D targeting offshore wind specific technology barriers. This four-year Joint Industry Project (JIP) initiative will target U.S.-specific offshore wind challenges including unique U.S. resource and operating conditions, floating platforms to access the extensive deep-water resource in the U.S., new approaches to installation, turbine-turbine wake interaction, and the high cost of offshore wind operations and maintenance. The Consortium will include industry stakeholders, turbine OEMs, universities, DOE National Laboratories, and states with offshore wind resources. Offshore wind conditions in U.S. waters are significantly different from European settings, as evidenced by hurricanes and bimodal marine conditions along the east coast and extreme water depths and metocean conditions along the west coast. The unique conditions in the U.S. may therefore lead to innovative solutions not seen in European market. Projects will be conducted to address these challenges, and the most promising technologies will be developed, de-risked and commercialized as the Consortia works closely with the supply chain throughout the process.

Funding also supports investment in activities to increase the economic viability of distributed wind energy systems ($4.4 million), relative to other distributed generation technologies and retail electricity rates. Distributed wind is deployed onsite at residential, commercial, and industrial facilities to supply all or a portion of local energy consumption or to support local grid operations. In FY 2017, the subprogram will award a competitively selected project targeting soft cost reductions for distributed wind systems. In addition, the subprogram will continue its annual competitive solicitation for system optimization to increase performance, advanced manufacturing to reduce hardware costs, and turbine testing to increase the number of certified small and medium wind turbines, with the goal of reaching 40 cumulative certified turbine model designs by the year 2020 (13 certified turbine designs as of 2015).

The program supports the Clean Energy Manufacturing Initiative (CEMI), with R&D aimed at increasing U.S. manufacturing competitiveness in wind energy. Additive, or 3-D, manufacturing could remove limitations on tooling, configuration, component design and variations, or production time and transform the wind manufacturing industry. The U.S. will need to aggressively research this nascent technology and its application to the wind industry to ensure a worldwide competitive advantage and maintain domestic manufacturing strength.

Activities and Explanation of Changes

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
Technology RD&T and Resource Characterization $24,789,000	**$87,500,000**	**+$62,711,000**
• Conduct joint computational-experimental campaigns, including the following core activities: ▪ 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. ▪ High-fidelity simulations in conjunction with scaled experiments to study turbulent inflow and near-wake development.	• The program will continue efforts to overcome the issues with moving from large-scale weather forecasting to wind plant time and space scales while quantifying the uncertainty remaining in the forecasts for land and offshore wind applications. • The program will continue to execute the joint computational-experimental program for new research rotors at the Sandia SWiFT Facility and high-quality measurements to understand the development of wind turbine wakes and its impact on the power production and loads of a downstream turbine under realistic atmospheric inflow conditions. Engage the wind stakeholder community to conduct detailed validation of the computational models to improve wind plant performance prediction capability.	• Field data campaigns will provide data to experimentalists, meteorological and oceanographic modelers to overcome the issues of wind plant inflow on scales the wind industry demands of DOE research. • The SWiFT experimental campaign will obtain one of a kind, unique datasets of high quality measurements that will be used to advance the industry's understanding of rotor wakes and innovative control paradigms that can be used to minimize the adverse impacts that the wakes have on rotor performance and turbine loads. The scaled rotors will mimic the performance characteristics of a full-scale, modern-day, utility turbine. The use of scaled research rotors instead of full-scale equivalent has the advantage of being considerably cheaper to manufacture and test for longer periods.
• Initiate a new aeroacoustics experimental testing program at the Scaled Wind Farm Test facility (SWiFT). The objective of this AOP task is to experimentally quantify noise reductions of promising technologies.	• No funding requested for this activity.	• Postpone further aeroacoustics analytic research to FY 2018.
• Use 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 percent energy losses in operating wind plants. Experiments will investigate the extent to which novel plant-level control strategies may be able	• Development and deployment of research blade sets for turbines at the SWiFT facility that mimics the performance of utility scale rotors. • Complete first round of wind turbine array experiments aimed at understanding and mitigating the effects of wake losses through improved wind turbine control methods.	• Continuing the implementation of wind turbine plant optimization projects through wind turbine array research at the SWiFT facility. Activities are aimed at addressing the underperformance of wind turbine plants, and developing technologies to mitigate these losses. Initial simulations have shown that yaw-based, wake-flow control strategies can increase the turbine power capture

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
to reduce wake losses in existing and future wind plants.		by up to four percent. The scaled rotor sets to be installed at SWiFT facility allow researchers to understand the performance issues related to rotor wakes at a fraction of the cost required for testing at full scale.
• Develop turbine component and wind plant system design tools that integrate cost models with system dynamics models for land-based and offshore applications.	• FY 2017 activities will build upon the capabilities developed in prior years to investigate the potential of co-designing controls and turbine layout to improve the performance of wind plants.	• No significant change. FY 2017 is a continuation of prior year activities.
• Correlate the uncertainty and underperformance of wind plants and associated financial risk to identify technology improvement opportunities.	• In partnership with turbine OEMs, wind plant owner/operators, and wind energy consultants, conduct a comprehensive benchmarking of the wind-plant power production estimation capability by comparing pre-production assessments to actual power production observed in existing wind plants. • Issue new "Tall Wind" manufacturing solicitation and select 2 to 4 projects. Project will demonstrate the design, manufacturability and testing of full-scale turbine components, such as tower and rotor technologies, showing the ability to address the technical challenges and have the cost performance needed to economically reach wind turbine hub heights of 110m to 140m.	• The benchmarking effort will help industry assess the limitations of their current assessment approaches, quantify the risk and uncertainties associated with pre-production estimates, and develop appropriate mitigation measures to reduce the financial risk and ensure profitability of wind plant operation. • "Tall Wind" investments will demonstrate turbine components, such as tower and rotors. When coupled with innovative drivetrains, deployment is enabled in regions of the U.S. that have not been feasible for wind deployment at conventional wind turbine hub heights.
• Analyze and continue to collect meteorological and oceanographic data using offshore buoys. • Investigate the impacts of hurricane wind and wave conditions on offshore wind turbines.	• No funding request for this activity.	• Offshore wind resource characterization efforts will be part of the proposed Offshore Wind R&D consortium starting in FY 2017.
• 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	• Investigation of root cause of component failures for turbines and condition monitoring techniques to alleviate the costs of maintenance. Specific objectives include investigation of main bearing and high-speed shaft bearing root cause failures, advanced non-destructive inspection techniques for production and operational environments,	• Investigation of electrical collector system and power electronics, and blade damage caused by lightning will allow for characterization of two major sources of failures and will alleviate downtime for maintenance and costly replacement of parts.

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
bearing damage; evaluation of novel diagnostic and prognostic methods based on turbine SCADA data; and continuing to populate and analyze the gearbox failure database.	lightning damage characterization in carbon fiber material, and electrical collection and power electronics reliability analysis.	
• 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.	• Field deployment phase of the WFIP 2 will close at the end of FY 2017. Analysis and model development in coordination with wind industry partners will continue in FY 2018.	• No significant change. FY 2017 is a continuation of analysis of the ending field campaign.
• 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. • 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.	• Provide maintenance, upkeep, and safety support for facilities at the National Wind Technology Center (NWTC), and the Scaled Wind Farm Test Facility (SWiFT), and maintain testing partnerships including those at Massachusetts Blade Test Facility and the Clemson Drive Train Facility. (NWTC facilities include the blade structural test facility, 225kW, 2.5MW and 5.0MW dynamometers, 7.0MVA Grid Simulator, and the Controls Advanced Research Turbines. The SWiFT facility includes an array of test turbines, meteorological towers, wake measuring systems, and instrumentation.)	• Continued support for the operations and maintenance of wind turbine test facilities provides the U.S. with a world-class suite of test capabilities for R&D of innovative designs. The facilities are integrated into important research initiatives such as A2e, providing researchers with a scientific experimentation capability, where high fidelity data can be collected under controlled circumstances.
• Support distributed wind LCOE reduction to be competitive with other distributed generation technologies and retail electricity rates, and increase the number of certified turbine models.	• Continued funding of the Competitiveness Improvement Program (CIP) will address LCOE and turbine certification goals. Based on insights from workshops and feedback from	• While CIP is not funded in FY 2016, there is no change in strategy or scope of work in FY 2017 for CIP as compared to CIP activities funded in FY 2015.

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
• Produce an annual Distributed Wind Market Report covering U.S. wind power in distributed applications — including small, mid-size, and utility-scale installations.	stakeholders additional topic areas may be developed in the areas of wind resource and site assessment. Examples of the 12 projects funded to date include: component improvement, manufacturing process upgrades, certification testing, and type certification. • Annual Distributed Wind Market Report and data portal management. • Deployment scenario analysis with newly developed dGen model for distributed wind market potential assessment and national strategy development. • In FY 2017, a competitive solicitation will be issued to develop innovative approaches to reducing soft costs. Based on results of FY 2016 workshop and development of high-fidelity soft-cost dataset design and implement competitive solicitation to support states and localities developing innovative approaches to soft cost reduction for distributed wind systems. • New activity in FY 2017 to establish an Offshore Wind R&D Consortium. The primary key objective is to collect data and understand unique U.S. weather and ocean conditions challenging offshore deployment. In addition to expansive data collection, the Consortium will research, develop, and deploy innovative and cost effective floating offshore wind platforms and mooring systems including new approaches to installation. The Consortium, which will include a turbine OEM, will RD&T technologies to mitigate turbine-turbine wake interaction as well as test health monitoring systems and components that will reduce the frequency that personnel have to go to the offshore platforms, reducing O&M costs.	• There is no change in strategy or scope of work in FY 2017 for the Annual Distributed Wind Market Report and associated activities. • The newly developed Distributed Generation (dGen) will be exercised in support of developing a national strategy for distributed wind. As a market diffusion model, dGen provides an analytical framework for understanding future distributed wind deployment and provides the capability for quantifying and communicating the opportunities and challenges of the distributed wind market sector. The program has identified high soft costs (non-hardware balance-of-system costs such as siting, permitting and financing) as a barrier to distributed wind system deployment. The competitive solicitation will fund activities targeted towards identifying pathways to reduce permitting costs and increase public confidence in distributed wind systems. • The new Offshore Wind R&D Consortium will enable resource characterization including modeling input and verification, extreme storm monitoring and equipment development. • Using innovative mooring systems for floating offshore wind platforms, it is possible that floating wind can be more cost effective than bottom fixed foundations in transitional water depths, 40-60 meters, in the U.S. • Wake interaction losses for downwind turbines can be up to 30 percent. Current research indicates that wake recovery can be accelerated through new control strategies. NREL has shown the Operations and Maintenance (O&M) costs are nearly 30 percent of the LCOE for offshore wind, in large part due

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
		to the expense of going to and from the offshore platforms.

Wind Energy
Technology Validation and Market Transformation

Description

The primary objective of the Technology Validation and Market Transformation subprogram is to demonstrate and test new technologies at commercial scale. This is particularly important for new sectors, such as offshore wind that have no or limited U.S. supply chain, and it is a critical step to show potential manufacturers and investors the value of these new technologies. In addition to validating through demonstration, the subprogram collects performance and environmental data from demonstration projects and produces public datasets that researchers and private industry may use. These demonstrations and public datasets are critical to advancing and creating new technologies that may transform markets. Demonstrations of new technologies such as floating offshore wind may also transform markets by removing existing market barriers such as the lack of U.S. flagged offshore wind installation vessels.

In FY 2012, the subprogram launched the U.S. Offshore Wind Advanced Technology Demonstration Projects to install innovative offshore wind systems in U.S. waters in the most rapid and responsible manner possible, and to establish the credible potential for commercial development and deployment, and lowering the levelized cost of energy.

Seven geographically and technologically diverse projects were selected in 2012 with the initial objective of advancing project engineering, design and permitting. After a down-select in FY 2014, three projects moved into a second phase encompassing front-end engineering design, further detail on installation, operations and maintenance plans, finalization of necessary permitting, National Environmental Policy Act processes, and securing necessary power offtake arrangements. In addition to the three Awardees moved to the second phase at the FY 2014 down-select, two alternate projects were selected to complete additional engineering and cost estimation work on their innovative foundations addressing unique U.S. offshore wind conditions – deep water and ice, respectively. The subprogram will have performed rigorous annual reviews of all of the three primary Awardees before moving into subsequent budget periods in which fabrication, offshore construction, and operations will take place. The selected offshore wind demonstration projects will collect turbine performance, structural load, wind, wave and environmental data for a period of five years after construction is complete while connected to the electrical grid. This data will inform technology developers, turbine manufacturers, project developers, regulatory agencies, researchers, and others, maximizing the benefits of the projects to the public.

In FY 2017, year six of the program to demonstrate commercial offshore wind innovations will be funded at ($30 million). The demonstration will validate innovative technologies, including foundations and turbines; installation and deployment methods; and unique and cost-effective O&M strategies. The subprogram will plan the procurement, fabrication, and initial construction of the offshore wind demonstration projects with the goal of grid connection in CY 2018. The remaining balance of ($10 million) is planned for FY 2018.

Technology Validation and Market Transformation

Activities and Explanation of Changes

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
Technology Validation and Market Transformation $47,650,000	**$30,200,000**	**-$17,450,000**
• 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.	• Continue fabrication of three Offshore Wind Technology Demonstration projects; following the U.S. content requirements of the Award, the fabrication of the innovative offshore wind foundations will use the U.S. labor force. • Continue installation of the three Offshore Wind Technology Demonstration projects.	• Decreased funding due to strategic refocus to support fundamental offshore wind R&D under the Technology RD&T and Resource Characterization (Land, Offshore, and Distributed) subprogram while still ensuring the success of the demonstration projects. • Fabrication of these demonstration scale projects will allow for study of how the U.S. can use and expand existing capabilities to support commercial offshore wind development in the U.S., creating jobs and reducing GHG emissions. • Installation of these demonstration scale projects will allow for analyses regarding the U.S. existing fleet of vessels and evaluate the cost-benefit of building a purpose-built U.S.-flagged offshore wind turbine installation vessel or using foreign-flagged vessels in coordination with Jones Act compliant vessels.
• Fund the two alternate Offshore Wind Technology Demonstration projects to further substantiate the design and economic value proposition of alternate project designs for offshore wind power. These include concrete semi-submersible foundations as well as monopile foundations designed to reduce ice loading.	• No request for funding of alternates in FY 2017.	• The alternate projects offer additional innovative approaches that, with additional engineering and design, will further enhance the portfolio of American offshore wind technology options. The program will continue to work with these teams to advance their designs to deployment readiness, further positioning the U.S. to lower the barriers to significant offshore wind, contributing to a low carbon future.

Wind Energy
Mitigate Market Barriers

Description

The Mitigate Market Barriers subprogram focuses on addressing environmental, infrastructure and human-based considerations — including birds, bats, grid integration, competing uses, and public acceptance — that must be taken into account to enable and significantly expand wind deployment. The subprogram works with the Department of the Interior agencies, the wind industry, and the conservation community to address issues related to the effective co-existence of wind and wildlife. In permitting wind facilities and complying with state and Federal laws protecting wildlife, such as the Endangered Species Act, Migratory Bird Treaty Act, and the Bald and Golden Eagle Protection Act, developers and operators of wind energy facilities often must take measures to mitigate (avoid, minimize, or compensate for) the potential impacts of their facilities on protected species. Wind energy developers and operators are likely to face increasing siting and environmental compliance challenges over the next several years as threats to bat populations (e.g., White Nose Syndrome) and other wildlife, such as prairie grouse species, drive the potential listing of those species under the Endangered Species Act and as a new permitting regime for Bald and Golden Eagles is implemented. The wind industry has identified these issues, in particular, as some of the most important for DOE to address.

This subprogram conducts grid integration R&D in collaboration with electric grid operators, utilities, regulators, and industry to enable incorporation of increasing amounts of wind energy into the power system while maintaining economic and reliable operation of the national transmission grid. With a number of states having wind electrical generating capacity greater than 10 percent of their total installed capacity and some utilities seeing instantaneous wind generation production of up to 60 percent, the U.S. continues to move closer to wind penetration levels that 10 years ago were purely theoretical. While these penetration levels are still lower than scenarios studied in reports such as the Western Wind and Solar Integration Study (Phase 1-3) and the Eastern Renewable Generation Integration Study, the studies have helped lay the groundwork for utilities to understand how to effectively operate the power grid under high penetrations of wind energy.

The subprogram works to resolve remaining questions for offshore wind developers regarding the types and magnitude of environmental impacts, and the most effective way to monitor for and mitigate those impacts. Uncertainty around impacts has caused project delays and increased costs for proposed offshore U.S. projects. Since some of these questions cannot be adequately resolved using traditional land-based methodologies, the offshore wind developers need novel technology solutions.

Reducing impacts to wildlife from wind projects will require an ability to predict and identify risks, minimize impacts, and where impacts are unavoidable, to compensate for them. Work funded in FY 2016 and FY 2015 focused on developing deterrent solutions to minimize impacts to eagles and bats respectively. While these tools are critically important to the industry, efforts are still needed to identify variables that lead to high-risk projects, to improve curtailment options and strategies, and to establish the scientific basis for accepted compensatory mitigation tools. Thus, in FY 2017, the subprogram will issue a new competitive solicitation on wind-wildlife impact reduction ($6 million) which will develop or improve eagle risk assessment, compensatory mitigation tools, and refinement of curtailment approaches, which will complement and build-upon the projects funded over the past two years.

Collaboration will continue in FY 2017 with DOD, FAA, and NOAA through the FY 2015 interagency Wind Turbine Radar Interference Mitigation MOU to address the impacts of wind development on critical radar missions, such as completion of a suite of wind-turbine radar-interference mitigation algorithms for DOD, DHS, and FAA long-range and terminal radar systems.

In FY 2017, support for Wind Energy Regional Resource Centers (RRCs) will continue to provide technical assistance on wind energy development to state and local decision-makers and ensure that the public has accurate, impartial information about the benefits and potential impacts of wind deployment on their communities. The subprogram will continue to support the innovative research strategy using the Collegiate Wind Competition (CWC) to challenge teams of undergraduate students from multiple engineering, business and liberal arts disciplines to design, fabricate, test and market new wind turbines, provide opportunities for networking and mentoring with wind industry professionals, and build valuable skills through hands-on experience needed for careers in wind energy. The subprogram will also conclude work on

and release results of a pioneering three-year study to quantify public acceptance and opposition to wind energy development in the U.S. to determine drivers of acceptance and inform future investments.

In partnership with the Canadian and Mexican governments, the subprogram will complete a two-year Pan-North American Renewable Integration Study. Recent changes in the utility industry, coupled with a rapidly changing energy source and grid landscape, provide an opportunity for North American countries to conduct an in-depth study of changing energy futures in the region. The tri-national study focuses on the operational and planning impacts of higher penetration levels of wind power, hydropower, and possibly solar power between the U.S., Canada, and Mexico.

Within the FY 2017 Budget Request, the Wind Energy Program supports the Grid Modernization Initiative ($12.7 million). 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.

Mitigate Market Barriers

Activities and Explanation of Changes

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
Mitigate Market Barriers $12,395,000	**$34,000,000**	**+$21,605,000**
• Fund Eagle Impact Mitigation Technologies research 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. 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.	• The program will continue to support work to better understand and significantly reduce wind/wildlife impacts. To this end, the program will issue a new competitive solicitation on wind-wildlife impact reduction (6 to 8 projects) which will develop or improve eagle risk assessment, compensatory mitigation tools, and refinement of curtailment approaches for significant reductions in bat mortality. These efforts will complement and build-upon the projects funding over the last two years (which focused on developing deterrent solutions to minimize impacts to eagles and bats), to provide a robust set of new tools and approaches for assessing, minimizing, and compensating for impacts of wind energy development on wildlife.	• Additional funds support advanced risk assessment methods, compensatory mitigation tools, and refinement of curtailment for bat mitigation. These tools will help reduce wind/wildlife impacts on key species and provide increased regulatory certainty for wind projects.

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
• Continue laboratory efforts to address the effects of wind development on sensitive bird and bat species.	• Continue and expand work with DOE National Laboratories, Federal partners, and other entities to address the effects of wind development on sensitive bird and bat species, to accelerate testing and evaluation of instrumentation for wildlife monitoring and impact mitigation for both land-based and offshore wind, and work with interagency, industry, NGO and international partners to aggregate and disseminate environmental research findings through avenues such as the Tethys database, National Wind Coordinating Collaborative, Bats and Wind Energy Cooperative, and International Energy Agency white papers and workshops.	• These efforts will help ensure that the wind community has the tools necessary to monitor environmental impacts both onshore and offshore. These tools are critical to reducing project risk and for informing the design of effective mitigation measures. This work will also ensure that the wind community has access to the most recent science and research occurring worldwide to help inform siting, mitigation efforts, target future research, and reduce uncertainty regarding impacts. Work will be a continuation of previous efforts, with added emphasis on monitoring of environmental effects of offshore wind farms expected to be operational at this time.
• 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.	• Complete the final year of work and publish results of the National Public Acceptance Baseline Study.	• Building off data collected in FY 2015 and FY 2016, FY 2017 will focus on final data analysis and publishing this first-of-a-kind study to inform future outreach and stakeholder engagement activities as well as best practices for project development and community engagement in the wind industry.
• With interagency partners, continue to develop measures to mitigate wind turbine-radar interactions.	• Complete development and proof-of-concept demonstration of mitigation algorithms for long-range and terminal radar systems.	• Increased funding to expand mitigation efforts to cover offshore wind/radar interference issues as well as to increase the number and robustness of mitigation demonstrations.
• 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.	• Continue support to WINDExchange and Wind Energy Regional Resource Centers, and publish information on the impact and effectiveness of these initiatives.	• Six Regional Resource Centers are scheduled to complete their work in FY 2017; focus will shift from implementation to evaluation of Regional Resource Center performance to measure the success of the three year effort and inform the future direction of the program's education and outreach.

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
• 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 12 universities across the country, including Alaska to Puerto Rico.	• Continue support to the Collegiate Wind Competition and plan for the third full competition to be held in FY 2018.	• The Collegiate Wind Competition takes place every two years. Building off a successful FY 2016 competition, FY 2017 work will focus on identifying university teams, developing new challenges for students to tackle, and otherwise laying the substantive and administrative foundation for the FY 2018 Collegiate Wind Competition.
• Conduct next generation integration studies using newly developed 10-year wind data sets, including a Pan-North American variable generation and hydropower integration study looking across North America. • Further develop the wind-based transmission line planning tool architecture and improve integration of wind forecast information into grid operational tools.	• Complete the Pan-North American Renewable Integration Study that analyses scenarios of wind, solar, and hydro deployment, operational considerations and possible grid infrastructure and energy transactions planning options between the U.S., Canada, and Mexico.	• The strategy for supporting analysis of renewable integration across North America is unchanged. This analysis is a first of its kind look at the energy future of the three countries related to new renewable development and understanding the operational impacts of future energy transactions between the countries. FY 2017 will be an expanded effort from FY 2016 by including a third country, Mexico.
• In support of DOE's Grid Modernization Crosscut, funding will be used to evaluate regional flexibility, 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.	• Focus activities related to integration of distributed wind including integrated control of distributed wind with other EERE technologies such as building control systems. Work to better include wind-forecasting tools into power system operations, Evaluate new grid controls paradigms to better operate the grid with large amounts of wind energy and work in partnership with utilities and regulators to provide a better understanding of the deployment of wind energy. Forecasting efforts will be operationalized through partnerships between the national labs and utility industry members. For example, Idaho National Labs (INL) has been working with a number of utility partners in an effort to operationalize work related to dynamic transmission line rating.	• Overall, these grid integration efforts will build upon the work initiated in FY 2016 to better refine work scope and specific needs based on progress made in FY 2016. • 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 provides unbiased data reporting of costs and market trends; performs analysis of wind impacts on economic and social factors and metrics, such as GHGs, criteria pollutants, water, wind land use and jobs; creates proactive annual, multi-year and multi-decade planning documents, technology roadmaps and vision reports; and performs analysis to inform and assist prioritization of programmatic RDD&D activities. Focal areas include cost analysis, system engineering, and technology deployment models, cost-benefit impact evaluations, market trends analysis, and reporting. These activities focus on optimization of wind cost reductions, maximizing social benefits, and optimizing wind technology RDD&D investment returns.

The Modeling and Analysis subprogram produces annual, periodic, and one-time reports that are critical to informing the wind industry and wind policy makers. The Wind Technology Market report is the definitive annual publication analyzing the most recent wind installations, cost data and technology and economic trends. The "Wind Vision: A New Era for Wind Power" in the U.S. is a periodic report that in 2015 provided the most comprehensive analysis and monetization of wind impacts ever issued. Over 250 scientists, engineers, and economists, including industry and a wide range of stakeholders contributed to and vigorously reviewed this report. Additional one-time reports, such as the 2015 "Enabling Wind Power Nationwide" report, provide specific insights into regional wind deployment opportunities. Using state of the art modeling and accessing the most detailed wind data available, the subprogram is constantly improving insights and providing detailed data analysis to enable informed policy and investment decisions.

In FY 2017, the subprogram will continue to invest in wind techno-economic and life-cycle assessments to help the program focus its research and technology development priorities and identify key drivers and hurdles for wind-energy technology commercialization. These continually enhanced capabilities will allow the program to identify and fund technology improvement opportunities that will have a significant and immediate impact on the wind industry. The subprogram will complete a revised wind LCOE model to provide a more refined estimate of total system cost, based on current cost trends that exist today in the wind energy market, including fully integrating the Distributed Wind Deployment System (DWDS) expansion model into the Regional Energy Deployment System (ReEDS) Capacity Expansion model, which enables policy scenarios impact analysis (e.g., Clean Power Plan, State RPS analysis, alternative CO2 tax scenarios).

Modeling and Analysis

Activities and Explanation of Changes

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
Modeling and Analysis $8,166,000	**$4,300,000**	**-$3,866,000**
• Conduct technology characterization data gathering, system cost analyses using laboratory generated analysis tools and evaluate the impact of new and emerging technologies on system cost (sensitivity analyses). • 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.	• Data collection and publication of wind technology trends and sensitivities analysis; analyzing congressional and State and Federal agency policy scenarios, such as Clean Power Plan, State, and National RPS and Carbon Tax scenarios. • Implementation of improved Systems Engineering and LCOE analysis models.	• Funding level unchanged. Continued improvement of annual reporting of rapidly changing wind market costs and analysis of trends and sensitivities and improvement of modeling capabilities and range of modeling scenarios considered. • Emphasis now on plant or system level impacts rather than individual plant components (e.g., turbine, installation, and layout) and will support a much higher degree of sophistication in programmatic R&D strategy development.
• Apply and improve core-capacity expansion models — including ReEDS, Plexos and NEMS — to identify and leverage opportunities for accelerated wind deployment and understand variable wind generation's actual costs and benefits with the five Power Markets within the U.S.	• Improve programmatic capacity expansion, transmission and cost modeling functionality for continued identification of opportunities for decreasing wind deployment costs.	• Funding level unchanged. Continued improvement of wind models to improve detailed level of insight into wind deployment key factors and optimization of research impact.
• 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. • Support and participate in program comprehensive wind energy project reviews. • Develop and update MYPP technology roadmaps, and vision reports.	• Review and impact analysis of Wind Energy Program research, development and deployment projects; multi-year program plan (MYPP) technology and Wind Vision roadmap updates. Continue Wind Vision analysis detailing transmission impacts and economic assessments.	• Funding level unchanged. Continued improvement of detailed impacts analysis. Continue to conduct Wind Energy Program external/industry project reviews. Continue to update wind technology and Wind Vision roadmap activities that will identify the status and progress of all of the critical actions identified to optimize wind deployment.
• Collect and analyze wind cost and deployment data to understand current market status and future potential. • Provide unbiased wind market information to stakeholders to decrease uncertainty about wind-power project performance.	• Publish Annual Wind Market Report and domestic wind industry trends analysis.	• Funding level unchanged. Continued improvement of annual reporting of rapidly changing wind market costs and sensitivities. This highly referenced report is the definitive detailed analysis of wind data and trends to inform policy and investment decisions by industry and Government.

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
• Publish the Annual Wind Market Report that provides unbiased information to stakeholders on the status of the domestic wind market in the U.S.		

Wind Energy
NREL Site-Wide Facility Support

Description

In FY 2017, EERE will continue to directly fund National Renewable Energy Laboratory (NREL) Site-Wide Facility Support costs rather than fund those costs as laboratory overhead.

EERE proposes to eliminate the NREL Site-Wide Facility Support subprograms in its individual technology programs, and consolidate NREL Site-Wide Facility Support funding in the Facilities and Infrastructure Program. Locating this funding in the Facilities and Infrastructure Program will provide clarity and transparency in communicating EERE's stewardship for NREL, and will simplify planning and execution of EERE's annual budget. This consolidation into a single program allows for better integration and coordination of operations and investments.

NREL Site-Wide Facility Support

Activities and Explanation of Changes

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
NREL Site-Wide Facility Support $2,450,000	**$0**	**-$2,450,000**
• 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 funding requested within the Wind Energy Budget Request.	• Reduction in the Request is offset by a corresponding increase in the Facilities and Infrastructure Budget Request. Funding is consolidated in EERE's NREL Site-Wide Facility Support.

Wind Energy
Performance Measure

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 2015	FY 2016	FY 2017
Performance Goal (Measure)	**Onshore Wind -** Cost of land-based wind energy (cents/kWh, adjusted for inflation in $2010)		
Target	6.4	6.2	6.1
Result	Exceeded - 6.3	N/A	N/A
Endpoint Target	5.7 cents/kWh by 2020 4.2 cents/kWh by 2030		
Performance Goal (Measure)	**Offshore Wind -** Cost of offshore wind (cents/kWh, adjusted for inflation in $2010)		
Target	18.5	18.1	17.8
Result	Unmet – 19.3	N/A	N/A
Endpoint Target	16.7 cents/kWh by 2020 13.6 cents/kWh by 2030		

Water Power

Overview

Water power — which includes hydropower, pumped storage, and marine and hydrokinetic (MHK) energy — promotes energy security, economic growth, and environmental quality by providing additional opportunities for clean, affordable, and reliable renewable energy from the full range of the Nation's water power resources. Increased use of water power significantly contributes to achieving EERE's goals of increased generation of electric power from renewable resources, reducing greenhouse gas (GHG) emissions, and enabling the integration of other forms of clean energy into a reliable and resilient electricity grid.

U.S. hydropower technology has provided reliable and affordable power for over a century, contributing an average of over 10 percent of cumulative U.S. power generation from 1949 to 2014. Today, hydropower provides approximately 50 percent of all U.S. renewable electricity generation and approximately 7 percent of total U.S. electricity production annually. DOE has also identified significant technical potential for new hydropower deployment: at least 5 GW (13 TWh/year) from rehabilitation and expansion of existing generating assets; up to 12 GW (31 TWh/year) at existing dams without power facilities; and over 60 GW (340 TWh/year) of low-impact new development in stream reaches. The Water Power Program invests in research, development, demonstration, and deployment (RDD&D) to lower costs, and develop the next generation of hydropower technologies across three major hydropower resource classes: existing water infrastructure, undeveloped streams, and pumped-storage hydropower. The program engages other Federal agencies, industry partners, and the environmental community to reduce environmental impacts, promote efficiencies in the regulatory process, and reduce barriers to increased generation and responsible new hydropower development.

Pumped storage hydropower (PSH) also provides energy storage, load balancing, frequency control, and reserve peak-power generation to the energy transmission and power supply system, and constitutes 97 percent of the Nation's bulk storage capacity. Expanded PSH could enable the continued integration of variable renewable power generation, such as wind and solar, into the U.S. electrical grid.

Marine and hydrokinetic (MHK) technologies convert the energy of waves, tides, as well as river and ocean currents into electricity. With more than 50 percent of the U.S. population living within 50 miles of the Nation's coasts and consuming 80 percent of the Nation's electricity, MHK technologies hold significant potential to supply clean renewable electricity to consumers in coastal load centers. This form of renewable energy is attractive due to its long-term predictability and near-term forecast ability, which creates confidence in performance and facilitates grid integration. MHK technologies are in a relatively early stage of development, with a wide variety of designs and architectures and no full-scale, multiple-device commercial deployments in the U.S. This stage of development is analogous to the early stages of U.S. wind power technology development in the 1970s. DOE estimates a U.S. technical resource potential of 1250-1850 terawatt-hours (TWh) of generation per year from ocean wave, ocean current, ocean tidal, and river current energy, a portion of which may be practically and economically feasible to develop. For context, one TWh of electricity could power 90,000 homes each year. The program invests in RDD&D activities to advance cost-effective and environmentally responsible MHK technology for: (1) near-term deployment in early-adopter markets (e.g., coastal population centers with high electricity costs); and (2) long-term deployment in large-scale utility markets. The subprogram's approach to enable near-term deployment focuses on evolutionary technology development to increase annual energy production and reduce costs and market barriers through test and evaluation. The subprogram's long-term efforts focus on achieving techno-economically viable MHK technologies through validation of revolutionary, breakthrough innovations.

Highlights of the FY 2017 Budget Request

The Water Power Program will pursue the following major activities in FY 2017:

- The Hydropower subprogram will competitively fund new research and development projects for new stream reach development (NSD) for innovative hydropower designs and construction methods that mitigate challenges from traditional construction methods, such as economic, operational, or environmental (e.g., blockage of fish migration, or fish habitat fragmentation) factors. These efforts build on FY 2015 competitively selected projects focused on modular civil infrastructure and advanced powertrain components to enable reduced construction costs and minimized environmental footprints for hydropower-related construction. Activities will leverage these advances and will include innovative advanced tunneling methods and water diversion techniques that could capture hydropower potential from

undeveloped streams without using a major dam or impoundment, which would support broad-scale development of new hydropower. The Hydropower subprogram will continue its multiyear efforts to develop metrics for evaluating the environmental performance of new and existing hydropower projects in the U.S. Successful outcomes could support future development of more advanced environmental standards and/or low-impact certifications for hydropower projects, resulting in substantially accelerated project permitting and qualification under state or regional energy development plans. The subprogram will also complete the development of the Renewable Energy Application and Permitting Desktop (RAPID) toolkit for hydropower.

- The MHK subprogram will increase its investment in specialized testing infrastructure, which will directly accelerate development and deployment of U.S.-developed MHK technologies by reducing technical and financial risks, the cost of testing, and time-to-market of commercially ready systems. Building on the subprogram's FY 2016 engineering design and cost estimate, and leveraging knowledge gained from existing test sites, FY 2017 will mark the procurement and construction of the Nation's first open water, fully energetic, grid-connected wave energy test facility. The subprogram will also begin a large-scale field study to evaluate risk to fish from tidal turbines, which builds off successful DOE-funded laboratory and flume experiments, leverages core research capabilities that exist across the Water Power portfolio, and will significantly reduce uncertainty of MHK device environmental effects.
- Following development of novel high-energy capture wave energy conversion (WEC) concepts through the Wave Energy Prize, the MHK subprogram will fund system demonstrations to support the subprogram's long-term approach. Through the design, buildout, and testing of integrated WEC systems, the subprogram will demonstrate that the revolutionary performance requirements of the Wave Energy Prize can be met by a fully outfitted WEC system at a relevant scale (i.e. 1/10 to ¼ scale depending on archetype). The MHK subprogram will also invest in resource characterization to support meeting both near-term and long-term goals. This characterization will identify locations where wave and tidal MHK technologies can be installed quickly to reliably demonstrate near-term commercial-readiness. This first-of-its-kind wave classification scheme will allow developers to strategically design product lines according to resource classes.

Within the FY 2017 Budget Request, the Water Power Program supports one Departmental Crosscut: Energy-Water Nexus (EWN). In FY 2017, the program will fund a new initiative to develop innovative technologies and perform demonstrations and performance/reliability testing, in partnership with water utilities. This effort will focus on small (e.g., multi-kilowatt-to-megawatt scale), modular hydropower systems appropriate for recovering excess energy from the Nation's thousands of municipal water supply and wastewater treatment systems. National Laboratories will validate and publish testing results, with the ultimate goal of increasing the confidence of water utility managers in the reliability and economic viability of these new technologies. The program will also continue to fund the characterization of interactions between hydropower and other water and energy systems and uses, evaluating potential long-term risks.

FY 2017 Crosscuts ($K)

	EWN	Total
Water Power	**6,000**	**6,000**

Water Power
Funding ($K)

	FY 2015 Enacted	FY 2015 Current[1]	FY 2016 Enacted	FY 2017 Request	FY 2017 vs FY 2016
Water Power					
Hydropower Technologies	19,200	18,877	24,750	25,000	+250
Marine and Hydrokinetic Technologies	41,100	40,422	44,250	55,000	+10,750
NREL Site-Wide Facility Support	700	700	1,000	0	-1,000
Total, Water Power	**61,000**	**59,999**	**70,000**	**80,000**	**+10,000**

SBIR/STTR:

- FY 2015 Transferred: SBIR $880,000; STTR $121,000
- FY 2016 Projected: SBIR $1,123,000; STTR $168,000
- FY 2017 Request: SBIR $1,257,000; STTR $177,000

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

Water Power
Explanation of Major Changes ($K)

	FY 2017 vs FY 2016 Enacted
Water Power	
Hydropower Technologies: No significant change in funding.	**+250**
Marine and Hydrokinetic Technologies: Increased funding to fully fund procurement and construction phase of grid connected, open water wave energy test facility.	**+10,750**
NREL Site-Wide Facility Support: In FY 2017, EERE proposes to move funding for the NREL Site-Wide Facility Support subprogram from individual technology programs to the Facilities and Infrastructure program. Locating this funding in the Facilities and Infrastructure Program will provide clarity and transparency in communicating EERE's stewardship of NREL, and will simplify planning and execution of EERE's annual budget. This consolidation into a single program allows for better integration and coordination of operations and investments.	**-1,000**
Total, Water Power	**+10,000**

Description

The U.S. has significant technical potential for hydropower capacity upgrades and development that can deliver clean and reliable power, reduce GHG and criteria pollutant emissions, and provide valuable grid balancing services. The subprogram identified these resources and characterized opportunities for growth through comprehensive National Laboratory research efforts. The national challenge to expanding hydropower's role in the U.S. clean energy portfolio is to develop these resources in a sustainable and environmentally responsible manner. To address this challenge, in FY 2015 the Hydropower Technologies subprogram developed and launched a first-of-its-kind comprehensive strategy, the HydroNEXT Initiative.

HydroNEXT employs science and technology innovation and widespread stakeholder engagement to address technology development challenges and critical environmental and market barrier concerns that new hydropower development encounters. Through this strategy, the subprogram targets specific technology areas that can lower construction costs of basic hydropower-related structures such as dams, diversions, and power plants, as well as reduce costs and lower operation and maintenance expenses of hydropower generation components. Specifically, the endpoint target for cost of energy from small, low-head non-powered dams is 9.2 cents/kWh by 2020 and 7.5 cents/kWh by 2030 and the endpoint target for cost of energy from small, low-head new stream developments is 10.9 cents/kWh by 2020, 8.9 cents/kWh by 2030. HydroNEXT leverages existing technologies, develops new world-class science to identify environmental and market barrier challenges, and informs the industry of new, transformative, and sustainable pathways to additional hydropower development. The HydroNEXT Initiative will directly leverage the FY 2016 national Hydropower Vision report, a collaborative analysis and roadmap examining the costs and benefits associated with hydropower development and addressing the challenges to achieving higher levels of hydropower deployment within a sustainable national energy mix. This multi-year, DOE-led project involved hundreds of individuals and organizations to ensure a diversity of opinions, and included representatives from equipment manufacturers; environmental organizations; Federal, state, and local government agencies; utilities; developers; independent power producers; research institutions and laboratories; and industry associations.

The subprogram engages in partnerships with a wide range of entities and stakeholders across the hydropower industry. Through continued effort under a Hydropower memorandum of understanding (MOU) — a partnership with the Department of Energy, Department of the Army, and Department of Interior — the subprogram collaboratively addresses many of the challenges related to the existing Federal hydropower fleet and applies solutions to the private U.S. hydropower industry by leveraging scientific and technical expertise already established within these agencies. Informed by this expertise, in FY 2015 the subprogram released a first-ever Hydropower Market Report, detailing the current state of hydropower in the U.S. and highlighting the benefits and value that hydropower can and does provide to the Nation.

In FY 2017, the subprogram will continue its multi-year efforts to ensure sustainable development and lower-cost new hydropower development in the U.S. The absence of a full-scale hydropower test facility has presented a significant commercialization barrier to new technology developers who intend to effectively use existing infrastructure. Results of an FY 2016 test facility feasibility effort will be leveraged to support competitively selected front-end engineering and design concepts, and cost-benefit analysis for a potential hydropower test site.

A competitive solicitation for new stream reach development (NSD) will be run to develop new strategies including more innovative water diversion techniques (no-dam hydropower) and advanced tunneling methods that would allow development of areas where hydropower projects cannot be built using traditional construction methods ($7.8 million). In FY 2017, the subprogram will finalize analytic results of small modular applications of PSH (m-PSH) technologies and issue a report capturing the feasibility and economic value proposition of m-PSH.

The sub-program will continue several multi-year research efforts to address the most significant barriers to hydropower development in the U.S. A series of reference studies will be conducted using candidate sustainability indicators, and then the sub-program will issue a draft sustainability framework for evaluation by partners and external stakeholders. This builds upon FY 2016 work where the subprogram initiated a 3-year project to develop agreed-upon scientific metrics for evaluating the environmental sustainability of new hydro projects in the U.S. The subprogram will also support the third year of a 4-year effort to develop new tools that will enable more effective incorporation of biological parameters into

hydropower turbine design, with the objective of dramatically reducing fish passage injury and mortality. This work will be applicable to new facilities, turbine upgrades, and turbine rehabilitations at existing projects.

In FY 2017, research and engagement will continue with other Federal agencies and other partners to reduce environmental impacts and promote regulatory process efficiencies. In partnership with the Corps of Engineers under the interagency Hydropower MOU, the subprogram will conclude the development, testing, and validation of a new, cost-effective injectable acoustic tag capable of tracking juvenile American eel and Pacific lamprey to improve mitigation practices for those species of concern. In partnership with other Federal agencies, the subprogram will complete development of the Renewable Energy Application and Permitting Desktop (RAPID) toolkit for hydropower, with the goal of increasing transparency and access to information about hydropower regulatory processes, ultimately reducing the time and complexity associated with permitting new projects.

In coordination with other DOE research focused on the Energy-Water Nexus Crosscut, in FY 2017 the Hydropower subprogram will initiate a new effort in Wastewater and Municipal Systems by investing in demonstrations and performance/reliability testing of advanced, low-cost different small, modular hydropower systems. In partnership with water utilities, this will address recovery of excess energy from the Nation's water supply and wastewater treatment systems ($5 million). The subprogram will also continue the second year of a 4-year effort to improve accurate representation of hydropower systems in integrated energy assessment models, with the aim of identifying any significant future water and energy systems-level risks ($1 million). The U.S.–China Clean Energy Research Center (CERC) will support some of the work in this area.

Activities and Explanation of Changes

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
Hydropower Technologies $24,750,000	**$25,000,000**	**+$250,000**
• Under the HydroNEXT initiative, solicit and competitively select up to four 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.	• Issue a competitive solicitation (4 to 6 awards) for new stream reach development (NSD), targeting technology readiness levels (TRL) 3 to 5, including innovative water diversion techniques (no-dam hydropower) and advanced tunneling methods such as horizontal drilling that would limit negative aesthetic effects to the surrounding landscape and/or disruption of river topography.	• In FY 2017, focus shifts from hydropower development at non-powered dams to new strategies and novel techniques for NSD, which offers the largest technical potential for hydropower development. To address the environmental challenges of this potential, the traditional project designs and construction methods used to construct hydropower projects will be reexamined in light of more environmentally compatible designs and techniques. Successful demonstration of these techniques could open areas previously considered off limits to new development.
• Issue a solicitation and competitively select up to four projects that will assess the commercial viability of new and advanced pumped storage hydropower (PSH) technologies.	• Finalize analytic results of small modular applications of PSH (m-PSH) technologies and issue a report capturing the feasibility and economic value proposition of m-PSH.	• In FY 2017, the focus shifts from assessing the commercial viability of new and advanced PSH technologies to completing research on lower technology readiness level (TRL) small modular PSH applications. This research will identify opportunities for reductions in m-PSH deployment costs, including use of Commercial Off-the-Shelf (COTS) pumps, turbines, piping, tanks, and valves.
• Identify and leverage existing Federal, university, or industry hydro-mechanical test facilities for full-scale performance and reliability testing of low-impact powertrain and components testing.	• Building upon previous year feasibility activities, a follow on effort will be focused on the detailed development and requirements necessary to initiate a full-scale hydropower test site.	• FY 2017 represents an increased level of effort to support preliminary engineering and design concepts for potential full-scale testing sites.
• 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.	• A competitive solicitation (3-4 awards) will invest in development of a design process accelerator for early stage innovative small hydropower machines to facilitate eventual field-testing.	• Continuation of low-cost, low-impact design strategy. This effort will help enable sustainable and cost-effective new hydropower development.

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
• Validate the environmental performance and sustainability of new hydropower technologies.	• Continue development of biological design tools for new hydropower turbines; the establishment of scientific metrics for evaluating the overall environmental sustainability of new hydro projects in the U.S.; and design and testing of new monitoring technology for American eel and Pacific lamprey.	FY 2017 represents the final year of work to engineer and demonstrate injectable acoustic tags for American eel and Pacific Lamprey, prior to commercialization in FY 2018. These tools will allow for greatly improved monitoring of impacts on these key species of concern. Scientific metrics for evaluating hydropower system sustainability will also be expanded beyond the initial project-scoping phase, which was initiated in FY 2016.
	• Complete development of the Renewable Energy Application and Permitting Desktop (RAPID) toolkit for hydropower, with the goal of increasing transparency and access to information about hydropower regulatory processes, ultimately reducing the time and complexity associated with permitting new projects.	• FY 2017 represents the final year of development planned for the RAPID toolkit, with future efforts being realigned towards measuring and documenting usage and impact.
• Energy-Water Nexus Crosscut: 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).	• Energy-Water Nexus Crosscut: Fund demonstrations and performance/reliability testing, in partnership with water utilities, of different small, modular hydropower systems to recover excess energy at municipal water supply and treatment systems. Also, continue work to characterize the interactions of hydropower with other water and energy systems and evaluate potential long-term risks.	• Initiate a significant new research and demonstration initiative aimed at new hydropower technology systems suitable for deployment within the Nation's existing water infrastructure. This will enable water utility managers to make more informed decisions about the potential future deployments of innovative hydropower technologies within their systems.

Water Power
Marine and Hydrokinetic Technologies

Description

Marine and hydrokinetic (MHK) technologies convert the energy of waves, tides, and river and ocean currents into electricity. The MHK subprogram focuses on funding innovation to drive down the cost of electricity and increase market viability through significant performance improvements and reductions in initial investment costs. These investments in technology deployment, high-risk early-stage technology advancement, resource characterization, market barrier reduction, and other key supporting functions fill a critical gap that the private sector is unable to comprehensively address on its own. The MHK subprogram is committed to investment in RDD&D that allows the domestic MHK sector to rapidly advance and achieve cost competitiveness with local hurdle rates in major coastal load centers by 2030, and nationally by 2050.

The investment strategy has two parallel and complementary objectives: (1) near-term deployment in early-adopter markets; and (2) long-term deployment in large, utility-scale markets. Early-adopter markets — such as remote coastal communities and Department of Defense installations with high electricity costs — are prime locations to demonstrate early technology viability and success. MHK investment focuses on technology innovations to increase annual energy production through improved reliability and availability, and reduction of capital and operating/maintenance cost. Testing of technology improvements, in the open water, will be targeted at locations with early-adopter market potential, where technical and environmental performance can be evaluated and addressed. Longer-term subprogram investments focus on advancing the technology to be viable and cost competitive in large utility-scale markets, such as the western U.S. coast. The program is also exploring using MHK for direct desalination of water (without the need for external electricity to drive the desalination system) in coordination with the AMO Desalination Hub, to address critical freshwater needs in the U.S. The subprogram's long-term approach focuses on revolutionary, breakthrough innovations to develop technologies that are competitive with other energy sources in large markets and can lead to eventual cost-competitive domestic manufacturing.

The subprogram seeks to address the high costs and long regulatory and permitting timeframes for MHK projects, which — when combined with uncertainty of the environmental effects of the technologies and associated impact on permitting requirements — represent a critical hurdle for individual technology developers. As environmental data is difficult to collect in high energy environments with existing instrumentation, the subprogram supports innovation and development of new monitoring and mitigation technologies to facilitate data collection that will enable reduction of environmental risks. Subprogram investment in environmental data collection for individual MHK projects enables the subsequent aggregation, synthesis, and communication of this data to the industry and supports long-term improvements of the permitting process.

In FY 2017, the MHK subprogram will commence procurement for and construction of the critical infrastructure needed for an open water, fully energetic, grid-connected wave energy test facility ($20 million). Commissioning of this multiple-berth wave energy test facility will provide affordable access to world-class test facilities for emerging MHK components and systems to accelerate development and deployment of U.S.-developed technologies through reductions in technical and financial risk, testing cost, and time-to-market. Concurrent FY 2017 investments will include front-end engineering design and sustainable business model concept for a Wave Energy Converter Drivetrain Test Facility.

In FY 2017, through competitive solicitation, the program will fund sub-scale MHK system design, prototype development, deployment, and operation to achieve system performance at a relevant scale. This builds upon the Wave Energy Converter (WEC) concepts that emerge from the Wave Energy Prize, which will solicit WEC concepts that double the energy capture per unit structural cost of today's WEC systems at 1/20 scale. This will also leverage lessons learned from the FY 2014 WEC demonstrations at the Navy's Wave Energy Test Site to ensure that a comprehensive measurement strategy and methodology for data collection is used for validation and learnings from device performance.

In FY 2017, the MHK subprogram will continue to support high-fidelity resource characterization to further understand how to design for and harness the resource potential of the Nation's waves, tides, and ocean and river currents. Pre-commercial site evaluation and characterization of U.S. locations will be conducted to identify those with the highest economic viability and resource potential for pre-commercial, early-market adopters and long-term commercialization. Resource

characterization data obtained through on-site measurements, in combination with validated and verified models, will be used to develop a wave resource classification scheme.

In FY 2017, the MHK subprogram will support (1) the collection of data to systematically address the highest priority MHK environmental issues to drive down regulatory uncertainty and reduce the time and cost of deployment; (2) the development of tools and techniques to effectively address high priority environmental questions; and (3) the aggregation, synthesis and dissemination of environmental research to ensure that successful monitoring strategies from around the world are used in the permitting process of future MHK projects and that research efforts globally are well-aligned. Major new FY 2017 activities will include a large-scale field study to evaluate risk to fish from tidal turbines, which builds off of successful DOE-funded laboratory and flume experiments and will significantly reduce uncertainty of MHK device environmental effects; and an environmental monitoring performance, cost evaluation, instrumentation testing campaign. This campaign will both collect environmental performance data, and will be used to develop baseline cost metrics for environmental monitoring and identify cost reduction pathways.

In FY 2017, the subprogram will complete and deliver validated open source WEC modeling tools and a methodology for extreme conditions modeling that allow industry to confidently design devices to survive extreme sea states without overdesigning and adding substantial material costs for structural reinforcement. Through collaboration with and use of naval facilities, the MHK subprogram will also deliver WEC advanced controls strategies complete with associated experimental data. Other R&D efforts include funding to develop new concept designs through a structured innovation process, materials development and structural health monitoring, and testing and certification of advanced component and systems.

Activities and Explanation of Changes

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
Marine and Hydrokinetic Technologies $44,250,000	**$55,000,000**	**+10,750,000**
• 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.	• Procure and construct an open water, fully energetic, grid connected wave energy test facility including construction of shore-based infrastructure and grid interconnection. • Deliver 100 percent front end engineering design and sustainable business model development of a WEC drivetrain test facility for testing electric machines in oscillation to represent wave power capture.	• Affordable access to a world-class wave energy test facility will directly accelerate development and deployment of U.S.-developed MHK technologies by reducing technical and financial risks, reducing the cost of testing, and reducing time-to-market of commercially-ready systems. • Supporting the preliminary design and business model development of a test facility enables industry to evaluate the costs and benefits of constructing and maintaining such a facility.
• Award up to three competitive MHK subprogram demonstration projects that will integrate advanced components into MHK systems.	• Revolutionary WEC System Performance funding for system design (phase I), and building and testing (phase II) to move high energy capture system concepts resulting from the Wave Energy Prize to demonstrated performance of a fully functional system in open water.	• Complementary to the FY 2016 near-term approach effort to demonstrate of existing systems with evolutionary advancement through next-generation component integration, this FY 2017 demonstration activity addresses the long-term approach. Revolutionary system advancements demonstrated through this effort will aid technology developers in securing investment through exhibiting the equivalent threshold power performance metric established in the Wave Energy Prize at 1/10 to 1/4 scale.
• 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.	• Continue Structured Innovation R&D (year 2 of a 4 year effort) by engaging and leading the sector to use the TPL metric and functional requirement definitions to develop early TRL 3) MHK solutions with greater than TPL 7, and begin planning for simulation and tank testing of the top ranking solutions. Initiating an open innovation environment will allow National Laboratory and industry expertise together to conceive of and advance high TPL system concepts for viability in large utility scale	• No changes. Project proceeding according to 4 year project plan.

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
	markets, in alignment with the subprograms' long-term approach.	
• Coordinate with relevant Federal agencies to continue environmental research and aggregate, analyze, and disseminate environmental research data. Award up to five competitive projects for the development and testing of new sets of instruments for environmental monitoring. 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.	• Coordinate with relevant Federal agencies to continue environmental research and continue the aggregation, analysis, and dissemination of environmental research data. • Provide infrastructure and technical expertise to test and validate mid-level TRL monitoring instrumentation through the Marine Energy Environmental Technologies Initiative (MEET) at PNNL. • Continued environmental research and dissemination will help reduce the time and cost associated with siting and permitting MHK projects, currently a critical barrier in the technology development cycle. • Continued support of environmental models will provide tools that developers and regulators will be able to use in the future to assess project risk in lieu of expensive field studies. • Initiate large-scale field study to evaluate strike-risk to fish from tidal turbines. This issue has been one of the highest environmental concerns in previous years. • Launch environmental monitoring performance, cost evaluation, and instrumentation testing campaign.	• Building off of lab-scale experimentation and initial field monitoring conducted to date, we will initiate a new, 2-year study to further evaluate risk of fish strike from tidal turbines. The aim of the study is to provide rigorous field data to help eliminate uncertainty and associated regulatory risk surrounding this issue. • These efforts will reflect increases in support for the collection of environmental data at deployed projects. An environmental monitoring and instrumentation testing campaign will both fill critical gaps in environmental performance data and will be used to develop baseline cost metrics for environmental monitoring and identify cost reduction pathways.
• Validate open source advanced design tools for extreme conditions modeling, greatly reducing engineering time required to obtain confidence in robust system design. • Validate two-fold improvement of absorbed power of wave energy capture devices in the laboratory with controls technology.	• Complete and deliver open source WEC modeling tools based on extreme conditions modeling validation results and additional industry desired inputs. • Deliver WEC advanced controls strategies complete with associated validation data from testing control strategies in a wave tank (Navy	• In 2017, using the validation data from 2016, the extreme conditions modeling methodology and associated tools will be updated and made ready for developers to apply to their device design process thus aiding them to alleviate risk of design failures from extreme conditions. • In 2016, predictions of performance

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
	collaboration). • Provide public access to control strategies and test data for developers to leverage by selecting the appropriate control strategy and application to their unique device types that will most effectively increase its energy capture.	improvement from multiple control strategies will be published, whereas in 2017, top ranking control strategies will be tested and validated and openly disseminated.
• Complete and release a wave classification scheme to enable design of technology products for resource classes rather than individual designs for specific sites.	• Deploy instruments for detailed pre-commercial site characterization in support of gathering data to enable developer entry into potential early markets. This effort to collect and publish resource classification data will accelerate development of wave energy sites by allowing developers to start planning and engineering earlier and with greater knowledge of device loads. • Refine coarse resolution estimates to establish an initial wave classification scheme ready for industry comment to show early market opportunity locations with demarcations of which regions are which wave class. Refined resource characterization information will help project developer's select suitable sites and technology innovators to better predict survival loads that are critical for MHK device design.	• In 2017, prior year predictions can be supplemented and/or validated with test data. Development of a *validated* wave resource classification scheme will inform industry selection and size of purpose built WEC devices, and provide a catalyst for industry to develop instrumentation with higher fidelity and increased accuracy to observe site-specific resources. • High fidelity resource characterization data obtained through on-site measurements, in combination with validated and verified models, will be used to develop a wave resource classification scheme.

Water Power
NREL Site-Wide Facility Support

Description

In FY 2017, EERE will continue to directly fund National Renewable Energy Laboratory (NREL) Site-Wide Facility Support costs rather than fund those costs as laboratory overhead.

EERE proposes to eliminate the NREL Site-Wide Facility Support subprograms in its individual technology programs, and consolidate NREL Site-Wide Facility Support funding in the Facilities and Infrastructure Program. Locating this funding in the Facilities and Infrastructure Program will provide clarity and transparency in communicating EERE's stewardship for NREL, and will simplify planning and execution of EERE's annual budget. This consolidation into a single program allows for better integration and coordination of operations and investments.

NREL Site-Wide Facility Support

Activities and Explanation of Changes

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
NREL Site-Wide Facility Support $1,000,000	**$0**	**- $1,000,000**
• 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 funding requested within the Water Power Budget Request.	• Reduction in the Request is offset by a corresponding increase in the Facilities and Infrastructure Budget Request. Funding is consolidated in EERE's NREL Site-Wide Facility Support.

Water 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 2015	FY 2016	FY 2017
Performance Goal (Measure)	**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).		
Target	50% increase to PWR	Wave Energy Prize Metric(double ACE (energy capture per cost) from 1.5 meters/million dollars to 3 meter/million dollars)	66 cents/kWh LCOE for Wave Energy
Result	Met - 50	TBD	N/A
Endpoint Target	Competitive with local coastal hurdle rates by 2030		
Performance Goal (Measure)	**Dams -** Cost of energy from small, low-head non-powered dams (cents/kWh)		
Target	Baseline	9.8	9.7
Result	10	N/A	N/A
Endpoint Target	9.2 cents/kWh by 2020, 7.5 cents/kWh by 2030		
Performance Goal (Measure)	**New Stream Developments** - Cost of energy from small, low-head new stream developments (cents/kWh)		
Target	Baseline	11.7	11.5
Result	11.9	N/A	N/A
Endpoint Target	10.9 cents/kWh by 2020, 8.9 cents/kWh 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 nearly 3.6 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 secure 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 and barriers (e.g., optimizing and rationalizing regulatory processes, complementary revenue streams from geothermal brine co-products).

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 enables the geothermal sector to develop cutting-edge technologies and information that expands the potential for domestic geothermal energy growth and future production in new regions.

Highlights of the FY 2017 Budget Request

The Geothermal Technologies Program will pursue the following major activities in FY 2017:

- Continue full implementation of the Frontier Observatory for Research in Geothermal Energy (FORGE) to advance the field operations at the FORGE site. The FY 2017 Budget Request will support the commencement of drilling, continuation of site characterization, and advancement of a competitive solicitation for testing EGS and high temperature tools and techniques at the site.
- Accelerate validation of geothermal Play Fairway Analysis (PFA), which is a methodology for the assessment of exploration success probability and the potential for finding new resources on a regional scale, using analysis and integration of diverse geologic datasets. The objective is to quantify the prospective areas for new geothermal exploration and development. The FY 2017 Budget Request will advance resource validation through the drilling of select and specifically located wells in high-potential "blind" geothermal resource areas identified from Phase 1 in FY 2015 and Phase 2 in FY 2016.
    - 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 2017 Budget Request will support identification of potential sites and assess these new geothermal resource opportunities. Additionally, R&D of thermal desalination technologies will continue in collaboration with the AMO Desalination Hub.

[1] Hydrothermal resources exist 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. Hydrothermal 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.

- Advance the Subsurface Technology and Engineering RD&D (Subsurface) Crosscut in coordination with other Department of Energy (DOE) offices including the Office of Fossil Energy, Office of Nuclear Energy, Office of Environmental Management, and the Office of Science. The Geothermal Technologies Program will fund innovative research and development (R&D) in four key areas — Wellbore Integrity, Subsurface Stress and Induced Seismicity, Permeability Manipulation and New Subsurface Signals — to reduce the cost and risk of geothermal exploration and development. In addition, funding will target a grand challenge R&D topic identified in an FY 2015 Subsurface workshop on "Advanced imaging of geophysical and geochemical signals in the subsurface," which was coordinated with the Office of Science. In FY 2016, the Geothermal Technologies Program will work with DOE partners in the Subsurface Crosscut and with stakeholders to define an ambitious goal with quantifiable metrics and outyear targets to measure progress toward mastery of the subsurface.

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. Subprogram objectives include developing technologies that will drive industry deployment of 30 GW of 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 FY 2014 costs of 22.4 cents/kilowatt hour (kWh) to 6 cents/kWh by 2030; 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 at 6 cents/kWh, which allows the program to target research, development and demonstration (RD&D) efforts on lowering the cost and risk of developing greenfield EGS, both blind and known hydrothermal resources, and greenfield low temperature.

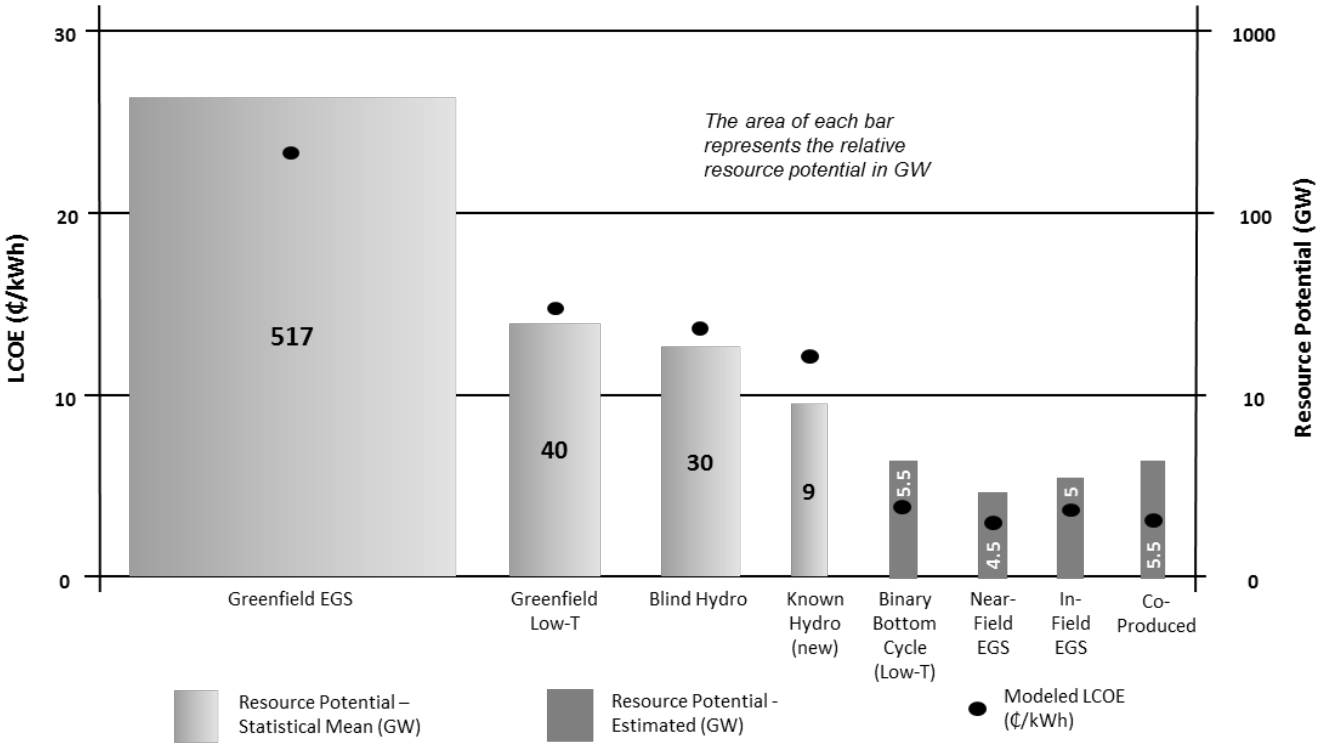


Figure 1: Resource potential (GW) and 2014 modeled levelized cost of electricity, by geothermal resource category.

Within the FY 2017 Budget, the Geothermal Technologies Program supports two Departmental Crosscuts: Subsurface Science, Technology and Engineering RD&D (Subsurface) and Energy-Water Nexus (EWN). The program's proposed Subsurface R&D will address four technical pillars in the subsurface: Wellbore Integrity, Stress State and Induced Seismicity, Permeability Manipulation, and New Subsurface Signals. The program's proposed Energy-Water R&D will continue advancement of unique, geothermal-driven desalination technology which, used in tandem with power generation technologies, could create an energy-neutral or net-positive geothermal desalination cycle. In FY 2017, desalination R&D will move into a pilot-scale demonstration stage.

FY 2017 Crosscuts ($K)

	Subsurface	EWN	Total
Geothermal Technologies	**80,640**	**2,000**	**82,640**

Geothermal Technologies
Funding ($K)

	FY 2015 Enacted	FY 2015 Current[1]	FY 2016 Enacted	FY 2017 Request	FY 2017 vs FY 2016
Geothermal Technologies					
Enhanced Geothermal Systems	32,100	31,998	45,000	45,000	0
Hydrothermal	12,500	12,088	13,800	40,500	+26,700
Low Temperature and Coproduced Resources	6,000	5,802	8,000	10,000	+2,000
Systems Analysis	3,900	3,900	3,700	4,000	+300
NREL Site-Wide Facility Support	500	500	500	0	-500
Total, Geothermal Technologies	**55,000**	**54,288**	**71,000**	**99,500**	**+28,500**

SBIR/STTR:

- FY 2015 Transferred: SBIR $626,000; STTR $86,000
- FY 2016 Projected: SBIR $885,000; STTR $133,000
- FY 2017 Request: SBIR $2,492,000; STTR $350,000

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

Geothermal Technologies
Explanation of Major Changes ($K)

	FY 2017 vs FY 2016 Enacted
Geothermal Technologies	
Enhanced Geothermal Systems: No change in funding	**0**
Hydrothermal: The increase in funding reflects full implementation of the Subsurface Initiative, including full funding for research for all four R&D pillars. The increase will also support additional R&D to address a new Subsurface grand challenge topic on "Advanced Imaging of Geophysical and Geochemical Signals in the Subsurface" identified in an FY 2015 Subsurface workshop.	**+26,700**
Low Temperature and Coproduced Resources: The increase will fund competitively selected projects to advance innovative geothermal deep direct use.	**+2,000**
Systems Analysis: Minimal change in funding.	**+300**
NREL Site-Wide Facility Support: In FY 2017, EERE proposes to move funding for the NREL Site-Wide Facility Support subprogram from individual technology programs to the Facilities and Infrastructure Program. Locating this funding in the Facilities and Infrastructure Program will provide clarity and transparency in communicating EERE's stewardship of NREL, and will simplify planning and execution of EERE's annual budget. This consolidation into a single program allows for better integration and coordination of operations and investments.	**-500**
Total, Geothermal Technologies	**+28,500**

Geothermal Technologies
Enhanced Geothermal Systems

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 that will cause 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, heating up during circulation. Via a production well, this heated fluid then transports that heat to the surface, which is used to generate electricity. In the long term, EGS success would potentially enable the use of an enormous, geographically diverse, baseload energy resource of approximately 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 space and over 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 2017 the EGS subprogram will pursue the development of innovative technology solutions through continuation of Phase 3 of the Frontier Observatory for Research in Geothermal Energy (FORGE), the Geothermal Program's flagship initiative ($35 million). FORGE is a dedicated EGS field laboratory where the program will test novel technologies and techniques, with a primary focus on EGS optimization and validation. By enabling transformative and high-risk science and engineering that the private sector is not financially or operationally equipped to undertake alone, it is a critical step toward creating a commercial pathway to EGS. FORGE is a collaborative and inclusive effort involving a diverse group of geothermal and subsurface stakeholders; participation and contribution from industry, DOE National Labs, and academia are integral to its success.

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 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.

Essential to informing the future direction of EGS is the capture of high-fidelity data from both surface and subsurface instrumentation, which ensures a comprehensive understanding of system-level engineering and reproducibility in a variety of geologic environments. Real-time dissemination of this 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.

Phase 3 activities launched in FY 2016 involve full implementation of FORGE by the winning Site Management Team (SMT) selected via a competitive down-select, including full-scale reservoir development and tasks specific to the solicitation, selection, testing, and evaluation of new and innovative EGS tools and techniques. By the end of FY 2017, drilling of the first full-sized FORGE well will be complete, followed by stimulation activities focused on demonstrating stimulation of at least five discrete reservoir zones within a single wellbore, an EGS subprogram FY 2017 goal. The stimulation is designed on stress orientations and magnitudes determined from subsurface characterization data collected in prior phases. The full-sized FORGE well and any auxiliary wells may be used for complementary R&D efforts, including those that are off-ramping from projects funded under the subprogram's FY 2014 EGS R&D funding opportunity announcement (FOA) and FY 2015 DOE National Laboratory projects.

In FY 2017, FORGE will issue an R&D solicitation focusing on reservoir creation technologies; researchers will use the subsurface characterization data collected since the inception of the project to develop comprehensive stimulation models to inform the methodology and technologies implemented in the first reservoir stimulation at FORGE. The subprogram will select ten to twenty projects, focused on innovative stimulation technologies suited specifically to the FORGE site, 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. Topics will include the following:

- Reservoir characterization (i.e., coupled imaging, drilling for interrogation and monitoring, high-temperature tools and sensors);
- Reservoir creation (i.e., formation access, fracture characterization, zonal isolation, permeability enhancement technologies); and
- Reservoir sustainability (i.e., long-term testing, monitoring, and operational feedback).

Although the majority of the subprogram's R&D will be conducted at FORGE, new R&D in strategic topical areas remain a 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 will maintain investment in R&D that feeds into FORGE operations, so that new technologies are postured for field-testing at the site, aligned with sequencing of the multi-year FORGE technical implementation strategy. Therefore, in FY 2017, EGS R&D will continue to address key identified challenges through competitively selected DOE National Lab R&D focused on the challenges associated with creating, improving, monitoring, quantifying, and sustaining EGS reservoirs. The primary focus area of the EGS subprogram, and a key objective of the FORGE initiative, is to design and test a methodology for developing large-scale, economically sustainable heat exchange systems to facilitate commercialization of EGS technologies via a rigorous and reproducible approach. Research activities associated with reservoir sustainability are therefore critically important as the optimization and economic viability of the reservoir hinges on its ability to sustain a productive fracture network(s).

Activities and Explanation of Changes

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
Enhanced Geothermal Systems $45,000,000	**$45,000,000**	**$0**
• Frontier Observatory for Research in Geothermal Energy : ▪ 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. ▪ Continue any further characterization of the in-situ stress field needed, utilizing various techniques and further characterization of fluid content and composition at depth. ▪ 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. ▪ Continue micro seismic and other geophysical and geochemical signature monitoring initiated in Phase 2 and input all data into ongoing dynamic reservoir modeling efforts. ▪ Upload all characterization and monitoring data collected throughout the initial year of Phase 3 to the FORGE Data System/Node in real-time. ▪ 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 appropriations.	• Frontier Observatory for Research in Geothermal Energy : ▪ Complete drilling of the first FORGE well and any additional auxiliary wells to use for shallow testing and complementary R&D, such as monitoring, characterization, and tracer analysis. ▪ Complete stimulation of the first full-sized FORGE well, demonstrating stimulation of at least five reservoir zones via a single wellbore, meeting an EGS Program FY 2017 goal. Design stimulation according to stimulation plan based on stress orientations and magnitudes determined from subsurface characterization data collected in prior phases. ▪ Incorporate field-testing of methodologies/tools/procedures developed through remaining EGS subprogram FY 2014 R&D solicitation awards. ▪ Continue micro-seismic and other geophysical and geochemical signature monitoring. Input all data and analysis into ongoing dynamic reservoir modeling efforts to design and appropriately site the second FORGE well. ▪ Upload all Phase 3 characterization and monitoring data collected to date to the FORGE Data System/Node in real-time. ▪ Issue second FORGE R&D solicitation, on research and technology testing related to reservoir creation technologies and other topics defined by the collaboratively developed FORGE multi-year R&D strategy.	• No change in funding; the Request reflects the continuation of Phase 3 of the Geothermal Technologies Program's flagship initiative, the Frontier Observatory for Research in Geothermal Energy (FORGE). Phase 3 activities include ongoing novel subsurface characterization, full-scale well drilling, and technology R&D.

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
	Competitively select 10-20 projects, based on appropriations.	
• Advance R&D (funded through the Annual Operating Plan and performed by National Labs 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.	• Initiate a concerted and focused effort to advance R&D (performed by DOE National Labs with industry or academic partners) focused on larger scoped, collaborative projects that integrate complementary technologies addressing the challenges associated with creating, improving, monitoring, quantifying, and sustaining EGS reservoirs.	• No change. Multi-year National Lab R&D work initiated in FY 2016 will continue into FY 2017.
• 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.	• 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.	• Laboratory-scale work and feasibility studies funded through the FY 2014 EGS R&D FOA will continue into FY 2017, representing the final year of performance.
• 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 Subsurface Crosscut.		• In FY 2017, all subsurface funding resides under the hydrothermal subprogram.

Geothermal Technologies
Hydrothermal

Description

The U.S. Geological Survey's (USGS) 2008 Geothermal Resource Assessment estimated that 30,000 megawatts (MW; range from a 95 percent probability of identifying 7,900 MW to a 5 percent probability of identifying 73,000 MW) of undiscovered hydrothermal resources exist 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 have the following 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 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 drill consistently economically viable wells is therefore a major barrier to near-term capacity expansion; these blind systems require new and innovative approaches to exploration.

The Hydrothermal subprogram supports the research and development of technologies necessary to effectively find and access blind resources at lower cost, enabling the private sector to develop and bring them online. 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 between 5,000-15,000 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, such as unique sub-surface attributes or geophysical properties (e.g., resistivity, magnetic, gravity, or seismic responses). Technologists developed many of the current geothermal exploration technologies to detect hydrocarbons and adapted them 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 geothermal sector is a relatively small player among the industries that operate in the subsurface and can benefit greatly from strategic collaborations to accelerate the development of undiscovered hydrothermal resources and optimize the management of operational reservoirs.

For example, in FY 2014, the subprogram launched Phase 1 of the Play Fairway Analysis (PFA) effort, a first-of-its-kind mapping effort for geothermal, borrowing proven methodologies from the oil and gas sector. Phase 2 efforts focused on refinements to Phase 1 favorability maps and additional exploratory geophysical data gathering. These exploration efforts provided critical information and techniques that successfully targeted exploration areas, improved the accuracy of prospect maps, increased the ability to define resource extent, and estimated preliminary economic impact (see Figure 2). In other words, fairway analysis and mapping is a foundational exploration tool to guide exploration, lower risk, and improve the chance of economic success; it is a first-in-the-world effort for geothermal exploration.

During Phase 1, the PFA teams incorporated the regional or basin-wide distribution of known geologic factors that control the occurrence of a particular geothermal system for their areas of interest. The resulting probability maps allow the PFA teams to generate composite probability maps summarizing the probability that a play exists given a specific set of causative factors. During Phase 2, the PFA teams — down selected from Phase 1 in early FY 2016 — collect additional geologic and geophysical data to refine their favorability maps to ultimately test and validate the various uncertainty models to explore for geothermal resources. Phase two ends in a down-select in late 2016 or early 2017. In FY 2017, Phase 3 of the Play Fairway Analysis Validation ($5 million) effort will use the updated favorability maps and uncertainty analysis from Phase 2 to validate Play Fairway Analysis methodologies. Temperature gradient or slim hole wells will be drilled in the most promising resource locations to accomplish this objective. Activities will culminate with a comprehensive economic and uncertainty analysis of each play fairway to spur future exploration activities and potential development by the geothermal industry.

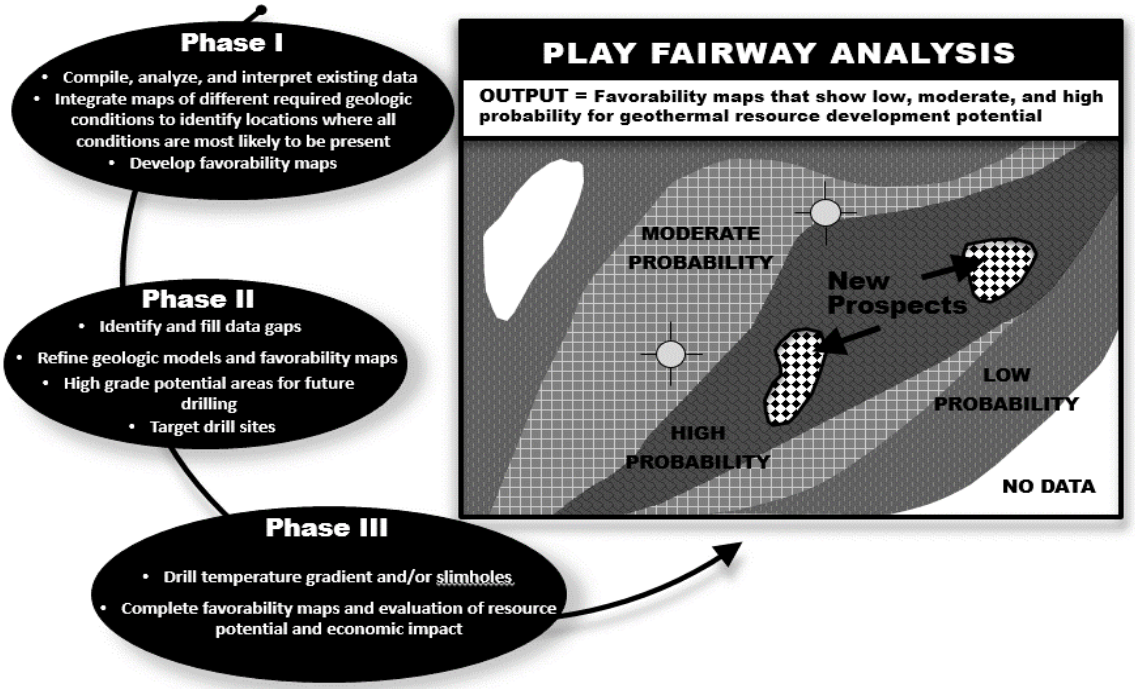


Figure 2: Illustrative Example of Geothermal Play Fairway Analysis and Phases

In addition to the subprogram's Play Fairway Analysis and validation efforts, the subprogram pursues opportunities to adopt and advance leading subsurface practices from other sectors to geothermal, which commenced in FY 2015 with investments in the Subsurface Crosscut across several Department of Energy offices. In FY 2017, the subprogram proposes advancing this coordinated RD&D effort, with the overarching goal of promoting subsurface control for a safe and effective energy future. This is a nationally important topic as it is central to increasing domestic renewable energy production and supply, enhancing environmental protection, and mitigating operational risk. Furthermore, core economic and social benefits include job creation, increased public confidence, U.S. sectoral leadership and 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: Wellbore Integrity, Subsurface Stress and Induced Seismicity, Permeability Manipulation, and New Subsurface Signals. In addition to R&D targeting the four pillars, R&D to address, "Advanced imaging of geophysical and geochemical signals in the subsurface," will commence, based on results from a Subsurface workshop held in FY 2015. Current limitations to fully exploiting our subsurface energy resources in an environmentally responsible manner are typified by the inadequate resolution attainable in conventional seismic imaging, which investments related to this high impact, R&D would seek to address. The subprogram proposes the following RD&D activities ($33 million total) under Subsurface:

- **Pillar 1: Wellbore Integrity ($8 million)**
  - Wellbore integrity is critical for geothermal energy and is particularly challenging in the harsh subsurface environments surrounding geothermal wells. FY 2017 R&D will focus on developing materials and sensors that can be embedded into casing and cement materials that can detect when and where a wellbore has been compromised. R&D will also address new tools and technologies to access and remediate wellbore failure where it has occurred and new self-healing materials that can withstand a decades-long operational lifetime in a dynamic subsurface environment.

- **Pillar 2: Subsurface Stress and Induced Seismicity ($9 million)**
  - Improved methods to measure and manipulate subsurface stress are key technology pathways for interpreting the orientation of existing fracture networks, and engineering optimal fracture networks that are used to mine heat from the Earth's subsurface. Proposed FY 2017 activities include continuing the development of tools and methodologies to measure stress in the subsurface. This effort will leverage prior year R&D efforts to establish baseline measurements in field-testing of new methods. Activities will include R&D into methods for stress measurement from the borehole and from the surface. FY 2017 investments will also support the field-testing of a high-resolution deployable surface and borehole seismometer array.

- **Pillar 3: Permeability Manipulation ($4 million)**
  - Technologies that can reliably manipulate permeability in the subsurface are critical to reducing risk in geothermal development and to making enhanced geothermal systems a fully cost-competitive power generation technology. Of particular importance to advancing geothermal technologies is extending engineering capabilities into increasingly harsh, high-temperature and high-pressure environments. FY 2017 R&D will include development of new stimulation technologies that uniformly enhance permeability in crystalline rocks. Activities proposed in FY 2017 for this pillar will also include field-testing of new technologies to selectively impede flow developed in prior year R&D. Opportunities to use accessible subsurface mines to conduct innovative tests on fluid flow through fractures will be leveraged.

- **Pillar 4: New Subsurface Signals ($4 million)**
  - Improved technologies and methods for imaging the subsurface are essential to reduce risk in geothermal development by providing greater information on the subsurface environment at early stages of development. Proposed FY 2017 activities will focus on inversion of geophysical techniques for subsurface imaging. R&D will also look at new ways to integrate multiple types of data (e.g., geophysical and geochemical) to gain a better understanding of the subsurface for exploration and for subsurface operations. The program will initiate planning and design at field sites for strategic drilling to verify observations made from the surface.

- **Grand Challenge: Advanced imaging of geophysical and geochemical signals in the subsurface ($8 million)**
  - The Request will target R&D for advanced imaging of geophysical and geochemical signals in the subsurface, a topic identified in a FY 2015 Subsurface workshop. R&D will include the testing of innovative techniques and technologies using existing wells and field sites and focus on field-testing high-fidelity imaging and modeling using massive microseismic datasets. In FY 2016, the Geothermal Technologies Program will work with DOE partners in the Subsurface Crosscut and with stakeholders to define an ambitious goal with quantifiable metrics and outyear targets to measure progress toward mastery of the subsurface.

Hydrothermal

Activities and Explanation of Changes

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
Hydrothermal $13,800,000	**$40,500,000**	**+$26,700,000**
• Hydrothermal subprogram activities independent of the Subsurface Engineering crosscut: ▪ 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. ▪ The subprogram initiated competitively selected, three-year funding of DOE National Lab R&D to reduce cost and risk of drilling, wellbore materials, and advance innovative exploration techniques.	• Hydrothermal subprogram activities independent of the Subsurface crosscut: ▪ Following a down-select from Phase 2, FY 2017 will consist of Phase 3 activities focused on Play Fairway Analysis validation through drilling of temperature gradient or slim hole wells based on high graded areas identified through refined mapping analysis in Phase 2. ▪ Year two of funding for targeted DOE National Lab R&D to reduce cost and risk of drilling, wellbore materials, and advance innovative exploration techniques	• Hydrothermal subprogram activities independent of the Subsurface crosscut: ▪ FY 2017 PFA activities will use the updated favorability maps and uncertainty analysis from Phase 2 to validate Play Fairway Analysis methodologies.
• Joint competitive funding opportunity with other DOE offices involved in the Subsurface Engineering crosscut, a critical effort for advancing innovative RD&D in Subsurface Stress and Induced Seismicity, Permeability Manipulation, and New Subsurface Signals. The crosscutting nature of these topics aims to result in outcomes that are accretive across multiple DOE Offices. In addition, ongoing R&D projects at the lab support the subsurface Initiative. The program will also work through the Subsurface Tech Team to define an ambitious goal with quantifiable metrics and outyear targets to measure progress toward mastery of the subsurface.	• Continuation of the Subsurface crosscut ($33 million), 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 Wellbore Integrity, Subsurface Stress and Induced Seismicity, Permeability Manipulation, and New Subsurface Signals. The crosscutting nature of these topics aims to result in outcomes that are accretive across multiple DOE Offices. Ongoing and new R&D projects at DOE National Laboratories will continue to support the Subsurface Initiative.	• Hydrothermal subprogram activities associated to the Subsurface Crosscut: ▪ The increase in funding reflects full R&D implementation of Subsurface activities by issuing Funding Opportunity Announcements for TRLs 2-6 for industry, academic, and lab collaborations resulting in 10-15 multi-year funded projects.

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 thermal desalination processes 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 — attractive 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., combined 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.

In FY 2017, 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. Specific developments in this area will include renewable power hybrid cycles, energy storage in conjunction with geothermal power generation, and power system improvements — with the goal of steadily increasing the value of geothermal resources.

The subprogram will also address 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. Specifically, the subprogram will competitively fund ($4 million) for Geothermal direct use R&D, (also known as thermal applications) which 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 used widely throughout the world, most notably in Iceland, where geothermal direct use provides nearly 90 percent of the country's heating.[1]

Direct use geothermal applications have the potential to provide cost-effective, renewable thermal energy in large portions of the U.S. A recently completed USGS assessment estimates 46,500 MW thermal (MWth) of total beneficial heat that is available from geothermal resources below 90°C in the U.S.[2] Preliminary calculations by NREL suggest that full utilization of this resource would equate to supplying nearly one quarter (23 percent), of the total U.S. residential heating demand for the next 30 years. In 2011, as an example of the initial scale of penetration of this technology, in Europe, there were 212 geothermal district heating systems in operation with a total installed capacity of approximately 4,700 MWth.[3] Many of these direct-use 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.

The subprogram's proposed direct use evaluations 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 military installations, 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. This direct use initiative could also lead to dramatically expanded geothermal development in the central and eastern U.S. through a

[1] Orkustofnun, National Energy Authority Iceland, http://www.nea.is/geothermal/direct-utilization/.
[2] Williams, et al., Revisiting the Assessment of Geothermal Resources <90°C in the U.S. April 10, 2015.
[3] Sass, et al., Urban Heating. Proceedings World Geothermal Congress 2015. Melbourne, Australia, 19-25 April 2015.

combination of deep wells, coupled with advanced low temperature electricity generation units and cascaded-use surface technologies, which involve engineering the surface system to optimize useful applications for the geothermal resource based on aligning the decreasing temperature of the fluid with the lower thermal demands of the "cascaded-uses". If the results of the initial feasibility studies are positive, there is potential for the direct use market to grow in size to approximate that of geothermal heat pumps (~ 12,000 MWth[1]), an amount that loosely equates to displacing 7,000 MW of conventional electricity, which NREL research suggests will result in an approximate reduction of 11.6 million metric tons/yr of CO_2.

Additionally, in support of the Energy-Water Nexus Crosscut, and in collaboration with the AMO Desalination Hub, the subprogram will separately fund geothermal desalination activities ($2 million). These efforts will be complimentary to those of AMO's desalination work and will advance both GTO and aligned Hub R&D. As part of this effort, the subprogram will continue to investigate using low-enthalpy geothermal energy to desalinate various non-fresh waters. Specifically, forward osmosis is a potential water purification technology with low energy requirements that the subprogram will move into a pilot-scale stage. This and other thermal processes used in tandem with power generation technologies can create an energy neutral or net positive geothermal desalination cycle.

[1] Anderson, et al., the Economics of Enhanced Geothermal Systems. 2012.

Low Temperature and Coproduced Resources

Activities and Explanation of Changes

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
Coproduced Resources $8,000,000	**$10,000,000**	**+$2,000,000**
• To allow for well-structured timing between the completion of the nine Phase 1 projects and an open call for Phase 2 projects, 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. • The subprogram initiated competitively selected, three-year funding of DOE National Laboratory R&D in value-added technologies; hybrid systems and geothermal desalination technologies including at least one pilot-scale demonstration of geothermal water purification processes.	• No FY 2017 funding requested for Phase 2 of the Low Temperature Mineral Recovery initiative. • The Low Temperature and Coproduced Resources subprogram will fund competitively selected RD&D at the DOE National Labs in the following topics: ▪ Hybrid Systems: Continue funding projects that validate the feasibility of hybrid geothermal systems. Efforts may include engineering of other renewable energy or fossil energy with geothermal power; as well as combinations of different power generation cycles in geothermal systems. ▪ Geothermal Desalination: The program will continue scaled-down testing of a forward osmosis (FO) switchable polarity solvent (SPS) technology. This work supports the Energy-Water Nexus Crosscut. • Deep Direct Use (DDU): In this new subprogram effort, systemically engineered DDU applications will optimize the use of the heat entrained in geothermal brines to provide the energy needed for large-scale residential and commercial thermal applications. Activities in FY 2017 would consist of market assessments and feasibility studies through a ($4 million) FOA This effort will be developed in consultation with the Building Technologies Program,	• Low Temperature Mineral Recovery Phase 2 fully funded in FY 2016. • Minimal change in funding; the Request reflects multi-year funding at the DOE National Labs for projects initiated in FY 2016 that will continue in FY 2017.

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 strategic planning and either validate or refine the program's overall direction. The Systems Analysis subprogram conducts these activities in partnership with the DOE National Labs, Federal agencies, academic institutions, and industry stakeholders.

In FY 2017, 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:

- Completion of a robust, Vision Study of the potential future of geothermal deployment for EGS, Hydrothermal, Low Temperature and Coproduced Resources, and cascading geothermal technologies as well as the economic and environmental benefits of these deployments. This will be a critical analysis, modeled after other Vision Studies in scope and approach that engages the geothermal industry, academia, DOE National Labs, and government stakeholders.
- Continued support for data collection and dissemination across all Geothermal Technologies subprograms, such as assisting FORGE teams in deploying a node on the National Geothermal Data System (NGDS) tailored to researcher data requirements, which will expedite EGS research results by leveraging data collection efforts-to-date. The Systems Analysis subprogram will deploy integrated datasets from the Play Fairway Analysis effort into the NGDS to maximize the number of mapping tools that can use the data, thereby reducing the cost of determining geothermal potential. The subprogram will also assist in populating the Geothermal Data Repository (GDR) with high-quality geochemical data sets from the Mineral Recovery project activities.
- Educational activities that 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.

Activities and Explanation of Changes

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
Systems Analysis $3,700,000	**$4,000,000**	**+$300,000**
• 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 crosscutting analysis to identify, validate, and assess progress being made across the geothermal sector. Proposed work under this Budget Request include: ▪ A robust, Vision Study to illustrate the geothermal potential and impacts based on scenarios within a geothermal continuum addressing the valuation of a full spectrum of geothermal technologies. ▪ Support data collection and dissemination across GTO subprograms, specifically the EGS FORGE, Low Temperature Mineral Recovery, and the Hydrothermal Play Fairway Analysis initiatives. ▪ 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 applications to use the full range of geothermal resources, including EGS technologies. ▪ Continued regional water resources assessment, 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	• The Systems Analysis subprogram will continue conducting analyses and develop tools to reduce development and deployment barriers to geothermal development in the U.S.; as well as conduct analysis to identify, validate, and assess progress across the geothermal sector. Proposed work under this Budget Request include: ▪ Complete a robust, forward-looking Vision Study to illustrate the geothermal potential and impacts based on scenarios within a geothermal continuum addressing the valuation of a full spectrum of geothermal technologies. ▪ Continue to support data collection and dissemination across GTO subprograms, specifically the EGS FORGE, Low Temperature Mineral Recovery, and the Hydrothermal Play Fairway Analysis initiatives. ▪ Educational activities that include a student competition and fellowship opportunities	• Minimal change in funding; the request reflects the completion of the Vision Study in FY 2017 as well as the Systems Analysis subprogram's continued focus on analysis and tools that help reduce barriers to "speed and scale" adoption of geothermal in the U.S., and validate and assess technical progress across the geothermal sector.

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
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 2017, EERE will continue to directly fund National Renewable Energy Laboratory (NREL) Site-Wide Facility Support costs rather than fund those costs as laboratory overhead.

EERE proposes to eliminate the NREL Site-Wide Facility Support subprograms in its individual technology programs, and consolidate NREL Site-Wide Facility Support funding in the Facilities and Infrastructure Program. Locating this funding in the Facilities and Infrastructure Program will provide clarity and transparency in communicating EERE's stewardship for NREL, and will simplify planning and execution of EERE's annual budget. This consolidation into a single program allows for better integration and coordination of operations and investments.

NREL Site-Wide Facility Support

Activities and Explanation of Changes

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
NREL Site-Wide Facility Support $500,000	**$0**	**-$500,000**
• 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 funding Requested within the Geothermal Technologies Budget Request.	• Offset reduction in the request with a corresponding increase in the Facilities and Infrastructure Budget Request. Consolidated funding in EERE's NREL Site-Wide Facility Support.

Geothermal Technologies
Performance Measure

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 2015	FY 2016	FY 2017
Performance Goal (Measure)	Reduce the LCOE from newly developed geothermal systems (cents/kWh)		
Target	22.3	22.2	22.0
Result	Met – 22.3	N/A	N/A
Endpoint Target	6 cents/kWh by 2030		

Advanced Manufacturing

Overview

Through research, development, and demonstration (RD&D) activities, the Advanced Manufacturing Office (AMO) program brings together manufacturers, research institutions, suppliers, and universities to develop cutting-edge manufacturing process, information, and materials technologies critical to efficient and competitive domestic manufacturing of clean energy products and to support energy productivity across the entire U.S. manufacturing sector.

The program supports the Administration goals of promoting economic growth and a strong middle class. Manufacturing generates 12 percent of U.S. gross domestic product (GDP)[1] and employs more than 12 million Americans. The U.S. manufacturing sector also has an annual energy bill of about $200 billion and uses roughly one-third of primary energy (and produces a proportionate amount of related GHG emission) in the U.S.[2] DOE's works to improve the energy efficiency and productivity of U.S. manufacturers, which helps keep manufacturers of all kinds more competitive in the global marketplace, creating good jobs for Americans while helping all Americans enjoy cleaner air and a healthier environment. The program accomplishes this by focusing on the development of cross-cutting, cutting-edge, platform materials and manufacturing process technologies relevant to multiple clean energy technologies, helping ensure that clean energy technologies and processes invented in the U.S. ultimately result in the manufacture of high-quality clean energy products in the U.S.

AMO supports RD&D projects and technical assistance for manufacturers, research institutions, suppliers, and universities through competitive, merit reviewed funding opportunities designed to investigate processes, information, and materials technologies in line with the program goals[3,4]. The program addresses early stage manufacturing technologies through three different modes of support as sub-programs: individual RD&D projects, pre-commercial RD&D consortia and facilities, and technology assistance through partnership participation, assessment, and evaluation tools.

AMO's efforts in the R&D Projects and R&D Facilities subprograms are organized around a limited set of major high priority technical focus areas that have been developed through extensive engagement and consultation with private sector firms, non-profits, universities, and National Laboratory partners, and others across the Department. The AMO technical focus areas support manufacturing process, information and materials technologies, and directly align with the fourteen high priority energy-related advanced manufacturing technologies identified through the 2015 DOE Quadrennial Technology Review (QTR) as shown in the figure from Chapter 6, below.[5]

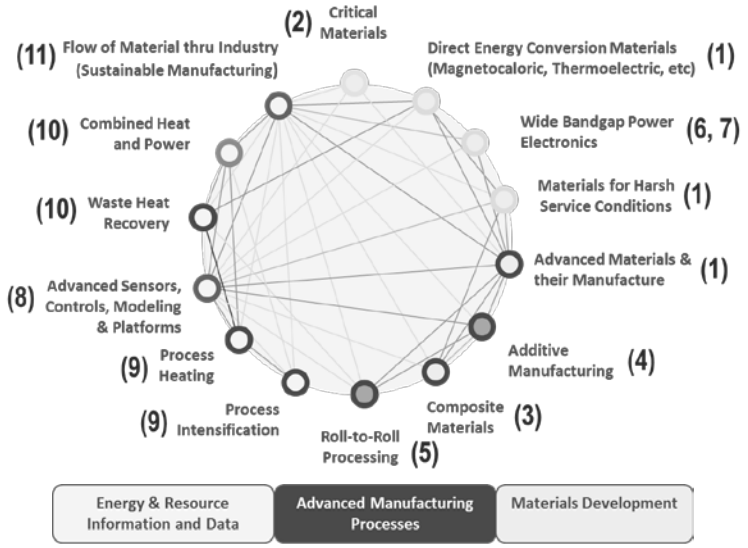
[1] "GDP by Industry / VA, GO, II, EMP," 2013, Bureau of Economic Analysis; available from: http://www.bea.gov/industry/xls/GDPbyInd_VA_NAICS_1997-2013.xlsx.

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

[3] EERE Strategic Plan (2016-2021): http://energy.gov/sites/prod/files/2015/12/f27/EERE_Strategic_Plan_12.16.15.pdf

[4] Advanced Manufacturing Office mission and goals: http://energy.gov/eere/amo/mission-and-goals

[5] 2015 Quadennial Tecchnology Review, Chapter 6 "Innovating Clean Energy Technologies in Advanced Manufacturing" http://energy.gov/downloads/chapter-6-innovating-clean-energy-technologies-advanced-manufacturing.



The AMO priority technical focus areas corresponding to the highest priority energy-related advanced manufacturing areas identified in DOE's 2015 QTR priorities are described below:

1. Advanced Materials: Advanced materials broadly applicable to clean energy products, including advanced steels, energy conversion materials, materials for extreme conditions, thermal insulation materials, lightweight metals, and nanomaterials;
2. Critical Materials: Critical materials essential to the production of clean energy products for which there is potential for supply chain disruption, including rare earth materials;
3. Advanced Composites and Lightweight Materials Processes: Advanced composites and lightweight materials processes generating high-strength and low-weight materials with applications ranging from fuel efficient vehicles to high-pressure natural gas tanks;
4. Additive Manufacturing: Additive 3D manufacturing processes capable of directly achieving net-shape production of metals, polymers, and ceramic materials for application in products ranging from electric vehicles to heat exchangers;
5. Roll-to-Roll Processing: Roll-to-roll processes capable of continuously and reliably producing complex two-dimensional multi-material assemblies, functional membranes and structures, including photovoltaics, batteries, membranes and fuel cells;
6. Wide Bandgap Power Electronics: Wide bandgap power electronics based on semiconductors that reduce energy losses in electrical systems;
7. Next Generation Electric Machines: Next-generation electric machines that leverage advances in materials and electronics to reduce energy loss, lower costs, and increase functionality in systems ranging from wind turbines to chemical process units;
8. Smart Manufacturing: Smart manufacturing technologies that deploy advanced sensors, controls, platforms, and models to enable real-time operational energy efficiency improvements in unit processes to enterprise wide energy management; this thrust area also includes the application of High Performance Computing to improve high-impact materials and manufacturing process technologies;
9. Chemical and Thermal Process Intensification: Chemical and thermal process intensification to reduce the size and energy intensity of manufacturing processes through higher reaction efficiency, novel mixing and separations, and low thermal budget heating and cooling;
10. Grid and Resource Integration in Manufacturing: Grid and resource integration, including new technologies for high efficiency Combined Heat and Power (CHP), waste heat to power, distributed generation, and real-time manufacturing demand response; and
11. Sustainable Manufacturing: Sustainable manufacturing, including technologies for the efficient use of raw materials and water in manufacturing, including materials recycling.

Highlights of the FY 2017 Budget Request

AMO's FY 2017 activities support Administration, Department, and program goals of enhancing the competitiveness, energy efficiency, and energy productivity of U.S. manufacturers. These include:

- Merit based RD&D project funding to develop technologies for reducing the energy intensity or energy dependency of manufacturing processes as well as platform technologies broadly relevant for competitiveness and cost-reduction in multiple clean energy technologies, including high performance computing for manufacturing.
- Funding for projects at the Manufacturing Demonstration Facility to support industrial research partnerships related to additive manufacturing, carbon fiber materials.
- Advanced Manufacturing Incubator Funding Opportunity Announcement (FOA), representing an open funding opportunity allowing the business community to propose new early stage technical ideas that may revolutionize the field of advanced manufacturing.
- On-going annual funding of five existing Clean Energy Manufacturing Innovation Institutes and initial funding for one new Clean Energy Manufacturing Innovation Institute, all of which are part of the Administration's vision for a larger multi-agency National Network for Manufacturing Innovation (NNMI). In FY 2017, the program will fund:
  - 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);
  - Two Clean Energy Manufacturing Innovation Institutes ($28 million started in FY 2016); and
  - Start one new Clean Energy Manufacturing Innovation Institute (approximately $14 million starting in FY 2017).
- Support for funding of the Energy Innovation Hub focused on Critical Materials and funding support for a new Energy Innovation Hub focused on Energy-Water Desalination technology research and development. Hubs address technical challenges through a merit-based research consortium spanning basic discovery through potential test-bed deployment, funded over a five year period with the potential for a second, final five-year phase based on merit, performance, and other criteria.
  - First year of second and final five-year phase of the highly successful Critical Materials Hub ($20 million started in 2012); and
  - First year of a new Energy-Water Desalination Hub ($25 million start in 2017).

EERE's role in the initial establishment of the Oak Ridge MDF ended in FY 2016. Beginning in FY 2017, EERE will only fund R&D projects that use the MDF facility and are in line with AMO program goals and technical merit based practices for the management of RD&D projects.

AMO 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. CEMI 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 the EERE Energy-Water Nexus Crosscut, described in the EERE's Overview and in the Advanced Materials Crosscut.

FY 2017 Crosscuts ($K)

	Energy-Water Nexus	Advanced Materials	Total
Advanced Manufacturing	**25,000**	**24,000**	**49,000**

Advanced Manufacturing
Funding ($K)

	FY 2015 Enacted	FY 2015 Current[1]	FY 2016 Enacted	FY 2017 Request	FY 2017 vs FY 2016
Advanced Manufacturing					
Advanced Manufacturing R&D Projects	84,000	81,227	101,500	102,500	+1,000
Advanced Manufacturing R&D Facilities	92,500	89,448	98,500	129,000	+30,500
Industrial Technical Assistance	23,500	23,500	28,500	29,500	+1,000
Total, Advanced Manufacturing	**200,000**	**194,175**	**228,500**	**261,000**	**+32,500**

SBIR/STTR:

- FY 2015 Transferred: SBIR $5,119,000; STTR $706,000
- FY 2016 Projected: SBIR $6,000,000; STTR $900,000
- FY 2017 Request: SBIR $7,408,000; STTR $1,042,000

[1] Funding reflected the transfer of SBIR/STTR to the Office of Science.

Advanced Manufacturing
Explanation of Major Changes ($K)

	FY 2017 vs FY 2016 Enacted
Advanced Manufacturing	
Advanced Manufacturing R&D Projects: The funding will result in an increase in the number and support of projects in high-impact foundational technology areas, allowing approximately ($10 million) in technically meritorious advanced manufacturing R&D projects aligned with the program's priorities at the Manufacturing Demonstration Facility (MDF). The funding also supports an increased level of funding ($20 million) for Incubator projects, as well as ($7.5 million) for efforts related to the use of high performance computing for manufacturing and ($2.5 million) for the support of small-business start-ups in partnership with National Laboratories and ($2.5 million) related to Advanced Manufacturing Traineeship activities.	**+1,000**
Advanced Manufacturing R&D Facilities: The increase in funding will maintain incremental annual funding levels for all existing and planned Clean Energy Manufacturing Innovation Institutes while renewing AMO's commitments to the Critical Materials Hub and supporting the launch of the Energy-Water Desalination Hub.	**+30,500**
Industrial Technical Assistance: The program will continue the growth of the Better Buildings, Better Plants program; maintain support for the Combined Heat and Power Technical Assistance Partnerships (CHP TAPs) and Industrial Assistance Centers (IACs); and incorporate the Superior Energy Performance (SEP) program elements into water and wastewater treatment facilities.	**+1,000**
Total, Advanced Manufacturing	**+32,500**

Advanced Manufacturing
Advanced Manufacturing R&D Projects

Description

Through competitively selected RD&D project investments in foundational energy-related advanced manufacturing technologies, the program will increase the impact of its work in areas relevant to energy-intensive and energy-dependent manufacturing processes as well as platform technologies widely applicable across multiple clean energy manufacturing industries. The Advanced Manufacturing R&D Projects subprogram will support innovative clean energy manufacturing projects cost-shared with companies and research organizations that focus on specific high-impact manufacturing technology and process challenges. Through a combination of merit based competitive FOA solicitations and peer-reviewed national laboratory based partnerships, these projects will fund the development of next-generation manufacturing materials, information and process technologies that facilitate the transition of emerging clean energy technologies to domestic production and improve energy efficiency in energy-intensive processes. The program will identify the specific research challenges based on stakeholder input, alignment with the program's technology thrust areas, and potential energy, environmental, and economic impacts.

In FY 2017, the program will support RD&D projects totaling $102.5 million. Approximately ($20 million) will be for advanced materials manufacturing for energy applications that will includes ($8 million) for materials used in direct energy conversion and also includes ($12 million) focused on a range of materials including advanced steel, thermal insulating materials, novel electrical conductors and nanomaterials. In FY 2017, there will be 2-3 competitive solicitations for Advanced Manufacturing RD&D projects totaling approximately ($40 million), including at least one FOA solicitation with emphasis on technologies for the integration of manufacturing to the power grid and the other FOA solicitations in the other well-defined AMO priority thrust areas identified in the DOE 2015 QTR.

The Advanced Manufacturing Incubator activity at ($20 million) will make competitively selected investments in a broad range of technologies that may revolutionize the field of clean energy manufacturing. This activity provides the incentive for small- and medium-size manufacturing companies to pursue emerging high-risk, high-impact advanced manufacturing technology or process developments that relate to improved energy efficiency or the production of clean energy technologies that they otherwise would not pursue. In addition, the program will support ($7.5 million) for high performance computing for manufacturing R&D that will assist U.S. industry with their most challenging problems by partnering world-class experts at the Nationals Laboratories with corporate researchers to model their technologies on some of the world's fastest supercomputers; ($2.5 million) for the support of small-businesses and start-ups in partnerships with National Laboratories on advanced manufacturing technologies, which will be done in coordination with the Office of Technology Transitions to leverage and avoid overlap with efforts across the Department; and ($2.5 million) related to Advanced Manufacturing Traineeship activities.

In FY 2017, AMO will fund up to ($10 million) in R&D projects at the Manufacturing Demonstration Facility (MDF) to support merit based industrial research partnerships related to additive manufacturing and carbon fiber materials. This work will include a specific focus of ($6.5 million) for additive manufactured materials and structures used in extreme environments such as high temperature, corrosive or high pressure energy related applications in support of the advanced materials crosscut.

Advanced Manufacturing R&D Projects

Activities and Explanation of Changes

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
Advanced Manufacturing R&D Projects $101,500,000	**$102,500,000**	**+$1,000,000**
• 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 four 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 million -$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 ($12.9 million).	• AMO will support competitive and meritorious RD&D projects in technology areas with significant potential for reducing the energy intensity or energy dependence of manufacturing or in platform technologies with significant potential to reduce life cycle energy consumption during use of the resultant clean energy product. In FY 2017, AMO will support ($20 million) for advanced materials manufacturing, ($40 million) for manufacturing information or process technology RD&D, ($7.5 million) for high performance computing in manufacturing R&D, ($2.5 million) for supporting small business partnerships with National Laboratories and ($2.5 million) for Clean Energy Manufacturing Initiative Traineeship activities. The Advanced Manufacturing Incubator for High-Impact Foundational Technology FOA of ($20 million) will make competitively selected investments in a broad range of technologies that may revolutionize the field of advanced manufacturing. Also will support R&D projects at the Manufacturing Demonstration Facility ($10 million) to support advancement of additive manufacturing and carbon fiber materials.	• The increased funding is a result of a transfer of the R&D project support for additive manufacturing investments in the Manufacturing Demonstration Facility at Oak Ridge National Laboratory ($10 million) into this subprogram from the Advanced Manufacturing Facilities subprogram.

Advanced Manufacturing
Advanced Manufacturing R&D Facilities

Description

The Advanced Manufacturing R&D Facilities subprogram helps the U.S. position itself as a world leader in manufacturing by bringing together manufacturers, research institutions, suppliers, and universities in public-private R&D partnership consortia. These public-private partnerships facilitate the transition of innovative advanced materials, information, and process technologies to industry and enable manufacturing scale-up. These technology development efforts help develop national capabilities that enable future global leadership in clean energy manufacturing. The program's facilities, including the Clean Energy Manufacturing Innovation Institutes and Energy Innovation Hubs, accelerate the development and implementation of cutting-edge industrial energy efficiency technologies as well as materials and process technologies broadly applicable to the manufacturing of clean energy products. These advanced manufacturing R&D facilities have spillover benefits from clean energy sectors into multiple industries and improve U.S. competitive advantage, especially for small- and medium-sized enterprises.

The FY 2017 funding of $129 million includes supports for one new $14 million[1] and five existing ($70 million) Clean Energy Manufacturing Innovation Institutes as well as one new Energy Innovation Hub focused on Energy-Water Desalination technologies and renewed support for the Energy Innovation Hubs focused on Critical Materials ($45 million). The Clean Energy Manufacturing Innovation Institutes are partnerships among government, industry, and academia, supported with cost-share funding from Federal and non-Federal sources and are competitively and openly selected through aan FOA solicitation. Each DOE institute focuses on a specific set of technologies that are broadly applicable to clean energy technology challenges and pervasive in multiple industries and markets with potentially transformational technical and manufacturing productivity impact. The specific technical topic for new institute in FY 2017 will come from the advanced manufacturing challenges identified in the DOE Quadrennial Technology Review published in 2015, not previously addressed in existing institutes. Within 5 years of launch, the program expects each institute to be financially independent and sustainable using only private sector and other sources without further Federal funding. These Institutes are part of the National Network for Manufacturing Innovation (NNMI).[2] The NNMI is expected to induce collaboration and spread risk, complement university research, and support innovation to increase competitiveness of U.S. manufacturers. In addition, the FY 2017 funding will provide annual support for five existing Institutes – Next Generation Power Electronics, Advanced Composites, and Smart Manufacturing as well as the fourth and fifth DOE-led Institutes launched in FY 2016 ($14 million each, for a total of $70 million). The FY 2017 budget request for DOE also includes a new Clean Energy Manufacturing innovation Institute within the Office of Electricity Delivery and Energy Reliability (OE). AMO will work with OE to ensure consistency in the development and execution of manufacturing institutes across the Department.

In FY 2017, the highly successful Critical Materials Hub will receive the first annual increment of funding ($20 million) in its second, final phase that will enable it to continue focusing on technologies that help American manufacturers 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.

Finally, FY 2017 funding will support the launch of an Energy-Water Desalination Hub ($25 million) to serve as a center of research focused on developing integrated technological system solutions and enabling technologies for de-energizing, de-carbonizing, and reducing the cost of desalination to provide clean and safe water. While some research is currently underway on these topics in pockets of the U.S. innovation ecosystem, the proposed effort would serve as a significant first-of-a-kind centralized critical-mass RD&D effort on desalination and would establish a central pillar in DOE and the Nation's RD&D efforts in this critically important and highly multi-disciplinary field.

[1] See DOE Quadrennial Technology Review (2015) for technical focus areas relative to clean energy manufacturing. http://energy.gov/downloads/chapter-6-innovating-clean-energy-technologies-advanced-manufacturing.

[2] See Advanced Manufacturing Partnership 2.0 (2014) report for description of the National Network for Manufacturing Innovation: https://www.whitehouse.gov/sites/default/files/microsites/ostp/PCAST/amp20_report_final.pdf.

The Advanced Manufacturing R&D Facilities subprogram will continue to track and assess the impact of the Clean Energy Manufacturing Innovation Institutes. AMO will review the impacts of its prior support of the Department of Defense-led pilot NNMI institute – the National Additive Manufacturing Innovation Institute (America Makes). Monitoring activity will ensure that supported facilities and activities contribute significantly to the program's clean energy, energy productivity, and manufacturing competitiveness goals, and ensure the institutes are of high value to both public and private sector interests.

Advanced Manufacturing R&D Facilities

Activities and Explanation of Changes

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
Advanced Manufacturing R&D Facilities $98,500,000	**$129,000,000**	**+$30,500,000**
• Supports the incremental funding of one new Clean Energy Manufacturing Innovation Institute, as part of the National Network of Manufacturing Innovation. DOE is planning to invest ($70 million) over 5 years into each new Institute. Also supports ($56 million) for four existing Institutes, ($25 million) of investment in the Critical Materials Hub, and ($3.5 million) for institute-related technical and analytical efforts located primarily at appropriate National Laboratories.	• Supports incremental annual funding for five existing Institutes, as well as one new institute to be launched in FY 2017. Provides ($25 million) for the newly launched Energy-Water Desalination Hub, as well as ($20 million) for the first year of the second, final five year phase of the Critical Materials Hub.	• The increase is primarily attributable to one additional institute, as well as a new Energy-Water Desalination Hub.

Advanced Manufacturing
Industrial Technical Assistance

Description

The Industrial Technical Assistance subprogram provides critical support to the deployment of advanced energy efficiency technologies and practices. In accordance with Executive Order 13264, the subprogram promotes the deployment of 40 gigawatts of new, cost-effective CHP by 2020. In addition, technical assistance activities help individual manufacturers reduce their energy intensity by 25 percent over ten years; demonstrate the viability of improved energy management approaches; and provide targeted energy efficiency, productivity, and waste/water use reduction technical assistance to small and medium-sized manufacturers.

In FY 2017, the program will continue to support the CHP Technical Assistance ($10 million); increase the number of Better Buildings, Better Plants program partners; provide support for the newly selected IACs ($10 million) with an increased emphasis on energy management systems and water-related issues; and expand the number of ISO/ANSI Certified facilities.

The CHP Technical Assistance Partnerships (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.

Better Plants (the manufacturing sector complement to the Better Buildings program in the Building Technologies Office) provides a framework for firms to identify and pursue opportunities to implement cost-effective energy efficiency improvements that save money, create jobs, and strengthen their competitiveness. The Better Plants program does this with both manufacturing partners and across their supply chains. In addition to the establishment of energy savings targets, the program continues to add companies that will establish water savings targets. Finally, the program works with water treatment and wastewater treatment facilities to establish targets for energy savings in this energy-dependent 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.

Superior Energy Performance (SEP) is an industry-led certification program that provides industrial facilities with a transparent, globally accepted system for verifying energy performance improvements and management practices, aligned with implementing the globally recognized ISO 50001 standards. 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.

IACs conduct energy efficiency, productivity improvement, industrial information technology and waste reduction assessments for small- and medium-sized manufacturers.[1] The IACs utilize 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, wastewater systems, and energy management practices.[2] In addition, 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.

[1] Profile of 24 existing Industrial Assessment Centers can be found at: http://energy.gov/eere/amo/industrial-assessment-centers-iacs.

[2] An archive of all prior industrial assessments can be found at: https://iac.university/#database. As of February 4, 2016, a total of 130,584 technical recommendations have been made in 17,227 assessments at small and medium sized manufactures across the nation.

Activities and Explanation of Changes

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
Industrial Technical Assistance $28,500,000	**$29,500,000**	**+$1,000,000**
• 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.	• Increase the number of and support for the Better Plants program. • Provide ongoing support for the existing CHP TAP awards which were competitively awarded to 7 regional sites that provide technical assistance to help States and regions to increase CHP deployment. • Continue to support of IACs, with an increased emphasis on energy management systems and water-related issues ($10 million). • Expand the number of SEP ISO/ANSI Certified facilities and includes water treatment facilities, review results and quantify benefits from FY 2016 assessment the performance, nationwide impact, and overall benefit of the program.	• The program will continue the growth of the Better Buildings Better Plants program; maintain support for the IACs; and expand the SEP program into water facilities.

Advanced Manufacturing
Performance Measure

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 2015	FY 2016	FY 2017
Performance Goal (Measure)	**Demonstrations** – Number of Clean Energy Manufacturing Innovation Institute(s) selected negotiation to demonstrate advanced material and process technologies, leading to commercialization.		
Target	1	1	**TBD**
Result	**TBD**	N/A	
Endpoint Target	8 Manufacturing Innovation Facilities by 2017		

Federal Energy Management Program

Overview

As America's largest single energy consumer, the Federal Government has both 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 2014, the Federal Government used 1.4 quads of primary energy (1.4 percent of total U.S. energy use) at a cost of $23 million. Federal scope 1 and 2 greenhouse gas (GHG) emissions in 2014 totaled almost 81.9 million metric tons (1.2 percent of the Nation's total[1]), which were primarily from energy use. Energy used in buildings and facilities represents about 46 percent of GHG emission totals, with vehicles and equipment energy use accounting for 51 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[2]. Leadership by the Federal Government is a critical element of the President's Climate Action Plan, and the March 2015 Executive Order (E.O.) 13693. The E.O. establishes energy reduction and sustainability goals for agencies and calls for the Federal Government to provide leadership. The Department's Federal Energy Management Program (FEMP) will make a multi-faceted approach to helping federal agencies demonstrate leadership – while improving Federal sustainability. FEMP is uniquely positioned within EERE to coordinate innovative technologies and expertise from the other programs to bear upon the goals and aspirations of the Federal Government. The program assists and enables Federal agencies to meet the energy and sustainability goals and provide energy leadership to the Nation with tools and guides that are beneficial to both Federal and non-Federal organizations. 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 achievement of energy goals, facilitating innovative technologies, and creating change in the energy sphere.

Highlights of the FY 2017 Budget Request

The FEMP FY 2017 Budget Request supports key initiatives to help Agencies meet 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 2017, FEMP will focus on addressing the barriers Federal agencies face in meeting these aggressive goals by providing performance contracting support to key stakeholders and help make performance contracting business as usual; assisting agencies through technical assistance and training, and supporting progress accountability; to lead the Nation through Federal sustainability. Specifically, FEMP through a Memorandum of Understanding (MOU) with the U.S. Army Corps of Engineers will provide turn-key support for agencies implementing performance contracts. This support includes help facilitating and implementing performance contracts. In addition, FEMP will provide support for key stakeholders, data analysis on largest energy using sites and campuses and encourage energy efficiency through public-private sector challenges.

FEMP will also help federal agencies meet the goals in E.O. 13693 through direct assistance in the Federal Energy Efficiency Fund (FEEF), also known as Assisting Federal Facilities with Energy Conservation Technologies (AFFECT). In FY 2017, AFFECT will focus on implementing first-of-a-kind agency clean energy projects and projects that can provide deep energy savings. By providing direct funding to leverage cost sharing at Federal agencies for these projects, AFFECT provides a mechanism for FEMP to ensure the best projects with the greatest return on invest & best results 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 to help the Federal Government lead in the adoption of innovative technologies. For the FY 2014 and FY 2015 AFFECT awards combined, agencies submitted plans to leverage $23 of project investment for each dollar of FEMP project funding.

[1] http://epa.gov/climatechange/ghgemissions/usinventoryreport.html

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

Federal Energy Management Program
Funding ($K)

	FY 2015 Enacted	FY 2015 Current	FY 2016 Enacted	FY 2017 Request	FY 2017 vs FY 2016
Federal Energy Management Program					
Federal Energy Management	0	0	23,100	28,000	+4,900
Federal Energy Efficiency Fund/AFFECT	2,850	2,850	3,000	15,000	+12,000
DOE Specific Investments	2,160	2,160	0	0	0
NREL Site-Wide Facility Support	800	800	900	0	-900
Project Financing	9,500	9,500	0	0	0
Technical Guidance and Assistance	6,317	6,317	0	0	0
Planning, Reporting and Evaluation	4,073	4,073	0	0	0
Federal Fleet	1,300	1,300	0	0	0
Total, Federal Energy Management Program	**27,000**	**27,000**	**27,000**	**43,000**	**16,000**

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

	FY 2017 vs FY 2016 Enacted
Federal Energy Management (FEM): In FY 2017, FEM activities include making performance based contracts business as usual by providing turn-key performance contracting projects through an MOU with the Army Corps of Engineers (USACE). This approach leverages the expertise of the USACE and FEMP to provide a multiplier effect for agencies to efficiently use their assets for energy management. With FEMP focusing support for energy management at large campuses, and accelerating Federal sustainability through an additional public-private challenge, FEMP is leading the Federal Government as the primary advocate for Federal sustainability.	**+ 4,900**
Federal Energy Efficiency Fund/AFFECT: In FY 2017, FEEF or AFFECT will award approximately 30 projects and will focus on topics such as: first-of-a-kind agency clean energy projects and projects that provide deep energy savings. Together these initiatives will increase Federal leadership in energy efficiency, water conservation, and renewable energy investments.	**+ 12,000**
NREL Site-Wide Facility Support: In FY 2017, EERE proposes to move funding for the NREL Site-Wide Facility Support subprogram from individual technology programs to the Facilities and Infrastructure Program. Locating this funding in the Facilities and Infrastructure Program will provide clarity and transparency in communicating EERE's stewardship of NREL, and will simplify planning and execution of EERE's annual budget. This consolidation into a single program allows for better integration and coordination of operations and investments.	**-900**
Total, Federal Energy Management Program	**+ 16,000**

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), the Energy Independence and Security Act of 2007 (EISA 2007), and Executive Order (E.O.) 13693. 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. FEMP is the lead organization within the Federal Government tasked with helping all Federal agencies achieve these goals by providing assistance, developing implementation guidance and sharing high-impact tools, training, implementation of programs and data collection, analysis and reporting. FEMP facilitates technical services, project-financing services, and customer-driven services to agencies that need support or assistance.

The Federal Government is currently striving to achieve the following mandated goals from E.O. 13693:

- Improve energy efficiency of each agency through the reduction of energy intensity by 2.5 percent annually, or 25 percent by the end of FY 2025, relative to the baseline of the agency's energy use in FY 2015 ;
- Reduce Government-wide scope 1 and 2 (direct) GHG emissions from targeted sources by 40 percent in FY 2025 compared to FY 2008;
- Ensure that at least 10 percent of Federal building electric energy and thermal energy is clean energy in FY 2017 and 25 percent in 2025;
- Ensure that at least 10 percent of Federal electricity consumption is generated from renewable sources in FY 2017 and 30 percent in 2015;
- Reduce water consumption intensity by 2 percent annually, or 36 percent by the end of FY 2025 as compared to the FY 2007 base year; and
- Reduce the motor vehicle fleet's per-mile greenhouse gas emissions by 4 percent in 2017 and 30 percent in 2025 compared to FY 2014.

E.O. 13693, along with establishing many energy reduction and sustainability goals, calls for the Federal Government to provide leadership. Using the visibility of Federal actions allows the Federal building-stock to demonstrate best practices for sustainability to the Nation. FEMP helps Federal agencies lead by example by providing assistance to Federal agencies through tools to make performance contracting business as usual; using success in Federal facilities as an example of energy management Nation-wide; and providing technical assistance, training, as well as measurement and accountability.

Congress authorized Federal use of performance contracts to help Federal agencies achieve energy conservation and sustainability goals through investment in energy efficiency, renewable energy, and water efficiency improvements in Federal facilities. By using performance contracts such as Energy Savings Performance Contracts (ESPCs) and Utility Energy Service Contracts (UESCs), the Government can engage a third-party (private sector energy service company) to invest in needed energy projects and pay for the improvements through the energy, water, and operations and maintenance savings achieved over the life of the contract.

To promote better, faster adoption of performance contracting investment, FEMP has signed a MOU with USACE to work together to standardize the process for delivery to help make performance contracting business as usual. As FEMP and the USACE have the only two Indefinite Delivery, Indefinite Quantity (IDIQ) contracts in the Federal Government, the more they can be synchronized, aligned, and implemented consistently, the more streamlined and routine the contracting process becomes. As part of the MOU, FEMP will fund USACE to provide contracting support to other agencies that lack the needed resources to handle the turnkey procurement services themselves. Using existing authorities through the Skaggs amendment (42 USC 8287d), the upfront funding will be returned to FEMP after agencies' projects produce savings and will be used as a revolving fund to ensure continuous program support and improvement. The return of the administrative funds from savings will take several years, but eventually, a revolving fund could be established to continue supporting the upfront administrative costs of performance contracting. FEMP will support approximately 15 projects in FY 2017 through this fund. Given that the average performance contract investment is $17 million, this could result in approximately $255 million of additional project investment.

FEMP performance contracting assistance also includes the continued use of the eProject Builder National ESPC & UESC database — a tool developed by FEMP for Federal and non-Federal entities to standardize the collection, calculation, and reporting of performance data for all performance contracts to have better access and availability of project data across Government and the private sector projects. 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 (and potentially non-Federal) contracts.

In FY 2017, FEMP will accelerate Federal sustainability by providing tailored customer service to managing energy at large campuses, rather than at a stand-alone building. Nearly two thirds of all Federal facility energy use occurs in the top 450 campuses of Federal facilities. Furthermore, 81 percent of Federal square feet is within buildings that exist in campuses of 10 buildings or more. Given the large energy use and percent of square feet within campuses, FEMP is creating a Large Campus Initiative to help large campuses achieve their energy management goals. FEMP will create tools or programs tailored for large campuses as well as using existing tools such as renewable analysis, to drive project implementation. The Large Campus Initiative will use specialized assistance to target a large portion of the Federal facility energy use to achieve energy management goals.

FEM will also develop a new voluntary leadership challenge in FY 2017 to spur progress in reducing energy intensity in energy-intensive facilities. In FY 2017, FEMP will continue to support the better building challenge established in FY 2015 to improve partners' data center efficiency by 20 percent over 10 years and will add an additional public-private challenge to spur Federal achievement and to share effective solutions broadly across the economy. The FY 2017 challenge will focus on promising building related technology such as high-performance indoor lighting, advanced HVAC, water heating and ventilation and advanced controls.

FEM also provides technical assistance, training, and progress measurement and accountability to Federal agencies in tracking and achieving their energy management goals. FEM provides accountability for the Federal energy management goals by effectively tracking the Government's progress and status in energy and related goal achievement; ensures the program's capabilities are a known resource for energy management. The National Energy Conservation Policy Act (NECPA) (as amended by EISA 2007) requires that DOE collect, verify, and report on Federal agencies' progress toward their goals to address energy efficiency in facilities. In FY 2017, 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.

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 including direct technical assistance on capital projects, targeted customer service for agencies, renewable energy technical assistance, support to meet water efficiency goals, specification of energy-efficient products for agency procurement, new technology deployment, training courses, 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

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 focuses on agency achievement of the 30 percent renewable energy by 2025 requirement.

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). 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;
- Training and communication on mandates and best practices;
- Analysis of agency-reported data in the Federal Automotive Statistical Tool (FAST) for compliance with Federal mandates to reduce greenhouse gas per mile traveled, increase alternative fuel use, acquire sufficient volumes of alternative fuel vehicles, and install onsite alternative fuel infrastructure; and
- Coordination of INTERFUEL, an interagency working group that provides a forum for Federal fleet managers to learn about new/pending fleet requirements.

Activities and Explanation of Changes

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
Federal Energy Management $23,100,000	**$28,000,000**	**+$4,900,000**
• This is a new subprogram in FY 2016 that incorporates Project Financing; Technical Guidance and Assistance; Planning, Reporting and Evaluation; and Federal fleet. • 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. • 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 Better Buildings Data Center Challenge (BBDCC), improve partner's data center efficiency by 20 percent over 10 years. • Continue to track the Government's progress in energy goal 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 assisting agencies with meeting or exceeding requirements for reducing fleet petroleum consumption.	• Provide assistance to Federal agencies through tools to make performance contracting business as usual; using energy management success in Federal facilities as examples for excellent energy management Nation-wide; and providing technical assistance, training, and accountability.	• New activities in 2017 include making performance based contracts business as usual by providing upfront funding for turn-key performance contracting projects through a MOU with the Army Corps of Engineers, focusing support for energy management at large campuses, and accelerating Federal sustainability through an additional public-private challenge.

Federal Energy Management Program
Federal Energy Efficiency Fund
AFFECT

Description

In 2017, the FEEF or AFFECT Program will provide direct funding for technology deployment in areas such as: first-of-a-kind clean energy projects and deep energy savings strategies. AFFECT provides greater opportunities for agencies to develop and implement better projects that may not otherwise get off the ground. AFFECT will 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.

FEMP awards AFFECT assistance 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 well-designed projects with impactful and replicable results.

First-of-kind clean energy projects will implement commercially available, but underused, technologies in projects that have not been implemented by the organization. This program will help agencies overcome internal obstacles to new equipment, as well as drive projects forward and force schedule accountability. FEMP will emphasize technologies that are currently available on the market and can be competitively selected. These technologies are often not considered cutting edge, but offer the greatest potential to reduce energy use in the next ten years. Many AFFECT-funded projects have been jointly funded with appropriations and/or private investment through performance-based contracts, while some have been fully supported with appropriated funds or cost share between FEMP and other Federal agencies.

Deep Energy Savings Strategies will use the lessons learned in by the General Services Administration National Deep Energy Retrofit (NDER) projects to develop projects that produce deeper energy retrofits. FEMP co-sponsored NDER, which developed a process to produce deeper energy retrofits through an integrated design phase bringing together contractors, designers, and owners to synergistically explore using technology and processes to increase energy savings. The initial implementation of NDER achieved a 38 percent average reduction in energy use, where typical projects have reduced on average 19 percent.

Section 152(f) of the EPAct of 1992, Public Law 102-486, authorized the Secretary of the DOE to establish a FEEF 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)).

Activities and Explanation of Changes

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
Federal Energy Efficiency Fund/AFFECT $3,000,000	**$15,000,000**	**+ $12,000,000**
• Through FEEF/AFFECT, award approximately 6 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.	• Award approximately 30 projects in FY 2017. The AFFECT awards will focus on topics such as --first of a kind agency clean energy projects and projects that provide deep energy savings. Together these initiatives will increase Federal leadership in energy efficiency, water conservation, and renewable energy investments.	• In FY 2017, AFFECT will include a new emphasis on projects focused on deep energy saving strategies. These strategies will apply the lessons learned by the General Services Administration National Deep Energy Retrofit (NDER) projects. FEMP co-sponsored NDER, which developed a process to produce deeper energy retrofits through an integrated design phase which brought together contractors, designers, and owners to synergistically explore using technology and processes to increase energy savings. The initial implementation of NDER achieved a 38 percent average reduction in energy use, whereas typical projects demonstrate a 19 percent reduction on average

Federal Energy Management Program
NREL Site-Wide Facility Support

Description

In FY 2017, EERE will continue to directly fund National Renewable Energy Laboratory (NREL) Site-Wide Facility Support costs rather than fund those costs as laboratory overhead.

EERE proposes to eliminate the NREL Site-Wide Facility Support subprograms in its individual technology programs, and consolidate NREL Site-Wide Facility Support funding in the Facilities and Infrastructure Program. Locating this funding in the Facilities and Infrastructure Program will provide clarity and transparency in communicating EERE's stewardship for NREL, and will simplify planning and execution of EERE's annual budget. This consolidation into a single program allows for better integration and coordination of operations and investments.

NREL Site-Wide Facility Support

Activities and Explanation of Changes

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
NREL Site-Wide Facility Support $900,000	**$0**	**- $900,000**
• 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 funding requested within the Federal Energy Management Budget Request.	• Reduction in the Request is offset by a corresponding increase in the Facilities and Infrastructure Budget Request. Funding is consolidated in EERE's NREL Site-Wide Facility Support.

Federal Energy Management Program
Performance Measure

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 2015	FY 2016	FY 2017
Performance Goal (Measure)	**Investment -** Total Federal Investment in Facilities Energy Conservation Measures Government-Wide ($Million)		
Target	750	750	750
Result	N/A*	N/A	N/A
Endpoint Target	$750 million/year through 2020		

*FEMP does not have full data on this metric as FEMP will not receive direct investment information until after the end of January 2016. The total value of ESPC and UESC investments in Federal Facilities through FY 2015 is $475 million. This total is still preliminary and only includes agency-reported ESPC and UESC investments. Investment in Federal facility energy conservation measures funded by appropriations is not yet available.

Building Technologies

Overview

EERE's Building Technologies Program (BTP) develops and demonstrates advanced technologies and practices to make buildings in the U.S. more efficient, affordable, and comfortable. The program uses a three-pronged strategy to reduce energy use in residential and commercial buildings:

- High Impact Technology research and development (R&D) — target products and solutions with the highest potential energy efficiency and highest market impact;
- Technology-to-Market—validate and drive high-potential technology products and solutions into the market by verifying and improving performance and cost, provide improved data and information, and partner with manufacturers and users; and
- Lock in Savings — lock 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.

In 2015, BTP refined and updated its goals to focus on reducing building energy use per square foot, using a metric known as Energy Use Intensity (EUI), which is calculated by dividing the building sector's primary annual energy use by the building sector's total floor area. BTP set a goal of reducing the EUI of the building sector 30 percent by 2030, relative to 2010 – with a long-term objective of achieving a 50 percent reduction. Achieving these goals by 2030 would decrease total energy use by more than 5 quads, total energy-related CO_2 emissions by 450 million metric tons, and save building owners and occupants over $100 billion annually in energy costs (compared to 2010).[1] This aligns with the President's goal of doubling energy productivity by 2030, as well as the goal of reducing greenhouse gas emissions by 17 percent in 2020 and 26-28 percent in 2025 (relative to 2005) – putting the U.S. on a path to a 50 percent reduction by 2050.

To track progress toward achieving these longer-term goals, BTP established 16 performance indicators as well as 25 technology targets. BTP's Multi-Year Program Plan discusses in detail the goal framework, analytical basis, and plan for assessing progress.

Highlights of the FY 2017 Budget Request

FY 2017 activities support Administration, Departmental, and Programmatic goals. Highlights include:

- Establishing a Low-Global Warming Potential Advanced Cooling (Heating, Ventilating, & Air Conditioning) R&D program. This effort supports the Department's Clean Energy Manufacturing Initiative through the development of improved materials and fluids for next-generation HVAC systems. This R&D will address near-term needs for "drop-in" refrigerants suitable to replace HFCs in today's vapor-compression systems, while long-term solutions will focus on eliminating refrigerants entirely by transitioning to non-vapor-compression systems.
- Announcing the L Prize Contest for the Twenty-First Century Lamp prize, as part of EISA 2007, Section 655. This contest will challenge industry to create a lamp with 150 lumen per Watt with exceptionally high lighting quality to push the technology envelope and enhance future energy savings.
- Launching focused Technology-to-Market (T2M) initiatives to bridge the gap between R&D and commercialization through innovative approaches to reduce building energy consumption.
- Focusing on use of advanced sensors and controls and R&D to reduce the rapidly growing fraction of building energy usage coming from miscellaneous electrical loads (plug loads such as consumer electronics, entertainment systems, small kitchen appliances, etc.) – with these loads comprising more than 25 percent of residential electricity usage nationally.
- Creating a "Metropolitan Systems" initiative that enables the use of new sensing, communication, and computational capabilities that integrate measurement and data sources with advanced analytics to create actionable information for decision-makers about programs, policies, and practices for U.S. cities to achieve their economic, environmental, and energy targets. This new data-driven capability enables the design and development of low-energy, resilient infrastructure - considering the city as a complex integrated system.
- Conducting decision science R&D to better understand consumer decisions about whether or not to adopt energy efficient building technologies and solutions. For example, although cost-effective building energy efficiency measures

[1] Annual Energy Outlook 2014 with Projections to 2040, U.S. Energy Information Administration, April 2014

(i.e., ENERGY STAR rated appliances) exist today that can reduce building primary energy use by approximately 30 percent, there is still reluctance among consumers to invest in these technologies.

- Working as part of DOE's Grid Modernization Initiative addressing six technical areas identified in the Grid Modernization Multi-Year Program Plan (MYPP) in partnership with the Office of Electricity Delivery and Energy Reliability.

In addition, FY 2017 funds may be used to support efforts such as peer reviews; data collection and dissemination; and technical, market, and economic studies and other analyses across the BTP portfolio.

FY 2017 Crosscuts ($K)

	Grid	Total
Building Technologies	**25,000**	**25,000**

Building Technologies
Funding ($K)

	FY 2015 Enacted	FY 2015 Current[1]	FY 2016 Enacted	FY 2017 Request	FY 2017 vs FY 2016
Building Technologies					
Emerging Technologies					
Lighting R&D	25,800	25,006	24,000	27,800	+3,800
Space Conditioning and Refrigeration R&D	8,038	6,389	17,415	45,000	+27,585
Sensors & Controls	5,628	5,628	4,000	32,500	+28,500
Transactive Controls	3,226	3,226	18,000	25,000	+7,000
Building Envelope R&D	2,611	2,373	13,700	13,700	0
Analysis Tools	2,437	2,329	5,300	3,000	-2,300
High-Impact Technology R&D	8,000	7,866	3,500	6,000	+2,500
Tech-to-Market (T2M)	0	0	0	6,000	+6,000
Decision Science	0	0	0	10,000	+10,000
Total, Emerging Technologies	**55,740**	**52,817**	**85,915**	**169,000**	**+83,085**
Commercial Buildings Integration	**27,643**	**27,181**	**32,000**	**28,000**	**-4,000**
PSU Consortium for Building Energy Innovation	**10,000**	**10,000**	**0**	**0**	**0**
Residential Buildings Integration	**22,758**	**22,296**	**23,000**	**23,000**	**0**
Metropolitan Systems	**0**	**0**	**0**	**15,000**	**+15,000**
Equipment and Buildings Standards	**53,359**	**53,359**	**57,485**	**54,000**	**-3,485**
NREL Site-Wide Facility Support	**2,500**	**2,500**	**2,100**	**0**	**-2,100**
Total, Building Technologies	**172,000**	**168,153**	**200,500**	**289,000**	**+88,500**

SBIR/STTR:

- FY 2015 Transferred: SBIR $3,487,000; STTR $360,000
- FY 2016 Projected: SBIR $2,652,000; STTR $398,000
- FY 2017 Request: SBIR $5,184,000; STTR $729,000

[1] Funding reflected the transfer of SBIR/STTR to the Office of Science.

Building Technologies
Explanation of Major Changes ($K)

	FY 2017 vs FY 2016 Enacted
Emerging Technologies: Increase reflects new funding opportunity announcement (FOA) (up to $40 million) on Low-GWP Advanced Cooling (HVAC) R&D and a new FOA ($17.5 million) focused on use of advanced sensors and controls and R&D to reduce the rapidly growing fraction of building energy usage coming from miscellaneous electrical loads (plug loads such as consumer electronics, entertainment systems, and small kitchen appliances). Additionally, $6million is included for Tech-to-Market activities to enable commercialization of promising R&D technologies that will be coordinated with similar efforts within EERE as well as with the Office of Technology Transitions. $10 million is included for R&D focused on decision science related to consumer adoption of energy efficiency measures. There is also an increase in grid modernization funding ($7 million) to be used to ramp up of building related building-to-grid investments in support of planned demonstrations, business models, and market solutions.	**+83,085**
Commercial Buildings Integration: The funding reduction is due to a smaller Commercial Buildings FOA focused on investment in technology demonstrations that drive innovation and require the collaboration of dynamic demonstration teams that include energy organizations (states, local governments or Regional Energy Efficiency Organizations), efficient building hubs, utilities, and building energy modeling professionals and experts that ultimately influence multi-billion-dollar utility EE programs.	**-4,000**
Residential Buildings Integration: There is no change in funding between fiscal years.	**0**
Metropolitan Systems: New initiative focused on using new sensing, communication and computation capabilities to integrate measurement and data sources with advanced analytics and computation to create actionable information for decision-makers about programs, policies, and practices that can meet community environmental, economic, energy, and other objectives – considering the city as a complex integrated system instead of discrete components or sectors.	**+15,000**
Equipment and Buildings Standards: The funding reduction reflects the funding necessary to support the Building Energy Codes Program for FY 2017 upon having fielded both residential and commercial code assessment FOAs in earlier years, which are not required annual FOAs.	**-3,485**
NREL Site-Wide Facility Support: In FY 2017, EERE proposes to move funding for the NREL Site-Wide Facility Support subprogram from individual technology programs to the Facilities and Infrastructure Program. Locating this funding in the Facilities and Infrastructure Program will provide clarity and transparency in communicating EERE's stewardship of NREL, and will simplify planning and execution of EERE's annual budget. This consolidation into a single program allows for better integration and coordination of operations and investments.	**-2,100**
Total, Building Technologies	**+88,500**

Description

The Emerging Technologies (ET) subprogram conducts R&D on a broad array of high-impact technologies that reduce building energy consumption. These technologies include HVAC, water heating, building envelope, windows, solid-state lighting (SSL), sensors and control (S&C) including transactive controls, and appliances like clothes washers and dryer. The program also develops tools and capabilities to support building energy modeling. The ET goal is to develop cost-effective technologies capable of reducing a building's Energy Use Intensity (EUI) by 30 percent by 2020 (compared to high efficiency technologies available in 2010). To achieve this goal, ET will focus on cost-effective technologies that enable a 65 percent reduction in lighting energy use, 35 percent savings in water heating, 25 percent savings in HVAC, 35 percent savings in building envelope & windows, 30 percent savings in appliances, and 20 percent savings caused by sensors & controls (from the 2010 AEO baseline).

In FY 2017, funding supports competitive FOAs ($111.5 million). The FOAs include two that are released annually: Solid State Lighting (SSL) and Building Energy Efficiency Frontiers and Innovations Technologies (BENEFIT), plus three new FOAs: one to establish a Low-GWP Advanced Cooling (HVAC) R&D effort; one related to decision science focused on consumer adoption of energy efficiency measures; and one on Miscellaneous Electric Loads (MELs).

FOA details include:

- Solid State Lighting (SSL) FOA (up to $15 million) for projects that will achieve manufacturing cost for warm-white Light-Emitting Diode (LED) packages of 210 lumens per dollar, a 12 percent improvement compared to the FY 2016 level (188 lumens per dollar). The FY 2020 goal is 271 lumens per dollar.
- BENEFIT FOA (up to $29 million) for projects that focus on building envelope materials for retrofit applications, highly insulating windows, and advanced building sensors, as well as an open topic to address off-roadmap technology R&D Topic areas include:
  - Improved envelope materials, i.e., opaque insulating materials, are needed to retrofit existing residential and commercial buildings in the U.S. Approximately 50 percent (3.7 out of 7.4 Quads) of the heating load in residential buildings results from heat losses through roofs, walls, and foundations, and for commercial buildings it is more than 60 percent (3.2 out of 5.1 Quads). The 2015 Quadrennial Technology Review (QTR) highlighted thin, insulating materials as a research priority.
  - Heat conduction through windows contributes 28 percent of the heating load in residential buildings (2.1 out of 7.4 Quads), and 32 percent in commercial buildings (1.6 out of 5.1 Quads). The 2015 QTR also highlights the need for windows with superior performance at an affordable cost.
  - Substantial cost reductions are needed for building sensors while maintaining or improving performance, which will address the 2015 QTR recommendations. This effort will specifically address the ubiquitous need for sensors throughout buildings, both for controlling lighting, heating, air conditioning, ventilation, etc., and for enabling buildings and their equipment to transact with electric utilities.
  - An open topic targets all technologies and approaches (hardware and/or software) that can lead to substantial primary energy savings in U.S. buildings that the current portfolio does not address. The program will evaluate proposals based on their cost effectiveness by considering a simple payback analysis (using the national primary energy technical potential), which allows diverse approaches to be considered.
  - An optional Buildings University Innovators and Leaders Development (BUILD) FOA topic has been added to the BENEFIT FOA that encourages teaming between companies and university faculty and students, and will accomplish one or more of the following objectives while delivering cost-effective energy saving solutions to the market: improving the competitiveness of American universities to conduct building energy-efficiency R&D, enabling American universities to develop stronger partnerships with industry and drive more innovative solutions from academia to the market, and improving manufacturing education in American universities.
- A fully funded Low-GWP Advanced Cooling (HVAC) R&D FOA (up to $40 million) to advance cooling and heating technologies. The goal of this effort is to enable a paradigm shift in HVAC technologies, moving beyond today's refrigerants with potentially harmful environmental impacts to develop near-term low-GWP solutions and, over the long-term reach an end-state with no refrigerants required. This approach enables U.S. manufacturers to innovate in ways that enhance their competitiveness. The program will also develop vapor compression improvements to bridge

the technology gap, to meet obligations aligned with the millions of existing systems that have decades of life remaining, and to bring immediate economic benefits. Consequently, drop-in solutions will be a major part of the near-term focus. This effort will also develop better and different types of component and sub-component solutions for successful integration into a comprehensive system. The five-year objectives are:
  - Develop and demonstrate at least three emerging technologies full-scale prototype systems for advanced low-GWP vapor compression systems with at least 10 percent lower energy usage, at least 50 percent lower lifecycle GWP, and a high-volume modeled cost that is comparable to the current 2015 commercial state-of-the-art vapor compression technologies. These include drop-in low-GWP solutions.
  - Develop and demonstrate full-scale non-vapor compression (zero GWP cooling fluids) systems achieving efficiencies equivalent to or greater than current state-of-the art commercial vapor compression systems, and are life cycle cost effective using a high-volume modeled cost.
- Decision Science FOA (up to $10 million) for R&D to better understand consumer decision-making in the context of building energy efficiency technology deployment and fill the information gap between the availability of energy efficiency solutions and consumer adoption. For instance, although cost-effective building energy efficiency measures (i.e., Energy Star rated appliances) exist today that can reduce building primary energy use by nearly 30 percent; there is still reluctance to invest in these technologies. DOE's 2015 QTR calls out "decision science issues affecting purchasing and operating decisions" as a key research opportunity. The program will refine specific research targets via stakeholder engagement in FY 2016, but one of the metrics will be the ability to accurately replicate consumer-buying behavior based on existing empirical data for energy efficiency technologies. The overall goal will increase adoption of such technologies leading to immediate reductions in building primary energy consumption. The program will work with the Department of Housing and Urban Development to collaborate on and coordinate clean energy behavioral R&D efforts, particularly in the areas of behavior changes among builders, property owners and tenants.
- Miscellaneous Electric Loads (MELs) FOA (up to $17.5 million) for a new EERE R&D effort focused on use of advanced sensors and controls and R&D to reduce the rapidly growing fraction of building energy usage coming from miscellaneous electrical loads (plug loads such as consumer electronics, entertainment systems, small kitchen appliances, etc.) – with these loads comprising more than 25 percent of residential electricity usage Nationally. BTO will leverage the advancements made in power electronics by Advanced Manufacturing Office through new and improved wide bandgap semiconductor materials to reduce the overall energy needed for power conversion applications (such as converting AC line energy to the DC power needed by the MELs). Workshops and stakeholder engagement early in FY 2017 will be followed by a FOA to investigate R&D activities for MELs and Smart Devices that will include, but not be limited to, new control strategies that will shut off or turn down devices when they are not in use; consumer decision science to understand the pervasive use of such devices and what will influence consumers to only use devices when they are actually needed; and the deployment of these materials and devices, combined with improved sensors and controls, to enable a system's approach to improved building energy management.

In addition the SSL Program will announce the L Prize Contest for the Twenty-First Century Lamp prize, as part of EISA 207, Section 655. This contest will challenge industry to create a lamp with 150 lumen per Watt with exceptionally high lighting quality to push the technology envelope and enhance future energy savings.

The ET subprogram request includes up to $23.6 million for direct laboratory funding, comprising support for core and enabling capabilities, technical assistance, and laboratory calls. The entire ET laboratory portfolio underwent an external merit review in April 2015, resulting in the selection of three-year projects for all subprograms, except sensors and controls. The sensors and controls subprogram will undergo another merit review in FY 2016. Priorities for the direct laboratory funding will be as follows:

- Develop or maintain key experimental facilities necessary for manufacturers (large and small) to develop 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;
- Support high-impact energy efficiency R&D projects selected through a merit-reviewed laboratory call;
- Provide analytic and deployment support related to MELs; and
- Fill technology gaps in the ET MYPP not addressed through an ongoing or planned FOA projects.

ET subprogram includes $6 million in funding for "Tech-to-Market" (T2M) activities, to advance promising building energy efficiency technologies from R&D to commercialization using innovating approaches such as "crowd-sourcing" to reduce

building energy consumption, whether through software approaches (via the Catalyst Program initiated by SunShot) or through hardware approaches (via the JUMP Program initiated at ORNL). T2M bridges the gap between R&D and commercialization by incorporating partnerships that encourage commercialization into new and/or existing project plans. T2M activities leverage and crosscut energy efficiency solutions and initiatives from both Commercial Buildings Integration (CBI) and Residential Buildings Integration (RBI) subprograms. Building Technologies Office (BTO) Tech-to-Market activities will be coordinated with similar efforts in other EERE program offices and with the Office of Technology Transitions to promote consistency and best practices Department-wide.

As part of DOE's Grid Modernization Crosscut, ET subprogram includes $25 million primarily for grid integration controls and interoperability solutions development in support of demonstrations showing how the building related systems can deliver quantitative value back to the grid in different utility service areas, working in close partnership with the Electricity Delivery and Energy Reliability (OE). 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 are often rudimentary with heavy human interaction and extensive customization, which is neither cost effective nor scalable. The path to achieving advanced automated buildings that cost effectively transact with the grid encompasses several key topics for utilities, industry, and building designers, contractors, managers and owners to increase and expand the hosting capacity of Energy Efficiency and Renewable Energy technologies by empowering buildings. This enables buildings, fleets of equipment, and other building assets to deliver services to the grid while maximizing EE for the owners. Developing and demonstrating advanced controls are a key enabler of EE and EM (Energy Management), as they will be critical to delivering the value proposition for the equipment manufacturer, building owner and utility at scale. The ET subprogram will develop and help implement R&D demonstrations that manage buildings against a building and campus energy budget, especially those with resource constrained operations, and will validate and scale proactive controls – controls that adaptively learn, automatically commission and run "calisthenics" to understand individual building and equipment's probability of response and action We will also develop transactive applications and apply them to buildings and equipment to deliver solutions that satisfy various grid, user, energy and societal market use cases. It is the effective demonstration and documentation of these projects, in various utility and building situations, that will enable the market to scale these solutions beyond our limited efforts.

Activities and Explanation of Changes

FY 2016 Appropriation	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
Emerging Technologies $85,915,000	**$174,000,000**	**+88,085,000**
Lighting R&D ($24,000,000) • Continue support to improve performance and cost for LEDs and OLEDs. The roadmap-driven LED cost target for FY 2016 is 160 lumens/$, 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 (27,800,000)* • Continue support to improve performance and cost for LEDs and OLEDs. The roadmap-driven LED cost target for FY 2017 is 210 lumens/$, leading to the 2020 goal of 271 lumens/$. A 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 (+3,800)* • The SSL Program will announce the L Prize Contest for the Twenty-First Century Lamp prize, as part of EISA 2007, Section 655. This contest will challenge industry to create a lamp with 150 lumens per Watt with exceptionally high lighting quality to push the technology envelope and enhance future energy savings.
Space Conditioning and Refrigeration R&D ($17,415,000) • 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 CO2 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).	*Space Conditioning and Refrigeration R&D ($45,000,000)* • Direct laboratory funding for R&D in HVAC, water heating, and appliances was merit reviewed in FY 2016, and ORNL was awarded a three-year project (FY 2016-FY 2019) to continue their core work. Projects emphasized in FY 2017 include air-source integrated heat pumps; a commercial integrated heat pump with thermal storage; cold climate heat pumps; residential gas-fired absorption heat pumps; gas-fired adsorption and absorption water heaters; advanced compressor technologies; and high-efficiency, low-emission refrigeration systems. In addition, a Low-GWP Advanced Cooling (HVAC) R&D FOA will be released funded at up to $40 million.	*Space Conditioning and Refrigeration R&D (+$27,585,000)* • The increase in funding is due to the release of a new FOA for Low-GWP Advanced Cooling (HVAC) R&D.

FY 2016 Appropriation	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
Sensors & Controls ($4,000,000) • 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/ft2 in 2014 to $1.25/ft2 in 2020 (75 percent decrease).	*Sensors & Controls ($32,500,000)* • Direct funding for R&D will be merit reviewed again in FY 2016. Support will likely continue on the development of the open-source VOLTTRON control platform, on low-cost energy-harvesting sensors for buildings, and on the development and testing of occupancy-based controls. *An advanced sensors topic is included in the FY 2017 BENEFIT FOA to reduce the costs of sensors from more than $150/point to less than $10/point, while maintaining or improving performance.* Direct lab funding ($2.5 million) and FOA ($17.5 million) focused on use of advanced sensors and R&D to reduce the rapidly growing fraction of building energy usage coming from miscellaneous electrical loads.	*Sensors & Controls (+$28.5 million)* • Increased funding supports advanced sensors R&D, including a $17.5 million for Miscellaneous Electrical Loads (MELs) to reduce the rapidly growing fraction of building energy usage coming from plug loads such as consumer electronics, entertainment systems, and small kitchen appliances.
Transactive Controls ($18,000,000) • In coordination with DOE Grid Integration activities, funding supports R&D in the development of Transactive Energy Applications to better integrate Distributed Energy Resources directly within buildings and the electric power system. Through this work, the subprogram will develop a characterization methodology to quantify the capacity/availability of resources in buildings to deliver grid and other services; design, develop, and field a multi-purpose controller and algorithms that will ensure real time optimal operation, increase electric grid reliability; and lead to the goal of clean, efficient, reliable and affordable next generation buildings and energy systems.	*Transactive Controls ($25,000,000)* • In coordination with the DOE Grid Modernization Initiative, funding supports R&D in the development of advanced Transactive Energy applications and load control strategies for building level components and equipment to provide improved efficiency of the integrated electric energy system or extend the service life of utility and building assets. Through this work, the subprogram will develop whole-building supervisory load control and fault detection and diagnostics algorithms for improving the energy efficiency, reducing peak demand, and enabling grid responsive loads. The subprogram will continue to fund campus and neighborhood applications of Transactive Energy and related demonstrations.	*Transactive Controls (+$7,000,000)* • Increased funding supports the Grid Modernization effort representing a ramp-up of building related building to grid investments including the subprogram's continue focus on campus-focused and neighborhood deployment demonstrations of Transactive Energy, Additional funds will be used to support additional campus demonstrations where transaction-based controls can help increase the community's hosting capacity for clean energy while increasing system reliable. The demonstrations will serve as "recipes" for replication of experiments to help utilities, municipalities, and building owners who are facing larger deployments of clean energy technologies, aging infrastructure, and new regulations. Specifically, the program will advance transactive control for grid services – especially tools and applications needed for

FY 2016 Appropriation	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
		direct building/campus participation; building and campus scale microgrids and smart cities concepts that provide grid resource (e.g. transactive exchange/control with microgrids systems); and, utilize open communication standards, protocols, platforms to develop real solutions.
Building Envelope R&D ($13,700,000) • 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/ft2 in 2015, to 3 and $0.5/ft2 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/ft2 in 2015, to R-45 at $3/ft2 in 2020), daylighting technologies (25 percent lighting energy reduction at $20/ft2 in 2015, to 35 percent and $13/ft2 in 2020), and dynamic windows ($20/ft2 in 2015 to $15/ft2 in 2020) & films ($15/ft2 in 2015 to $8/ft2).	*Building Envelope R&D ($13,700,000)* • Direct laboratory R&D funding in building envelope and windows was merit reviewed and core work will continue. Projects include software tools for thermal and optical performance of the building envelope that will integrate with building energy modeling design tools, modeling and testing of window attachments to support rating and certification programs, and technologies that enable cost reductions for highly insulating envelope components. Two topics in building envelope R&D will be part of the BENEFIT FOA. The two topics in the FY 2017 BENEFIT FOA for windows & envelope are (i) envelope materials for retrofit applications, and (ii) highly insulating windows. The current status of envelope materials is a performance of R-6/in., at an installed cost premium of $1.1/ft^2, and the corresponding 2020 targets are R-8/in. and $0.35/ft^2. For windows, the current status for residential buildings is an R value of R-5.9 at an installed cost premium of $63/ft^2, and the corresponding 2020 targets are R-10 and $10/ft^2, respectively.	*Building Envelope R&D ($0)* • No Change.
Analysis Tools ($5,300,000) • Lab-directed funding will continue to support the development of the open-source EnergyPlus building energy modeling software, including	*Analysis Tools ($3,000,000)* • Direct laboratory funding for R&D of analysis tools was merit reviewed, and a team consisting of NREL, LBNL, and ORNL will continue core	*Analysis Tools (-$2,300,000)* • The decrease reflects the reduction in effort in the evolution of the EnergyPlus package towards a modular framework. The Analysis

FY 2016 Appropriation	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
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 supported. Contractors selected through a competitive request for proposal will develop modules for some building components.	work on a three-year project starting in FY 2016. Leading a group of competitively solicited development contractors, the core laboratory team will continue to maintain and enhance the open-source industry-leading EnergyPlus whole-building energy simulation engine and will release an update supporting manufacturer-developed component models late in the year. ASHRAE Standard 140 "BESTEST" will publish the updated thermal fabric test suite.	Tools Subprogram is just completing a significant updating and development cycle for our primary modeling software tools. Going into FY 2017, we will still have maintenance activities and some additional modeling algorithms to develop for new technologies and systems, however the cost will be substantially lower than the FY 2016 budget.
High-Impact Technology R&D ($3,500,000) • 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 laboratory call with the Commercial Buildings Integration Program targeting near-term technologies facing the "valley of death."	*High-Impact Technology R&D ($6,000,000)* • This funding is targeted for the open topic in the FY 2017 BENEFIT FOA.	*High-Impact Technology R&D (+$2,500,000)* • Additional funding is allotted to the open topic in the BENEFIT FOA.
Tech-to-Market (T2M) ($0) • No funding was requested in FY 2016 for T2M activities.	*Tech-to-Market (T2M) ($6,000,000)* • Funding supports a variety of activities focused on moving technologies from R&D to commercialization, such as crowd-sourcing efforts for both software and hardware approaches.	*Tech-to-Market (T2M) (+$6,000,000)* • T2M represents a new emphasis to overcome the barriers preventing promising R&D projects from reaching commercialization.
Decision Science ($0) • No funding was requested in FY 2016 for Decision Science in the Emerging Technologies subprogram.	*Decision Science ($10,000,000)* • Funding supports a FOA to improve our understanding of consumer decisions related to the gap between the availability of energy efficiency technologies and solutions and consumer adoption.	*Decision Science (+$10,000,000)* • Increase supports a FOA to improve our understanding of consumer decisions related to the gap between the availability of energy efficiency technologies and solutions and consumer adoption. DOE's 2015 QTR specifically calls out "decision science issues affecting purchasing and operating decisions" as one of the key research opportunities for buildings. This FOA will help bridge that gap.

Building Technologies
Commercial Buildings Integration

Description

Commercial buildings represent more than 80 billion square feet of real estate in the U.S.; account for nearly 40 percent of all U.S. electricity consumption; cost over $190 billion in energy annually; consume almost 20 percent (or 18 quads) of U.S. primary energy; and are responsible for about 20 percent of U.S. carbon dioxide emissions.[1][2] Reducing energy use in commercial buildings has a tremendous positive impact on our environment, energy security and the economy by saving money that can be used to help grow U.S. businesses. Energy savings of 20 percent or more are possible in commercial buildings if a variety market barriers to energy efficiency are overcome, especially in the commercial real estate market.[3]

The CBI subprogram addresses non-technical barriers and 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 the delivered energy savings. To do this, the CBI subprogram promotes voluntary activities with industry to prime and support improved energy efficiency, with an emphasis on underused high-potential products that meet performance and cost hurdles for investment. Market leaders play a key role in the testing out new solutions in the commercial sector, which if proven, will be adopted by the rest of the sector. CBI subprogram is partnering and developing solutions with market leaders to reduce commercial buildings Energy Use Intensity (EUI) by at least 35 percent by 2025 (relative to 2010 levels).

The goals for these activities are to demonstrate at a meaningful scale and level of integration 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 plans to achieve these goals through three strategic areas in FY 2017:

- Speeding the commercialization and market uptake of promising technologies through technology-to-market (T2M) and demonstration activities;
- Developing tools and resources needed to address non-technical barriers for greater investment in efficiency; and,
- Partnering and engaging with market leaders to accelerate adoption of advanced technologies and solutions by the commercial buildings market.

To address the first strategic area, CBI includes $7.5 million to update and guide investments through its high impact technology (HIT) Catalyst activities that accelerate the adoption of underused but commercially available, efficient, and cost-effective technologies. HIT Catalyst uses a rigorous investment prioritization process that leverages sophisticated technical and market data and analyses 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 market transformation activity. Through this work, CBI identified five HITs for which the program will develop and execute technology specific deployment activities. The deployment activities include organizing building owners and identifying required specifications to help challenge manufacturers to meet this demand; conducting technology demonstrations that identify, install, and monitor the performance of a HIT in a real world installation, and then communicating the results to the public via a case study; working with purchasers, technology providers, and other stakeholders to identify technology attributes that will enable product technical and energy performance through technical specifications; and developing of a technology campaign that works with industry partnership organizations and provides technical support to encourage their members to commit to installing a HIT.

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[1] "U.S. Energy Information Administration. "2012 CBECS Preliminary Results." Washington, DC: U.S. Department of Energy. Accessed September 23, 2014: http://www.eia.gov/consumption/commercial/reports/2012/preliminary/index.cfm?src=Consumption-b1.

[2] U.S. Energy Information Administration. *Annual Energy Outlook 2015 with projections to 2040*. DOE/EIA-0383(2015). Washington, DC: U.S. Department of Energy, April 2015. Accessed January 11, 2016: http://www.eia.gov/forecasts/aeo/pdf/0383(2015).pdf.

[3] Better Buildings Alliance. *2013 Annual Report*. U.S. Department of Energy: Washington, DC. DOE EE 0993. http://www4.eere.energy.gov/alliance/sites/default/files/uploaded-files/better-buildings-alliance-annual-report-2013.pdf.

Together the five HITs that CBI is working on in FY 2016 represent 2 quads of energy savings potential. They Include: LED troffers and controls; energy management information systems, shadings and awnings, refrigeration controls and display case retrofits; and fans and blowers. The selected HIT technologies shift each fiscal year as CBI completes its respective deployment strategies for each one. Thus, CBI will likely retire 1-2 technologies while then also adding 1-2 each year.

The CBI subprogram will also invest up to $6.5 million in a FOA that drives innovation in real building technology demonstrations that will require the collaboration of demonstration teams, which include energy organizations (states, local governments or Regional Energy Efficiency Organizations), efficient building networks at the regional or local levels (such as Innovation or Incubator network), utilities and building energy modeling professionals and experts. The FOA will solicit multi-system or multi-technology (groups of technologies) demonstrations, specifically targeting any two or more technology areas in envelope, lighting/electrical, plug, process, heating, ventilation, cooling, refrigeration, energy management and information, sensors and controls, with preference for those packages that include envelope retrofits and multi-system, interoperable controls. These "packages" will help unlock new efficiency opportunities within their networks and regions, create new synergies across the demonstration sites by collecting performance data (for energy consumption, cost and other benefits) that can be shared across utility territories, publicly published and distributed in order to support and accelerate the deployment of the demonstrated packages. Ultimately, this approach will help utilities develop and release or expand more aggressive and ambitious incentives or programs. In addition, the FOA supports the critical function of evaluation, measurement and verification (EM&V) by requiring selectees to use existing CBI tools and resources, like OpenStudio, to develop the multi-system savings calculations and then verify those savings and identify other market factors in real buildings.

CBI will also invest more than $1 million to accelerate the adoption of advanced technologies and energy-saving strategies for new buildings. The funding will support coordinated demonstration and deployment activities aimed at enabling market leaders to deploy multiple energy conservation measures to drive much deeper efficiency gains. As part of this approach, CBI has recognized that the new construction market is ready to also begin pushing toward zero energy buildings, an area CBI seeks to expand into by combining energy efficiency and renewable energy generation strategies that help these building projects achieve zero energy (i.e., consume only as much energy as can be produced onsite through renewable resources over a specified time).

To address the second strategic focus area, CBI will fund a project ($6.5 million) to increase the availability and interoperability of data on the energy performance and physical /operational characteristics of buildings. In 2017, CBI will continue to build and deploy data and decision support tools that focus on common data structures and processes to support and drive greater investment in energy efficiency across all commercial market sectors. CBI activities in this area include successfully improving access to decision-grade information on building energy performance and making information interoperable, accurate, and readily available at all levels of granularity. In FY 2017, the CBI subprogram plans to 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).
- Improving and standardizing 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 to make information about individual building conditions and local market trends available to renters, buyers, brokers, appraisers and lenders during real estate transactions.

To address the third strategic area, CBI will continue to fund $6 million its market-based public-private engagement efforts designed to support and partner with leaders in the commercial buildings market. Through this collaborative vehicle, CBI is able to support activities that economically develop and test new highly efficient and cost-effective building technologies and energy management strategies in the field. Ultimately, these efforts have helped partners identify and implement new, innovative solutions across 13 technology areas and achieve a combined energy savings of nearly $850 million. CBI will

expand this work in FY 2017 with new commercial sector leaders and non-governmental organizations to drive these solutions and tools further and faster through joint campaigns, new incentives, and other strategic activities. Central to the market engagement is the support and management of the Better Buildings Challenge (BBC) and the Better Buildings Alliance (BBA), which create opportunities to strategically link and accelerate the adoption of high-impact technologies, best practices, and market solutions with market leaders. Better Buildings is a broad, multi-strategy initiative to improve the energy use of the Nation's commercial, industrial, residential, and public buildings by 20 percent over 10 years. More than 250 leaders from diverse sectors have stepped up to the Challenge, representing over 3.5 billion square feet, 650 manufacturing plants, and $5.5 million in financing investments. These partners document their progress toward the goal by sharing information on the energy intensity of their portfolios against a baseline year. Across the country, partners have shared energy data for more than 32,000 properties and are reporting savings of 20 percent or more at 4,500 properties, and 10 percent or more at 12,000 properties; projected to meet energy savings goals, saving on average 2 percent each year or $840 million since the initiative was launched. In addition, the BBA includes more than 180 organizations, representing 10 billion sq. ft. and accounting for over 10 percent of total U.S. commercial building stock. These organizations work in collaboration with DOE and focus on specific technology and market-related solutions that are then adopted by members.

Specifically, DOE supports the 400+ Challenge and Alliance partners by conducting regular workshops and webinars; supporting 8 technology teams to advance packaged solutions customized for various market sectors; developing and building a one-stop-shop online solutions center; developing and highlighting innovative implementation models and showcase solutions; creating "Accelerators" to demonstrate innovative approaches in energy data, performance contracting, real estate, strategic energy management, outdoor lighting, and outdoor lighting to address the barriers to greater energy efficiency; hosting an annual summit; and recruiting new partners and collaborators. To date, CBI has leveraged BBA to issue two technology challenges, three technology adoption campaigns, 12 procurement specifications, 7 Accelerators, and numerous technical solutions reports 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 total $17 billion and more than 2.0 quads of source energy every year.

In FY 2017, CBI will continue collaborating with the ET subprogram on T2M activities to speed the migration of technologies from R&D to market availability. This effort 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, laboratory testing and systems integration demonstrations, and development of commercialization plans, training approaches, and early feedback from customers.

Activities and Explanation of Changes

FY 2016 Appropriation	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
Commercial Buildings Integration $32,000,000	**$28,000,000**	**-$4,000,000**
• Update the HIT Catalyst to guide technology-to-market activities. Execute technology demonstrations, procurement specifications and installation guides to accelerate market acceptance of FY 2015 focus technologies include interior lighting, building controls and technology systems. Assess HIT list to develop 3-4 focus technologies for FY 2016 and develop multi-year technology to market plan.	• Advance 5 HIT Catalyst technology priorities to spur market uptake and adoption. For each HIT, execute technology demonstrations and develop procurement specifications and installation guides to accelerate market acceptance. Develops HIT "watch list" and multi-year technology-to-market plan.	
• Supports a FOA in the small and medium commercial buildings sector through regional and national partnerships.	• Supports a FOA for cost-shared technology demonstrations for small and medium sized existing commercial buildings that will have a positive impact on building energy use, operational costs, market readiness, market penetration outlook (including commercial availability, sales channel plans and competitive pricing outlook) and other quantifiable and non-quantifiable benefits. Demonstrations should result in the application of the technology and collection of performance data (for energy consumption, cost and other benefits) that can be shared across utility territories, publicly published and distributed in order to support and accelerate the deployment of the demonstrated packages..	• FOA funding reduced from $10 million in FY 2016 to $5.5 million in FY 2017 to reflect the narrowed scope and packaged technology focus.
• 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.	• Develop initiative to accelerate the adoption of advanced technologies and energy-saving strategies for new construction, a new focus area for our Commercial program, including an effort to catalyze zero energy buildings. The initiative will support coordinated demonstration and deployment activities (technical resources and specifications, R&D,	

FY 2016 Appropriation	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
	case studies, tech demos) aimed at supporting market leaders so they can go much further across multiple energy conservation measures and therefor drive much deeper, more integrated efficiency gains.	
• Maintain successful market partnership programs such as the Better Buildings Challenge to accelerate adoption of energy efficiency technologies and practices. In 2006, the CBI will focus on developing robust partnerships with industry organizations to extend the impact.	• Advance successful market partnership programs such as the BBC and BBA. The focus will be on developing robust partnerships with new industry organizations and market segments to extend the impact and reach of new accelerators that address specific barriers.	
• Continue T2M activities with the Emerging Technologies subprogram and collaboration with the Equipment and Building Standards subprogram through high-impact technology commercialization projects.	• Continue T2M activities with the Emerging Technologies subprogram and collaboration with the Equipment and Building Standards subprogram through high-impact technology commercialization projects.	

Description

The Residential Buildings Integration (RBI) subprogram has a goal of demonstrating cost-effective technologies and practices that can reduce the EUI of new single family homes at least 60 percent and existing homes by at least 40 percent by 2020 (relative to a 2010 baseline) while maintaining performance in all major climate regions, with a focus on reducing heating, cooling and water heating loads.

The RBI subprogram conducts applied research to resolve the major technology-to-market challenges to achieving these goals. 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 initiatives, 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 demonstrated and accepted in the market by leading builders and retrofit contractors, they can be adopted into building energy codes based on their cost effectiveness, energy savings potential, and consumer interests.

Technical Solutions — In FY 2017, the RBI subprogram will invest $16 million on Building America research. The centerpiece of Building America will be its annual FOA ($8 million), which will fund a consortium of building science teams to develop and demonstrate technology and business solutions for three challenges identified below.

- Moisture Managed High-R Envelopes: Technical solutions ensuring moisture management in highly insulated and tighter, high performance building envelopes;
- Smarter Indoor Air Quality Solutions: Cost effective solutions to maintain indoor air quality, including effective whole-house and spot ventilation; and
- Optimized Low-Load Comfort Solutions: Solutions for high-performance homes with much lower heating and cooling requirements that need to ensure full mixing with much lower airflow and humidity control during longer swing seasons. Specialized solutions for these research areas may be required for different climates.

In addition to research to improve whole house retrofits, Building America teams will focus its research on retrofit technology to improve the energy efficiency of frequently installed single measure improvements, with significantly larger national energy and associated financial savings. In 2017, RBI will complete climate-specific guidance documents for implementing solutions to these problems based on this research.

Market Transformation: New Construction — in the new homes segment, the RBI's primary focus is to address the diverse and fragmented residential market by providing actionable technical information on more cost-effective energy efficient solutions for new homes and successful case studies from builders constructing zero energy ready homes. The Building America Solution Center provides a one-stop resource for builders to access the well-validated and successful building efficiency implementation approaches developed and demonstrated by the Building America teams. The Building America Solution Center provides better, faster, and easier-to-use web-based content for all housing industry stakeholders at substantially lower cost than fixed content. In addition to providing new Building America content and user feedback, the Center also provides cost-effective retrofit solutions for the existing homes retrofit market.

In addition, the RBI will fund system integration R&D on technologies developed by the ET subprogram that are nearly market-ready. The RBI subprogram will continue to use its market integration tools (e.g., Zero Energy Ready Homes, Home Performance with ENERGY STAR, Staged Upgrade Initiative) to help move technologies and solutions resulting from its R&D investments into the market, with the goal of achieving cost-effective adoption at scale. RBI will also continue to facilitate growing infrastructure of housing industry professionals with critical building science skills through the Race to Zero Student Design Competition and Building America Building Science Education Guidelines.

RBI's strategy also includes workforce education implemented through its annual "Race to Zero Student Design Competition", which provides an opportunity for schools and their students to learn building science skills from world-class experts, compete in designing zero energy ready new homes, and make important career connections. The expected outcome of the competition is that all major architecture, engineering, and construction management programs will

integrate building science in their courses. A complementary activity, the Building America Building Science Education Guidelines, is establishing a building science competency framework for all major building workforce classifications.

The "DOE Zero Energy Ready Home" is a labeling program that highlights and promotes builders who have built new homes that are 40 to 50 percent more energy efficient than homes built to the IECC 2006 model energy code — a significant improvement beyond the typical ENERGY STAR home. This program is designed to better inform consumers who are making these important home-buying decisions.

Together these comprehensive RBI demonstration and market transformation activities are intended to enable the new homes market to achieve the highest level of home performance while minimizing lifecycle costs to homeowners.

Market Transformation: Existing Homes—. The Better Buildings Residential Network (BBRN), and the membership of this market-facing network is open to all contractors and program administrators as a way to access EERE's proven tools and resources, as well as participate in meetings and webinars to share best practices to increase the number of homes that are energy efficient.

Home Performance with ENERGY STAR (HPwES) is a premier whole house residential program that develops guidelines for deep energy retrofits. While weatherization activities only include a very limited number of measures in a home, with HPwES, the full range of opportunities are evaluated for each individual home being improved. DOE, through HPwES outlines the necessary processes, including quality assurance, for deep energy retrofits yielding 20 percent savings on average to homeowners. DOE provides technical support to program sponsors, which includes development of work specifications, recommendations of best practices, communications, and outreach support centered on the ENERGY STAR brand, and an extensive network of existing retrofit programs that share lessons learned. HPwES provides a model retrofit program, with name recognition from both the retrofit community and homeowners. Nearly 500,000 homes have been retrofitted to date under HPwES. In FY 2017 HPwES will continue its progress in reducing the costs for participation by home retrofit companies and program sponsors to increase its availability to homeowners throughout the U.S. The Better Buildings Home Upgrade Program Accelerator is a companion effort focused on improving the processes used to manage and track home upgrades, review quality of work, and evaluate impacts. Identifying and sharing best practices to streamline administrative processes and data management will help HPwES partners achieve more upgrades.

A whole-house retrofit allows the owner the best opportunity to capture the benefits from the interactive effects of improving multiple systems at one time. However, to increase the uptake of energy efficiency improvements in existing homes without the significant first cost of a whole house upgrade, RBI will also focus on staged retrofit to address smaller, incremental market opportunities. This approach is intended to encourage more homeowners to complete home retrofit activities, leading to larger savings nationally.

A staged home improvement opportunity involves the interaction between a single trade company (e.g., an HVAC contractor) and the homeowner concerning what they can do to improve the performance of different home components and mechanical systems (e.g., HVAC, water heating, insulation, windows, roofs, etc.) in addition to informing how staging their retrofits can improve the end result from an efficiency and homeowner affordability perspective. RBI will initially work with one or more high volume home improvement industries such as HVAC, as a pilot.

In FY 2017, the RBI subprogram will continue to support the Home Energy Score (HEScore), providing information to homeowners, potential retrofit contractors, and others on the energy efficiency of homes. HEScore is similar to a vehicle miles-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 incentivize homeowners to make energy efficiency improvements, increasing home comfort and reducing energy costs. The Home Energy Scoring Tool is used by utilities, states, home contractors, and others across the U.S. to provide reliable information on the energy performance of homes, as well as cost-effective recommendations to improve their efficiency. RBI has initiated efforts to extend the use of this tool across the country and FHA/HUD recently announced the intent to insert the score into loan requirements. A companion effort, the Better Buildings Home Energy Information Accelerator, is working with dozens of local and national partners to overcome the barriers to widespread inclusion of HEScore and other energy metrics in MLSs.

Through the Better Buildings platform, RBI will continue to support a Home Upgrade Program Accelerator. The Home Upgrade Program Accelerator works with partners to identify methods for reducing transaction costs associated with home upgrade programs, with an initial focus on using improved and standardized data specifications to support data collection and analysis. Both Accelerators will develop a number of products, including tool kits that can help interested parties outside of the Accelerators address similar problems related to linking energy efficiency to real estate transactions and reducing administrative costs.

The Better Buildings Residential Program Solution Center is a counterpart to the Building America Solution Center (to be integrated in the future). This Residential Program 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, Home Performance with ENERGY STAR, Better Buildings Residential Network, and other utility efforts. These lessons include key success factors in financing, workforce development, contractor engagement, consumer demand, quality assurance, evaluation, and benchmarking characteristics of successful programs. DOE will continue to convene program administrators and allies through conference calls and webinars to ensure the Solution Center is up-to-date with the latest information on program administrators' successes as well as solutions to problems facing their programs through the Better Buildings Residential Network.

Activities and Explanation of Changes

FY 2016 Appropriation	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
Residential Buildings Integration $23,000,000	**$23,000,000**	**$0**
• Focus on applied research through its Building American 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. • 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.	• FOA ($8 million) that will focus on applied research through Building America and 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. This is a continuation of the investigation DOE is conducting to improve the overall energy efficiency of the nation's housing stock.	
• 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	• RBI will work with a range of partners including states, utilities, and home inspectors to scale up use of the Home Energy Score in the market. RBI will invest significantly in the underlying IT infrastructure (e.g., Scoring Tool, Assessor database, database of 30,000+ homes scored) to support this market expansion as well as improve usability; streamline and automate processes; and accommodate new applications of the Score (e.g., transferring a home's Score data to FHA to facilitate implementation of the new policy which allows higher debt-to-income ratios to borrowers based on a home's Score). Working in collaboration with real estate stakeholders, RBI will also increase efforts to	

FY 2016 Appropriation	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
STAR Program, the RBI subprogram will help efficiency programs and their partners to more comprehensively address barriers to adoption of retrofits.	make the Score and related data (e.g., expected energy use) easily accessible during real estate transactions, including integration of the Score into multiple listing services (MLSs). • 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. Through Home Performance with ENERGY STAR, the RBI subprogram will help efficiency programs and their partners to more comprehensively address barriers to retrofits. Continue to support infrastructure development through Solution Centers, providing technical and programmatic solutions to the market. The RBI subprogram will support standards development.	

Building Technologies
Metropolitan Systems

Description

Local governments have ambitious climate and energy goals aimed at building cities that are low carbon, affordable, livable, economically viable, and resilient to extreme events; however, developing and implementing long-term energy plans to achieve these goals based on sound analysis remains a challenge for cities due to a lack of information on potential integrated solutions and inadequate city-level resources, capacity, and expertise. This Initiative will use new sensing, communication and computation capabilities to integrate measurement and data sources with advanced analytics to create actionable information for decision-makers about programs, policies, and practices that can meet community environmental, economic, energy, and other objectives—considering the city as a complex integrated system instead of discrete components or sectors. This new capability will enable the use of historic and real-time, data-driven tools to support the design and development of low-energy, resilient infrastructure and will enable U.S. cities to achieve their climate and energy targets. Achieving this goal will require engagement of community leaders from government and the business sectors, to build out decision-grade tools that can inform programs and policies.

DOE can make an immediate impact in cities with a coordinated, fully integrated effort to help cities and metro areas: (1) assess, measure and benchmark data for cities and deploy new city relevant data collection platforms; (2) develop new multi-scale tools as well as data systems and test beds to collect data for tool development and validation; and (3) translate and apply the knowledge gained to city decision making. Taken together, these three efforts form the baseline of a multi-year program to achieve the vision outlined above. The $15 million provided for this initiative in FY 2017 will support projects in all three of these areas using a mix of competitive funding and laboratory funding. DOE anticipates devoting $2 million to the first task, $6 million to the second, and $7 million to the third. The funding will also support a cross-cutting (across items 1-3) competitive funding opportunity (or opportunities) – called the METRO FOA or Maximizing Efficiency, clean Transportation, and Renewable Opportunities FOA. The METRO FOA would solicit proposals from cities and local governments in metro areas that are poised to deliver smart, innovative cross-cutting efficiency and clean energy opportunities through city- or metro-level integrated systems approaches and solutions that drive deep, multi-sector efficiencies. This work will be coordinated across the applicable EERE offices to ensure that we are leveraging existing work. The FOA would help fund these metro area recipients (coalitions of local governments) to develop and utilize new sensing, communication and computation capabilities to integrate measurement and data sources with advanced analytics and computation, creating a smart cities portal that would create actionable information for metro and city decision-makers to better guide programs, policies, and practices that target community environmental, economic, energy, and other objectives. By thinking of efficiency and clean energy at the metro/city scale instead of by discrete components or sectors, the FOA would help optimize a systems approach as well as the use of advanced analytics, capturing interdependencies and new strategies that exploit non-linear interactions.

This initiative will be coordinated with other DOE efforts (e.g., Cities-LEAP, Climate Action Champions, SEE Action, and Clean Cities), multiple DOE offices (EERE, OE, SC, FE, EPSA, CI) and the National Laboratories, involve ongoing Federal efforts more broadly (e.g., HUD, EPA, DOT, NIST, and USDA) and external efforts (e.g., USDN, C40 Cities, NRDC/IMT City Energy Project, ICLEI, STAR Communities Index, Bloomberg What Works Cities, and Rockefeller 100 Resilient Cities). In coordination with these and other agencies, this initiative will help the Federal Government provide cities the knowledge, expertise and tools to achieve their energy and climate goals.

Metropolitan Systems

Activities and Explanation of Changes

FY 2016 Appropriation	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
Metropolitan Systems $0	**$15,000,000**	**+$15,000,000**
• No funding.	• FOA to fund RD&D projects that help cities and metro areas: (1) assess, measure and benchmark data for cities and deploy new city relevant data collection platforms; (2) develop new multi-scale tools as well as data systems and test beds to collect data for tool development and validation; and (3) translate and apply the knowledge gained to city decision making.	• New programmatic activity.

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 incrementally raises the standards over time to save energy by requiring the adoption of more efficient technologies. Test procedures and energy conservation standards support national energy policy objectives, such as increasing energy savings and energy productivity, and reducing carbon emissions.

The Appliance and Equipment Standards programs regulates the efficiency of new products that ultimately account for the vast majority of energy use in the building sector—nearly 90 percent of all energy used in residences and nearly 60 percent of all energy in the commercial buildings, as well as over 20 percent of energy use in the industrial sector. These activities aim to reduce the energy use intensity (EUI) of the entire building sector by at least 20 percent by 2025 (vs. 2010 levels).[1]

DOE is committed to meeting 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 ENERGY STAR, regulatory activities, and model building code activities. The Energy Policy and Conservation Act (as amended) legislatively mandates 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, DOE has issued 40 new or updated appliance standards, covering more than 45 products, which 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.

In FY 2017, $47.7 million for Appliance and Equipment Standards will fund all necessary and feasible steps to finalize legally required efficiency standards consistent with all applicable judicial and statutory deadlines. For products that do not have statutorily mandated deadlines, DOE will prioritize completing those rulemakings that deliver a high level of energy savings and CO_2 reductions beyond statutorily mandated rules. DOE will also maintain its activities regarding the certification and enforcement of existing energy conservation standards. With certification requirements commercial products coming into play in mid- to late 2014, DOE will have many more products to test. Specifically, in FY 2017, Appliance and Equipment Standards activities will:

- 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); and
- Perform laboratory research on covered product technology barriers.

This subprogram also includes $6.3 million for Building Energy Codes. This activity fulfills a legislative requirement for DOE to evaluate changes to model building energy codes, which inform the development of state and local building codes. Through this activity, DOE also 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. Building energy codes can provide 20-30 percent whole building energy savings. The associated cumulative energy savings through 2020 is estimated at 10.2 Quads since DOE Building Energy Codes activities began in 1992. DOE also evaluates typical design and construction practices, tracking progress towards a goal of new buildings using 40 percent less energy per square foot by 2025 (comparable to buildings built in 2010). DOE also participates in the development of residential and commercial model building energy codes, as administered by the International Code Council (ICC) and ASHRAE.

[1] This analysis was conducted using the National Energy Modeling System, which is used to generate the Annual Energy Outlook forecasts.

Activities and Explanation of Changes

FY 2016 Appropriation	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
Equipment and Buildings Standards $57,485,000	**$54,000,000**	**-$3,485,000**
• Program will complete work on final rules to increase the efficiency or set new standards that are projected to provide over 200 million metric tons of carbon emissions savings by 2030. Program will continue to enforce minimum standards and verify the performance of ENERGY STAR products.	• Program will meet statutory obligations and continue to work on all active rulemakings. Program will continue to enforce minimum standards and verify the performance of ENERGY STAR products.	
• 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. • Release a Commercial Building Energy Codes FOA.	• The Building Energy Codes activity will meet statutory obligations, including participation in national model code development and implementation. The program will continue to seek to increase the number of states that have adopted and are complying with updated codes.	• Funding reduction principally due to the absence of a Commercial Building Energy Codes FOA, which will be issued in FY 2016. There is no Codes FOA in FY 2017.

Building Technologies
NREL Site-Wide Facility Support

Description

In FY 2017, EERE will continue to directly fund National Renewable Energy Laboratory (NREL) Site-Wide Facility Support costs rather than fund those costs as laboratory overhead.

EERE proposes to eliminate the NREL Site-Wide Facility Support subprograms in its individual technology programs, and consolidate NREL Site-Wide Facility Support funding in the Facilities and Infrastructure Program. Locating this funding in the Facilities and Infrastructure program will provide clarity and transparency in communicating EERE's stewardship for NREL, and will simplify planning and execution of EERE's annual budget. This consolidation into a single program allows for better integration and coordination of operations and investments.

NREL Site-Wide Facility Support

Activities and Explanation of Changes

FY 2016 Appropriation	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
NREL Site-Wide Facility Support $2,100,000	**$0**	**-$2,100,000**
• 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 funding requested within the Building Technologies Budget Request.	• Reduction in the Request is offset by a corresponding increase in the Facilities and Infrastructure Budget Request. Funding is consolidated in EERE's NREL Site-Wide Facility Support.

Building Technologies
Performance Measure

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 2015	FY 2016	FY 2017
Performance Goal (Measure)	**Lighting -** Decrease the manufacturing cost of a warm white LED package (Lumens/$)		
Target	144	188	210
Result	176	N/A	N/A
Endpoint Target	271 lm/$ 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. In FY 2017 WIP proposes a new initiative to achieve greater scale in deploying clean energy technologies working with local governments and communities.

Aligning with the President's Climate Action Plan and the Administration's multi-faceted approach to clean 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 existing subprograms include the Weatherization Assistance Program (WAP) and the State Energy Program (SEP). In FY 2017 WIP will also establish a new Cities, Counties, and Communities Energy Program that will provide technical assistance and competitively-awarded funds to local governments, public housing authorities, non-profits and other locally-focused stakeholders to catalyze more extensive clean energy solutions in community development and revitalization efforts.

WIP and its national network provide strategic leadership, resource leveraging, and market expertise to accelerate deployment of energy efficiency and renewable energy products and technologies that, where implemented, 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, management of retrofit programs, and land use plans. Local governments are an important bridge between state action and community deployment. They uniquely have the understanding of municipal ecosystems and community needs and the significant role revitalization that are critical to integrating clean energy thinking into the built environment. WIP includes the ability to do the following:

- Use state energy and weatherization networks and competitive awards to state and 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 sustainable 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 2017 Budget Request

WIP's FY 2017 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 35,700 low-income residential energy retrofits, with annual per unit average energy cost savings of $250-$480 between 2017-2037; and
  - Continued improvements in workforce training, quality standards, and worker certification to improve the quality of the work performed.
- SEP will continue to support core capacity and innovation in state energy offices and dissemination of best practices to:
  - Maintain a portfolio of diverse energy efficiency and renewable energy programs and policies through an active

network of state energy offices with the capacity to develop, improve, and implement these initiatives through the provision of funding through formula grants.

  - Assist states in reducing energy use in government facilities; accelerating investment in public sector use of energy service performance contracts; and supporting 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 (achieved through the provision of funding through competitively awarded cooperative agreements and the provision of technical assistance).

- The Cities, Counties and Communities Energy Program will provide support to local governments, public housing authorities, non-profits and other stakeholders to catalyze more extensive clean energy investments in revitalization efforts. Competitive funding and technical assistance will be provided to Climate Action Champions, Choice Neighborhood grantees, and other eligible entities for energy efficiency and renewable energy integration planning and implementation projects. The program will coordinate with the Neighborhood Revitalization Initiative to harmonize efforts as appropriate.

Weatherization and Intergovernmental Programs
Funding ($K)

	FY 2015 Enacted	FY 2015 Current	FY 2016 Enacted	FY 2017 Request	FY 2017 vs FY 2016
Weatherization and Intergovernmental Programs					
Weatherization Assistance Program					
Weatherization Assistance (formula and competitive grants)	189,600	189,600	211,600	225,000	+13,400
Training and Technical Assistance	3,000	3,000	3,000	5,000	+2,000
NREL Site-Wide Facility Support	400	400	400	0	-400
Total, Weatherization Assistance Program	**193,000**	**193,000**	**215,000**	**230,000**	**+15,000**
State Energy Program	**50,000**	**50,000**	**50,000**	**70,000[1]**	**+20,000**
Cities, Counties & Communities Energy Program (3C Energy Program[2])	**0**	**0**	**0**	**26,000**	**+26,000**
Total, Weatherization and Intergovernmental Programs	**243,000**	**243,000**	**265,000**	**326,000**	**+61,000**

[1] The FY 2017 State Energy request is for $45 million in formula grants, $15 million in competitive financial assistance, and $10 million in technical assistance.

[2] In FY 2016 EERE requested $20 million in funding for a Local Energy Program (LEP) with a different focus than the 3C Energy Program. No funding was appropriated for the LEP in FY 2016.

Weatherization and Intergovernmental Programs
Explanation of Major Changes ($K)

	FY 2017 vs FY 2016 Enacted
Weatherization Assistance Program	
Weatherization Assistance: The $13.4 million increase will support formula program operations and provide weatherization retrofits for an additional 3,000 or more low-income families across the country.	**+13,400**
Training and Technical Assistance: The $2 million increase 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.	**+2,000**
NREL Site-Wide Facility Support: In FY 2017, EERE proposes to move funding for the NREL Site-Wide Facility Support subprogram from individual technology programs to the Facilities and Infrastructure program. Locating this funding in the Facilities and Infrastructure program will provide clarity and transparency in communicating EERE's stewardship of NREL, and will simplify planning and execution of EERE's annual budget. This consolidation into a single program allows for better integration and coordination of operations and investments.	**-400**
State Energy Program: The increase ($6 million) for formula grants will expand state-led comprehensive clean energy and emergency energy assurance planning capabilities and address emerging environmental challenges a portfolio of multi-jurisdictional competitive energy projects; $10 million will have high impact/high-visibility and replicability to other state and local entities; and additional resources ($4 million) will facilitate clean energy technology delivery through additional "best practice" tools, "lead by example" methods, peer to peer forums, and strategic partnerships.	**+20,000**
Cities, Counties & Communities Energy Program: The $26 million for competitive awards and technical assistance for local governments, public housing authorities, non-profits, and other locally-focused eligible entities to catalyze more extensive clean energy solutions in community development and revitalization efforts.	**+26,000**
Total, Weatherization and Intergovernmental Programs	**+61,000**

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 over 6 million upgrades to low-income households, including 1 million retrofits supported through American Recovery and Reinvestment Act of 2009[1] funding.

WAP supports the largest and one of the most technically advanced networks of residential energy retrofit providers in the country. It plays a leadership role in strengthening the infrastructure of the residential energy retrofit market, through coordination with industry stakeholders; it develops and implements voluntary and comprehensive national certifications and standards in retrofit worker training, energy audits, and weatherization methods. For example, utility programs across the country have recognized and adopted the Home Energy Professional Certification program. These types of activities directly contribute to the following *Enhancing Employment and Workforce Training* recommendations found in DOE 2015 Quadrennial Energy Review (QER).

QER Recommendations in Brief: Enhancing Employment and Workforce Training[2]:

- Support an energy-job skills training system through the interagency Skills Working Group;
- Expand support for an open-source learning community to develop, facilitate, and expand use of state-of the art courses in energy-related fields;
- Coordinate efforts to accelerate the development of high-quality energy and manufacturing curricula and apprenticeship programs; and
- Facilitate national credentials for energy occupations.

Weatherization Assistance ($225,000,000)

The FY 2017 Budget Request for Weatherization formula grants provides resources to accomplish approximately 35,700 home retrofits in FY 2017. This work should save $225 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.). WAP allocates funds on a statutory formula basis and awards them 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 poverty guidelines updated periodically in the Federal Register by the U.S. Department of Health and Human Services under the authority of 42 U.S.C. 9902(2). 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. Active Federal, regional and state training and technical assistance programs ensure the consistent delivery of quality services. The program uses both Federal and non-Federal funding sources to expand the array of services available for each home and increase the number of homes weatherized.

Training and Technical Assistance ($5,000,000)

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

[1] http://www.gpo.gov/fdsys/pkg/PLAW-111publ5/pdf/PLAW-111publ5.pdf.
[2] U.S. Department of Energy, *Quadrennial Energy Review: Energy Transmission, Storage, and Distribution*, April 2015, S-29, http://energy.gov/sites/prod/files/2015/07/f24/QER%20Full%20Report_TS%26D%20April%202015_0.pdf.

variety of tools needed to implement work quality, training accreditation, and worker certification. Recent T&TA accomplishments include:

- Successful adoption of components of the WAP's Quality Work Plan guidance including:
  - Certification of over 1,500 Home Energy Professional Quality Control Inspectors;
  - Review and approval of updated grantee field guides aligned with the Standard Work Specifications; and
  - Review and approval of Grantee Training Plans to incorporate accredited trainings.
- Presentation to various industry groups on WAP tools including the Better Buildings network, multifamily stakeholder groups, Federal partners, and utility industry.
- Participation in Federal Health Homes Working Group and dissemination of WAP Healthy Homes training to various industry stakeholders.

T&TA initiatives continuing into 2017 include:

- 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, 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. All grantees and must maintain their HEP quality control inspector certification 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.
- 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 exchange.

In FY 2015, the program completed the national evaluation of WAP. The evaluation covered 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. An impact analysis estimated national energy savings and program cost effectiveness, as well as, non-energy benefits and a comprehensive process evaluation addressed program characterization, operation, training, and quality assurance. Publically released results include:

- Single-family home average annual energy cost savings of $283;
- 8,500 job supported;
- Program-wide savings-to-investment ratio of 1.4; and
- Program-wide benefit cost ratio when including health and safety benefits of 4.1.

NREL Site-Wide Facility Support ($0)

EERE proposes to eliminate the NREL Site-Wide Facility Support subprograms in its individual technology programs, and consolidate NREL Site-Wide Facility Support funding in the Facilities and Infrastructure program. Locating this funding in the Facilities and Infrastructure program will provide clarity and transparency in communicating EERE's stewardship for NREL, and will simplify planning and execution of EERE's annual budget. This consolidation into a single program allows for better integration and coordination of operations and investments.

Activities and Explanation of Changes

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
Weatherization Assistance Program $215,000,000	**$230,000,000**	**+$15,000,000**
Weatherization Assistance ($211,600,000 for formula grants) • Supports energy upgrades in the homes of low-income families through formula grants. • Award and actively manage 59 weatherization formula grantees, which will support approximately 33,600 comprehensive energy audits and residential energy retrofits.	*Weatherization Assistance ($225,000,000 for formula grants)* • Award and actively manage 59 weatherization formula grantees, which will support approximately 35,700 comprehensive energy audits and residential energy retrofits.	*Weatherization Assistance (+$13,400,000 for formula grants)* • The funding level for Weatherization formula grants will support critical infrastructure and an improved level of operations, while serving 2,100 additional low-income families across America.
Training and Technical Assistance ($3,000,000) • 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.	*Training and Technical Assistance ($5,000,000)* • Maintenance and improvement of the Guidelines for Home Energy Professional suite of resources including the Standard Work Specifications, Home Energy Professional Certifications, and Training Program Accreditation. • Expansion of Home Energy Professional certification program to include selected multifamily designations. • Enhancement and expansion of the multifamily capacity of the WAP network through coordination with training programs, local WAP agencies, and multifamily stakeholders.	*Training and Technical Assistance (+$2,000,000)* • The $2 million increase will accelerate retrofit standards infrastructure deployment and support expanded grantee monitoring and oversight.
• Facilitate the on-line use of a suite of residential energy auditing tools related to the WAP. • 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	• Migration of the single-family Weatherization Assistant energy audit tool onto an online platform. • Development and execution of research projects to improve the quality of services and enhancement of benefits to low-income WAP recipients. Specifically, WAP will utilize the results of the WAP National Evaluations to identify areas of program operation that could	• An online Weatherization Assistance energy audit tool will allow for greater local network efficiencies when at the recipients' homes and for interim desk reviews of energy audits occurring in the field for greater quality assurance. • Provides resources for the analysis and strategic implementation of changes to the WAP based on the National Evaluation results.

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
help qualify them to assess health issues along with conservation needs.	be improved through the development of best practices or further investigation. DOE will coordinate with partner federal agencies to ensure that this research is, where possible, applicable to a wide range of programs.	
• Continue grantee and subgrantee operations improvement through the WAP Quality Management Plan for training and skills development through identifying the knowledge, skills and abilities state and local staff need, reviewing existing training resources, and developing two or more curricula designed to address specific management needs. Improve grantee and subgrantee performance through state plan process with adoption of WAP Quality Work Plans features including certified quality control inspectors.	• Continue improvement of grantee and subgrantee performance through state plan process with expansion and enhancement of WAP Quality Management and Work Plans features. WIP will conduct a gap analysis of training needs and identify available resources to fill these needs. Tools will be developed for DOE staff and Grantees to aid in assessment of training needs and to develop curricula around management topics. WAP will also continue targeted technical assistance of the Quality Work Plan through the state plan process which includes a review of the current certified quality control inspectors by grantee.	• This expanded capability to assist grantees in updating training requirements and staff position duties will assist the network with identifying and securing the training needed to improve management of WAP programs across the country.
• 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.	• Plan and conduct a WAP National Conference as a forum that DOE will use to deliver and demonstrate advanced techniques, highlight successful models of training programs and enable peer exchanges.	• Learnings from the WAP National Evaluation and developments and replicable models curated from local network agencies need to be delivered more broadly to grantees and local agencies periodically to ensure continuous improvement of DOE's WAP.
NREL Site-Wide Facility Support ($400,000) • 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 ($0)* • No funding requested within the WIP Budget Request.	*NREL Site-Wide Facility Support (-$400,000)* • Reduction in the Request is offset by a corresponding increase in the Facilities and Infrastructure Budget Request. Funding is consolidated in EERE's NREL Site-Wide Facility Support.

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 appropriate to state and regional circumstances.

Most of the FY 2017 funding, $45 million, will provide 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 will also fund an increased in competitive projects and technical assistance targeted at high-impact projects within state energy offices to create more public-private partnerships initiated by states within and outside of their borders to address critical clean energy challenges. Examples of successful SEP competitive projects include:

- Iowa's deployment of regional energy managers (REMs) throughout the state to work with local governments to assist 20 local governments to create energy plans and move forward with energy audits for 1.8 million of building space;
- New Mexico's work with four local governments to pilot a state energy savings performance contracting program and assisting them to establish a pre-qualified list of providers. The first of the four local agencies has completed its retrofits and is realizing savings;
- Washington's efforts with its state legislature to strengthen its energy efficiency resources standard, which was implemented on April 6, 2015. Changes include removal of a formula based shortcut approach, a more flexible cost-effectiveness standard, and better documentation of measurement and verification protocols; and
- Massachusetts invested SEP competitive funding in the Schools and Public Housing Integrating Renewables and Efficiency (SAPHIRE) program for school districts. Upgrades through this program have significantly reduced the participating school districts' need to purchase heating oil and will yield an estimated $46,000 in energy savings per year while also reducing carbon emissions.

In FY 2017, SEP will competitively award $15 million to a variety of individual state projects as well as multi-jurisdictional approaches where state energy offices partner with other states and/or local government energy, environment, or economic development agencies to develop and implement initiatives 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 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 overcome barriers 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 establish 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 24 of the FY 2017 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 activities. 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 support resources are integral to:

- Tools development, decisional information, and other technical assistance to grantees and sub-recipients;
- National energy initiatives and strategic partnerships focused on deployment and best practices;
- Improvement of web-based reporting and monitoring systems; and
- Metrics and evaluation of state planning, analysis, and evaluation activities.

Of special note is the completion and release of a major SEP national evaluation in FY 2015, which developed independent estimates of key program outcomes and metrics, including energy savings, renewable energy production, carbon emissions reductions, and employment impacts. The evaluation covers the FY 2008 and American Recovery and Reinvestment Act of 2009 periods and results will be used to inform future program planning and goal-setting. Preliminary evaluation results for program year 2008 from the report, which is representative of a normal year of funding, include:

- For every SEP dollar spent, program participants received $4.50 in bill savings over the lifetime of the measures installed.
- The SEP investments resulted in lifetime energy savings and renewable generation of 9.7 trillion BTUs (primary source), enough energy to power up to 52,000 homes per year.
- There were SEP-attributable lifetime cost savings of $94.6 million.
- Social costs of $37.4 million were avoided due to reduced carbon emissions associated with program-induced energy savings and renewable generation. Those carbon emissions amounted to 0.57 million metric tons of carbon equivalent (MMTCE), which is equivalent to the annual emissions from nearly 440 thousand passenger vehicles.
- 2,044 SEP-attributable jobs were created or retained, which is equal to about 1 job per $12,500 in SEP dollars invested.

In addition to the work outlined above, SEP has made significant progress through the following initiatives and activities, which will continue in FY 2017:

- SEP leads the public sector section in EERE's Better Buildings Challenge and other cooperative initiatives. Between FY 2010 and FY 2015, the program established partnerships with:
  - Over 100 public-sector partners to catalyze energy efficiency across the country accelerating investment and sharing of successful best practices to reduce their energy intensity; and
  - 25 states to develop replicable approaches for improving public buildings, to include the use of energy savings performance contracts.
- SEP uses partnerships with national and regional organizations that represent key decision-makers 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.

The program directly contributes to the QER infrastructure recommendation to "Support the updating and expansion of state energy assurance plans."[1] With additional resources SEP could support the implementation of the following QER infrastructure and electric grid recommendations.[2]

[1] U.S. Department of Energy, *Quadrennial Energy Review: Energy Transmission, Storage, and Distribution*, April 2015, S-13, http://energy.gov/sites/prod/files/2015/07/f24/QER%20Full%20Report_TS%26D%20April%202015_0.pdf.

[2] U.S. Department of Energy, *Quadrennial Energy Review: Energy Transmission, Storage, and Distribution*, April 2015, S-13 and S-16, http://energy.gov/sites/prod/files/2015/07/f24/QER%20Full%20Report_TS%26D%20April%202015_0.pdf.

- Establish a competitive grant program to promote innovative solutions to enhance energy infrastructure resilience, reliability, and security.
- Provide state financial assistance to promote and integrate transmission, storage, and distribution infrastructure investment plans for electricity reliability, affordability, efficiency, lower carbon generation, and environmental protection.

Activities and Explanation of Changes

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
State Energy Program $50,000,000	**$70,000,000**	**+$20,000,000**
• Advance deployment of effective energy efficiency and renewable energy policies and technologies by state governments. • Award and actively manage 56 formula grants supporting $39 million in state energy projects. Competitively selected 12 or more projects, involving 20+ states (some projects will be multi-state) for 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; and, streamlining permitting and interconnection for renewables. Develop and deliver a portfolio of strategic technical assistance offerings to state energy offices. • Begin implementing changes based on the findings of the major national evaluation of the program. • Develop and deliver a portfolio of strategic technical assistance offerings to state energy offices.	• Advance deployment of effective energy efficiency and renewable energy policies and technologies by state governments. • Award and actively manage 56 formula grants supporting $45 million in state energy projects. • Award and actively manage 30+ competitive awards focused on state planning, analysis and innovative strategies/practices to advance deployment of clean energy technologies and provide replicable models for state and local government entities. Innovative state/regional projects will be funded in a variety of areas including comprehensive energy planning, public-private efforts to expand use and development of new financing and PACE models, expanding 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 and streamlining permitting and interconnection for renewable and other distributed energy resources, etc. • Technical assistance: DOE will provide additional technical assistance to states to enhance both their formula and competitive funded efforts, in addition to scaling up partnerships with state and local governments through initiatives such as Better Buildings, providing technical resources developed by DOE labs and other experts, and delivering replicable models and solutions through the State and Local Solution Center. The increase expands SEP's highly effective	• Formula grants: expands state-led capabilities in comprehensive clean energy planning, addressing emerging environmental challenges, and emergency energy assurance planning. • Competitive grants: Increase the number and types of state-lead projects to catalyze greater adoption of energy efficiency and renewable energy technologies. In FY 2016, 12 projects were awarded. The increase in FY 2017 will enable up to 20+ additional competitive efforts to be supported across the country.

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
	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
Cities, Counties and Communities Energy Program (3C Energy Program)

Description

In FY 2017 the Cities, Counties, and Communities Energy Program (3C Energy Program) will be established. It provide technical assistance and competitively-awarded funds to local governments, public housing authorities, non-profits, and other locally-focused eligible entities to catalyze more extensive clean energy solutions in community development and revitalization efforts.

Local government entities are in a unique position to reduce greenhouse gas (GHG) emissions and implement clean energy solutions. They are a bridge between state action and neighborhood-level deployment and uniquely have the understanding of community ecosystems and local needs that are critical to integrating clean energy into the municipal environment. The 3C Energy Program acknowledges this expertise and provides resources to support clean energy at the community-scale. The primary focus of the program will be providing competitive funding and technical assistance to Climate Action Champions, Choice Neighborhood grantees, and other eligible entities for energy efficiency and renewable energy integration planning and implementation projects in support of community development and revitalization efforts. The program will coordinate with the Neighborhood Revitalization Initiative to harmonize efforts where possible. Coordinated area-wide employment of Federal resources with local planning and decision-making can transform and improve entire neighborhoods and communities. The program will also support local government efforts to advance local energy efficiency and renewable energy solutions, transformative best practices, benchmarking, and lead-by-example policy strategies. Energy efficiency policies, implemented at the local scale, in a municipality, county or metropolitan area will lower energy costs, reduce GHG emissions, and support economic development goals.

The technical assistance provided by this program will significantly enhance the ability of project planners to incorporate clean energy solutions in community development and revitalization project designs. It will also help local governments to overcome market barriers and create major opportunities for energy savings, low carbon energy, and jobs, particularly in the context of community development and revitalization. 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.

This program will provide 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.

Cities, Counties and Communities Energy Program (3C Energy Programs)

Activities and Explanation of Changes

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
Cities, Counties and Communities Energy Program		
$0	**$26,000,000**	**+$26,000,000**
• No funding requested in FY 2016.	• Support a geographically diverse cross section of replicable, high impact, competitively selected community projects, focused on revitalization projects and community development, across the country. • Provide targeted policy and technical support to significantly enhance the ability of project planners to incorporate clean energy solutions in community development and revitalization project designs.	• The competitive awards and technical assistance will support local governments, public housing authorities, non-profits, and other locally-focused eligible entities to catalyze more extensive clean energy solutions in community development and revitalization efforts.

Weatherization and Intergovernmental Programs
Performance Measure

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 2015	FY 2016	FY 2017
Performance Goal (Measure)	**Retrofits -** Number of low-income family homes weatherized		
Target	30,000	33,600	35,700
Result	Met – 34,220	N/A	N/A
Endpoint Target	150,000 home energy retrofits between FY 2017 and the end of FY 2022		

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 global transition to a clean energy economy through high-impact research, development, demonstration, and market barriers activities to make clean energy as affordable and convenient as traditional forms of energy. The FY 2017 Program Direction Budget Request provides necessary resources to address both EERE and the Department's management and performance goals through exemplary program and project management, administrative support, contract administration, human capital management, headquarters and field site non-laboratory facilities and infrastructure, and contractor support.

Highlights of the FY 2017 Budget Request

The FY 2017 Program Direction Budget Request has five primary goals:

- Maintain staffing up to a planned maximum Full-Time Equivalent (FTE) level of 707;
- Strengthen EERE's workforce through training and talent management programs, including effective recruitment strategies, career and leadership development, and succession planning;
- Continue the IT Systems Integration (ITSI) effort launched in FY 2015, to develop and maintain an integrated IT-based platform for EERE's business processes: budget planning, formulation, and execution processes; FOA development through award selection; project management of EERE projects with industry and university performers; and award and management of EERE's projects with the National Laboratories. The purpose of the ITSI project is to improve EERE's operational effectiveness and efficiency by providing an information technology system that supports improved execution of its business processes for managing its programs, projects, and data.
- Support 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 2015 Enacted	FY 2015 Current	FY 2016 Enacted	FY 2017 Request	FY 2017 vs FY 2016 Enacted
Program Direction					
Washington Headquarters					
Salaries and Benefits	73,629	73,629	73,629	74,940	+1,311
Travel	3,196	3,421	3,190	3,490	+300
Support Services	18,345	18,345	13,930	18,809	+4,879
Other Related Expenses	22,716	23,241	22,023	31,700	+9,677
Total, Washington Headquarters	**117,886**	**118,636**	**112,772**	**128,939**	**+16,167**
Golden Field Office					
Salaries and Benefits	23,634	23,634	23,634	23,205	-429
Travel	170	170	160	280	+120
Support Services	2,364	2,364	1,700	1,700	0
Other Related Expenses	1,751	1,751	1,900	1,900	0
Total, Golden Field Office	**27,919**	**27,919**	**27,394**	**27,085**	**-309**
National Energy Technology Laboratory					
Salaries and Benefits	8,484	8,484	8,484	8,325	-159
Travel	177	177	150	230	+80
Support Services	621	621	700	821	+121
Other Related Expenses	4,913	4,913	5,500	5,500	0
Total, National Energy Technology Laboratory	**14,195**	**14,195**	**14,834**	**14,876**	**+42**
Total Program Direction					
Salaries and Benefits	105,747	105,747	105,747	106,470	+723
Travel	3,543	3,768	3,500	4,000	+500
Support Services	21,330	21,330	16,330	21,330	+5,000
Other Related Expenses	29,380	29,905	29,423	39,100	+9,677
Total, Program Direction	**160,000**	**160,750**	**155,000**	**170,900**	**+15,900**
Total FTEs	**697**	**697**	**697**	**707**	**+10**

	FY 2015 Enacted	FY 2015 Current	FY 2016 Enacted	FY 2017 Request	FY 2017 vs FY 2016 Enacted
Support Services					
Technical Support	7,586	7,586	4,899	6,399	+1,500
Management Support	13,744	13,744	11,431	14,931	+3,500
Total, Support Services	**21,330**	**21,330**	**16,330**	**21,330**	**+5,000**
Other Related Expenses					
Other Services	12,996	13,521	10,701	10,774	+73
Working Capital Fund (WCF)	16,384	16,384	18,722	28,326	+9,604
Total, Other Related Expenses	**29,380**	**29,905**	**29,423**	**39,100**	**+9,677**

Activities and Explanation of Changes

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016 Enacted
Program Direction $155,000,000	**$170,900,000**	**+$15,900,000**
Salaries and Benefits $105,747,000	**$106,470,000**	**+$723,000**
• Funding enables EERE to maintain and support a world-class Federal workforce of 697 FTEs 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 during FY 2016 as EERE recruits to reach its operational hiring goals.	• Funding maintains EERE's ability to support a world-class Federal workforce of 707 FTEs 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.	• Funding is increased to provide ten additional FTEs to ensure Federal management oversight commensurate with the increased program budget request.
Travel $3,500,000	**$4,000,000**	**+$500,000**
• EERE's FY 2016 travel budget supports management of projects across the country, providing government oversight of EERE-funded projects.	• EERE's FY 2017 travel budget supports management of projects across the country, providing government oversight of EERE-funded projects.	• Increase in funding of $500,000 to support travel needed for annual project site-visits to ensure proper risk management and oversight of projects.
Support Services $16,330,000	**$21,330,000**	**+$5,000,000**
• 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.	• 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.	• Increase of $5 million to fund continued development of ITSI and restore important contract support to FY 2015 funding levels.
Other Related Expenses $29,423,000	**$39,100,000**	**+$9,677,000**
• 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,	• 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,	• Growth accounts for cost increases in the DOE-wide WCF costs of approximately $3 million and the consolidation of the WCF into the program direction account from EERE program funds, accounting for about $6.7 million.

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016 Enacted
supplies/equipment, printing/graphics, copying, mail, contract closeout, purchase card surveillance, computer equipment (hardware, software, licenses, and support), utilities, postage, administrative expenses, security, and publications.	supplies/equipment, printing/graphics, copying, mail, contract closeout, purchase card surveillance, computer equipment (hardware, software, licenses, and support), utilities, postage, administrative expenses, security, and publications. All EERE working capital fund costs will be funded by the program direction account only.	

Strategic Programs

Overview

Strategic Programs funds high-impact, crosscutting, integrative activities that are most efficiently executed by a single cross-cutting EERE organization in coordination with EERE Technology Programs. Strategic Programs also supports a cohesive and limited set of high-priority, high-impact activities that help to inform, catalyze and increase the commercial market impact of the DOE National Laboratories' RD&D and the manufacturing competitiveness of U.S. companies developing and leveraging clean energy technologies.

Strategic Programs consists of four principal subprograms:

- Technology-to-Market (T2M) – strengthens the American energy innovation ecosystem by developing new, innovative and high-impact partnerships and programs across startups and small businesses, industry, universities, DOE National Laboratories, investors, and non-profit organizations to reduce technology commercialization barriers and maximize investment in the U.S. innovation ecosystem, leading to increased jobs and global competitiveness. Catalyzes more successful clean energy commercialization, entrepreneurship, technology transfer, and manufacturing competitiveness outcomes from EERE's research, development, & demonstration (RD&D) programs.
- Strategic Priorities and Impact Analysis (SPIA) – provides a portfolio-based analytical foundation to perform impact assessments of EERE's portfolio. Informs RD&D strategic planning and decision-making, enabling continuous improvement of EERE's approach. Analyzes crosscutting issues that affect EERE technologies, such as clean energy manufacturing, city energy use, and grid integration.
- 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.
- Communications and Outreach – provides key stakeholders and the 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 2017 Budget Request

- By capitalizing on prior year investments to strengthen the U.S. energy innovation ecosystem, Technology-to-Market (T2M) will focus on building out the "middle ground" of commercialization support between early-stage technology concept development and deployment. Technology-to-Market will accomplish this with new programming that builds more fruitful and direct collaborations between technology developers (e.g. at startups, small businesses, universities, and National Laboratories), and other pillars of the U.S. innovation ecosystem: (1) investment capital, (2) industry, and (3) technology development and manufacturing resources. The subprogram will continue its support of early-stage entrepreneurship (through the National Incubator Initiative for Clean Energy (NIICE) and Cleantech University Prize programs). It will also continue support of the Energy Transition Initiative for Islands, including its efforts in Hawaii and the Caribbean, and expanding its work in the Pacific region, including Alaska, coordinating closely with other agencies, especially the Department of Interior. Finally, the subprogram will continue the initial Lab-Corps pilot and conduct a Lab-Corps program evaluation that will inform decisions regarding the scope of this activity beyond FY 2017. The innovative commercialization and other models developed within the T2M subprogram are shared, planned and closely coordinated with OTT and other parts of DOE and EERE for potential expansion that meets the concomitant goals and objectives efficiently and cost effectively.
- The SPIA subprogram will conclude the initial stage of its Cities-LEAP initiative, partnering with cities to explore strategies to advance data-driven decision-making in support of their climate and energy goals, and the long-range potential for deployment of clean energy technologies in cities and municipalities. These assessments will include evaluation of the opportunities related to various sustainable transportation, efficiency, and renewable power technologies; the creation of tools to identify and assess the impact of city-level policies and practices on energy use and greenhouse gas (GHG) emissions; and evaluation of the potential carbon mitigation and economic benefits that could be realized if cities across the country deployed these technologies and practices. SPIA will also conduct impact evaluations using EERE's peer-reviewed methodology. The project will also sponsor analysis at the Clean Energy Manufacturing Analysis Center (CEMAC), a consortium of DOE National Laboratories that develops innovative models and tools to promote economic growth and the transition to a clean energy economy.

- The International subprogram will focus on collaborations with large emerging economies such as China, India, and Brazil that are continuing to construct power plants, commercial buildings, industrial facilities, and housing at historic rates. The subprogram will also focus on other markets, including South Africa and the Middle East, which may become first adopters of emerging energy technologies. The subprogram will also continue its support of bilateral clean energy research and development (R&D) with Israel. The subprogram will work with partner countries and U.S. clean energy technology and service providers on grid integration of renewable energy, development and enforcement of building energy codes, policy and regulatory frameworks to promote energy savings performance contracting, data center energy efficiency, reliability standards and joint testing of photovoltaics, standards for industrial boiler energy efficiency, and other topics of joint interest.

Strategic Programs
Funding ($K)

	FY 2015 Enacted	FY 2015 Current	FY 2016 Enacted	FY 2017 Request	FY 2017 vs FY 2016
Strategic Programs					
Technology-to-Market	6,263	6,263	5,974	11,500	+5,526
Strategic Priorities and Impact Analysis	6,506	6,506	6,769	6,000	-769
International	3,682	3,682	3,789	6,000	+2,211
Communications and Outreach	4,549	4,549	4,468	4,500	+32
Total, Strategic Programs	**21,000**	**21,000**	**21,000**	**28,000**	**+7,000**

Strategic Programs
Explanation of Major Changes ($K)

	FY 2017 vs FY 2016 Enacted
Strategic Programs	
Technology-to-Market: In FY 2017 T2M will focus on building out the "middle ground" of commercialization support between early-stage concept and deployment. T2M will accomplish this with new programming that builds more fruitful and direct collaborations between technology developers (e.g. at startups, small businesses, universities, and National Labs), and other pillars of the U.S. innovation ecosystem: (1) investment capital, (2) industry, and (3) technology development and manufacturing resources. Also, as part of the Energy Transition Initiative for Islands, the subprogram will expand its efforts to the U.S. Pacific territories and freely associated states, including Alaska, while maintaining its level of effort in Hawaii and the Caribbean. This includes further deployment of the Islands Playbook, training programs, and the development and dissemination of best practices and lessons learned from other island communities.	**+5,526**
Strategic Priorities and Impact Analysis (SPIA): SPIA will continue to focus on core crosscutting services including the Cities-LEAP initiative, which involves partnering with cities to explore strategies to advance data-driven decision-making in support of their climate and energy goals. SPIA will also provide core funding to the CEMAC, focusing on leveraging EERE technology program investments and developing the CEMAC benchmark report. SPIA will also support analyses supporting grid integration of high penetrations of renewable energy and the President's Climate Action Plan. SPIA will also continue to provide direct funding and management support for program impact evaluation studies covering EERE technologies, using EERE's peer-reviewed methodology.	**-769**
International: The subprogram will continue to support bilateral clean energy R&D with Israel. The subprogram will also support activities with up to 10 core partner countries 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 GHG emissions. Representative activities include: expanding the number of Chinese cities using DOE's low-carbon city planning tools; conducting demonstration projects featuring low-carbon technologies from U.S. companies; helping two states in India accelerate implementation of India's Energy Conservation Building Code and create new markets for U.S. energy efficiency technologies; collaborating with Brazil to develop the country's market for distributed generation from wind; and partnering with a South African organization or university to establish a testing facility in South Africa that can verify performance of building envelope components and open the door for exports of higher-performing U.S. products.	**+2,211**
Communications and Outreach: No major changes.	**+32**
Total, Strategic Programs	**+7,000**

Strategic Programs
Technology-to-Market

Description

The Technology-to-Market subprogram's mission is to accelerate the successful commercialization of EERE technologies toward market adoption by overcoming key barriers in the U.S. energy technology innovation ecosystem. In support of this mission, the subprogram, in coordination with the Office of Technology Transitions, works across the entire ecosystem, including technology developers, startups, and small and medium enterprises, sources of capital, and other key stakeholders, and provides them with tools, resources, and expertise to address barriers to commercialize promising technologies or otherwise develop new commercialization pathways especially those more particular to EERE technologies. The subprogram also supports development of the next generation of clean energy entrepreneurs at National Laboratories, universities, and emerging companies. The subprogram's efforts focus on the successful commercialization of EERE technologies through activities that are not fully and sufficiently addressed by the focused RD&D activities in EERE's individual Technology Programs. The Technology-to-Market commercialization work is critically important to new clean technologies reaching the market given the unique and significant market barriers, including high development costs and long development timelines, and the lack of sufficient venture capital and other private capital sources and well developed commercialization pathways. The innovative commercialization and other models developed within the T2M subprogram are shared and closely coordinated with OTT and other parts of EERE for potential expansion that meets their goals and objectives.

Ongoing front-funded Technology-to-Market activities include: The National Incubator Initiative for Clean Energy (NIICE)—a program that creates and strengthens a national network of high-impact clean energy technology business incubators, and the Cleantech University Prize (Cleantech UP)—a university-based clean energy entrepreneurship competition. The subprogram will continue to support the implementation of the EERE National Laboratory Impact Initiative, working with EERE Technology Programs to implement Lab-Corps—a program to create a market-based commercialization mindset among DOE National Laboratory researchers (modeled after the National Science Foundation's successful I-Corps), Small Business Vouchers, and Technologists-in-Residence pilot programs. In 2017, the subprogram will conclude the initial impact assessment of the Small Business Voucher pilot and evaluate the program for expansion across EERE. The Technology-to-Market subprogram will also continue to coordinate EERE's Small Business Innovation Research (SBIR) investments across all of EERE's Technology Programs.

Individual activities in the Technology-to-Market subprogram have demonstrated significant success both in launching early-stage energy entrepreneurs (NIICE, Cleantech UP and in accelerating deployment of commercial-ready technologies (Solar Decathlon, Energy Transitions Initiative). By capitalizing on the full strength of the U.S. energy innovation ecosystem, in FY 2017 Technology-to-Market will focus on building out the "middle ground" of commercialization support between early-stage technology concept development and deployment. Technology-to-Market will accomplish this with new programming that builds more fruitful and direct collaborations between technology developers (e.g. at startups, small businesses, universities, and National Labs), and other pillars of the U.S. innovation ecosystem: (1) investment capital, (2) industry, and (3) technology development and manufacturing resources. Only by engaging these stakeholders and resources in an integrated manner can the full potential of U.S. energy technology innovation be realized. New programming to connect EERE technology developers more directly with new sources of investment capital and with potential industry partners will strengthen the pathway to private sector support of initial government investment. Additionally, new programming to better leverage our national resources (e.g. National Laboratories, the National Network of Manufacturing Institutes, and local domestic manufacturers) for technology developers will shorten their paths to market and capitalize on existing innovation infrastructure. This new programming will complement an expansion of the "Cyclotron Road" concept of embedding entrepreneurs within National Laboratories and an expansion of the Small Business Voucher pilot that opens up the National Laboratories for collaboration with U.S. small businesses.

The Technology-to-Market subprogram will work closely with the new Accelerated Energy Innovation Initiatives subprogram and with the new DOE Office of Technology Transition (OTT). Technology-to-Market will continue to develop and implement new, highly innovative commercialization efforts. Lessons learned, impact metrics, and best practices will be closely coordinated and shared. Successful initiatives will be evaluated for their potential to be implemented on a larger scale, either in EERE R&D subprograms or in the Accelerated Energy Innovation Initiatives subprogram. OTT will play a critical role in coordinating technology transition efforts across DOE R&D programs, in developing tools to facilitate

program engagement with the private sector, in collecting, analyzing, and reporting data concerning technology transfer activities across the DOE enterprise, and in identifying best practices and working with R&D programs to implement those practices. The subprogram will continue support of the Solar Decathlon ($3 million), which provides a high-visibility platform for university teams to build new offerings with commercially available technologies. Solar Decathlon was transferred to the Technology-to-Market subprogram budget in FY 2016. In FY 2016, Strategic Programs issued a competitive solicitation to have an external organization administer the Solar Decathlon Program long-term, with a focus on sustainability of the effort beyond the period of DOE funding. This will be fully implemented in FY 2017.

Finally, the Technology-to Market subprogram will continue its support of successful deployment activities that target first–market adoption of new energy technologies as part of its Energy Transition Initiative activities. This effort initially focused on direct work with select island communities whose high energy costs offered a compelling need for integrated adoption of cost effective EERE technologies. In FY 2016, the Energy Transition Initiative shifted its focus from a limited number of communities and began developing tools and training for a wider range of locations and organizations pursuing energy transition efforts. The program deployed these tools widely in the Caribbean. In FY 2017, the geographic focus will expand to the U.S. territories in the Pacific, including Alaska, working closely with the Department of Interior. These efforts will be coordinated with, and will contribute to the goals of, the Administration's Clean Energy Solutions for Remote Communities.

Activities and Explanation of Changes

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
Technology-to-Market $5,974,000	**$11,500,000**	**+5,526,000**
• Launch a new program to accelerate investment from a range of philanthropic organizations to clean technology development and commercialization. • 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. • Scale the Lab-Corps Program from the FY 2014 — FY 2015 pilot effort to a full program across all National Laboratories. Expand other laboratory impact and commercialization activities for continued acceleration of moving EERE technologies into the market. • Continue implementation and management of existing programs including NIICE and the National Student Entrepreneurship Prize (NSEP). • Provide ongoing support to the Energy Transition Initiative for islands and expand to other sectors, specifically local governments. • Develop a customizable, online, multi-disciplinary energy mini-course for the public. • Continue minimal support of NTER as is necessary to complete transition to external entity.	• Launch new programming that builds more fruitful and direct collaborations between technology developers (e.g. at startups, small businesses, universities, and National Labs), and other pillars of the U.S. innovation ecosystem: (1) investment capital, (2) industry, and (3) technology development and manufacturing resources. We will achieve this by building direct mechanisms for industry feedback and design for manufacturability expertise into startup companies at the prototype phase. We will target $50 million+ in private-sector follow-on funding achieved by 25+ startup companies within two years of the program. • Continue support for “energy transition” activities, leveraging previous successes to expand geographic focus to territories in the Pacific in close collaboration with the Interior Department. • Continue supporting Lab-Corps and other programs designed to increase the commercialization of innovations from the DOE National Laboratories. Will complete impact effectiveness of the Small Business Voucher pilot and evaluate future expansion for EERE and rest of DOE. • Support 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.	• Launch programs to connect EERE technology developers more directly with new sources of investment capital and with potential industry partners. Additionally, launch programs to better leverage our national resources (e.g. National Laboratories, the National Network of Manufacturing Institutes, and local domestic manufacturers) for technology developers. • Expand Energy Transition Initiative efforts to the U.S. Pacific territories and freely associated states, including Alaska, while continuing to maintain level of effort in the Caribbean.

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
• Support 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. • 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.		

Strategic Programs
Strategic Priorities and Impact Analysis

Description

The SPIA subprogram's mission is to perform cross-cutting analyses of issues that affect multiple EERE program offices, assess the impact of investments made by EERE's technology programs, and inform strategic planning and decision-making, enabling continuous improvement of EERE's approach to managing its portfolio.

The SPIA subprogram provides 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; and provides analytical resources for responding to quick-turnaround requests from internal and external clients. The SPIA subprogram's analyses 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.

In FY 2017, SPIA will conclude the initial stage of the Cities-LEAP program 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 cities throughout the country to develop sustainability and clean energy plans that leverage the economic and environmental benefits of clean energy. In FY 2017, the SPIA subprogram will provide technical support to partner cities, competitively selected in collaboration with the Technology-to-Market subprogram in FY 2016. The subprogram will continue to develop and refine analysis tools and studies that can explore scenarios that employ a range of clean transportation, generation, and efficiency technologies and adoption and incentive policies. This will complement the new DOE Metropolitan Energy Science and Engineering Initiative, and will give cities the tools they need to develop and implement aggressive, achievable GHG emissions reduction, clean energy development and energy efficiency targets, programs and policies.

SPIA will also support impact evaluation studies of EERE technical programs. These studies will follow EERE's peer reviewed methodology, which follows similar methodologies used by NASA and the Department of Commerce. Impact assessments can be used to determine overall return on investment (ROI), either in terms of economic activity or in terms of accelerated development timelines resulting from Government support, enabling long-term management of EERE's technical activities.

SPIA will continue to support the CEMAC, a National Laboratory consortium that partners with industry and academia to deliver credible, timely, reliable analyses of clean energy technology supply chains, global trade flows, and factors that drive manufacturing strategy. SPIA has played a major role in funding, managing, and shaping the methodology of DOE manufacturing analysis since 2012. As these analyses have proliferated across EERE, SPIA has remained a key partner in developing a strategic vision around these analyses.

SPIA will also continue to provide analyses that support the President's Climate Action Plan, examining the potential of EERE technologies to reduce GHG emissions cost-effectively; and the grid integration initiative, examining the opportunities and challenges to integrating high penetrations of renewable energy into the electric grid while maintaining reliability requirements.

Activities and Explanation of Changes

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
Strategic Priorities and Impact Analysis $6,769,000	**$6,000,000**	**-$769,000**
• Complete retrospective impact and ROI evaluation studies that quantify EERE impact and guide future EERE program implementation. • Launch new funding opportunity announcement (FOA) to partner with competitively selected cities to acquire data and perform analysis toward long-term clean energy roadmaps. • 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. • Provide analytical support to assess impact of potential climate related policies to internal DOE stakeholders. • Provide support for grid integration efforts, focusing on scenarios that can achieve maximum grid flexibility with high penetration of renewable technologies. • 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. • Complete an assessment of EERE program 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 comparable information is available to inform policy decisions.	• Complete four new retrospective impact and ROI evaluation studies that quantify EERE impact and guide future EERE program implementation. • Continue to provide local governments selected during the FY 2016 Cities-LEAP funding opportunity announcement with laboratory and DOE technical assistance and support. • Provide core funding support to the CEMAC to develop, conduct and issue cutting edge clean energy technology manufacturing analyses. • Provide analytical support to assess impact of potential climate related policies to internal DOE stakeholders. • Provide support for grid integration efforts, focusing on scenarios that can achieve maximum grid flexibility with high penetration of renewable technologies. • 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.	• Support of new CEMAC competitive manufacturing assessment. • Reduced funding for Cities-LEAP as the initial stage of the initiative concludes. Remaining funds go primarily to technical assistance to partner local governments. • Reduced funding for Open Data as support for this cross-cutting initiative shifts to other DOE organizations.

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 GHG emissions, supporting both the President's Climate Action Plan and National Export Initiative. The International subprogram also facilitates R&D partnerships with strategic partners with 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 subprogram's activities in the EERE mission space are fully coordinated with DOE's Office of International Affairs and the Departments of State and Commerce. The subprogram also coordinates and collaborates with U.S. clean energy technology manufacturers and service providers when appropriate.

The International subprogram prioritizes partner countries and topic areas informed by Administration priority and by analysis of potential impacts. 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 measures 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 such as windows or solar photovoltaics; successful development and implementation of more stringent building codes, etc.).

The International subprogram's market priming activities in FY 2017 will 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. These activities include technical collaborations to establish business cases for adopting codes, standards, and advanced EERE technologies. The subprogram will also engage with other markets, including South Africa and the Middle East, that have the potential to become first adopters for emerging energy technologies.

EERE International also supports targeted efforts to demonstrate and deploy emerging U.S. products and services in specific markets, enabling early commercial success and enabling U.S. companies 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 (such as the Export-Import Bank and the U.S. Trade and Development Agency) to promote exports. The International subprogram assists its partners in developing and implementing policy and technology solutions to increase deployment of renewable energy and energy efficiency technologies — for example, by partnering with the state-owned electric utility in Indonesia to replicate renewable electricity generation approaches on remote and island grids across the archipelago nation.

Finally, the International subprogram will support the U.S.-Israel Energy Cooperative Program ($2 million) through an annual competitive solicitation that makes awards to 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. Under the program, U.S. Government funds are matched with Israeli government and company funding, effectively creating 3:1 leverage on DOE's investment.

International

Activities and Explanation of Changes

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
International $3,789,000	**$6,000,000**	**+$2,211,000**
• Provides U.S. contribution to support the U.S. - Israel Energy Cooperative Agreement. • Support market-priming and clean energy deployment activities with up to 10 core partner countries. Representative 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.	• Provides U.S. contribution to support the U.S. - Israel Energy Cooperative Agreement. • Support market-priming and clean energy deployment activities with up to 12 core partner countries. Representative activities include: expanding the number of Chinese cities using DOE's low-carbon city planning tools and conducting demonstration projects featuring low-carbon technologies from U.S. companies, helping two states in India accelerate implementation of India's Energy Conservation Building Code and create new markets for U.S. energy efficiency technologies, collaborating with Brazil to develop the country's market for distributed generation from wind, and partnering with a South African organization or university to establish a testing facility in South Africa that can verify performance of building envelope components and open the door for exports of higher-performing U.S. products.	• Engage with up to two additional key countries on EERE-specific collaborations, and/or add new topics for collaboration with existing partner countries, enabling U.S. companies to better compete with companies from Europe, Japan, China, and elsewhere.

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 by organizing, editing, and disseminating information to media and the public on EERE programs, activities, and technologies, as well as their associated impacts. This information fully leverages EERE's technology investments by helping raise awareness and overcome informational barriers to understanding EERE technologies, make stakeholders aware of resources and opportunities that may be available to them through EERE, and encourage the accelerated adoption of EERE technologies.

The Communication and Outreach subprogram's activities ensure that EERE information is available to the 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 FY 2017 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 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
Communications and Outreach $4,468,000	**$4,500,000**	**+$32,000**
• Maintains content for EERE web and social media presence. • Provides modest support for analysis of communications data. • Complete transition of subsites and content to the Energy.gov platform and maintain support for ongoing content management. • Maintain public inquiries and distribution function as digital publications strategy is executed. • Maintain support for legislative affairs and stakeholder engagement. • Expands support for high-priority crosscutting activities, including the Clean Energy Manufacturing and National Laboratory impact initiatives. • Continues support to EERE senior leaders in developing presentation materials and messages for frequent speaking engagements.	• Maintain high-priority media presence/activities with expanded use of website and social media for dissemination. • Maintain executive communications function. • Maintain support for key initiatives; stakeholder engagement, legislative affairs, international and tech-to-market programs; provide internal communications products in conjunction with business operations.	• No major change.

Facilities and Infrastructure

Overview

The Office of Energy Efficiency and Renewable Energy (EERE) is the National Renewable Energy Laboratory's (NREL's) steward, primary client, and sponsor of NREL's designation as a Federally Funded Research and Development Center. NREL strives to be the world's preeminent institution for delivering impactful scientific knowledge, technology innovations, and market insights that transform clean energy technologies, systems, and markets. NREL's research advances the science and engineering of energy efficiency, sustainable transportation, and renewable power technologies, and provides the knowledge to integrate and optimize energy systems. To succeed in this mission, EERE's Facilities and Infrastructure (F&I) Program Budget maintains NREL's research and support infrastructure and provides a safe and secure laboratory environment.

The objectives of the F&I Program are to:

- Provide the laboratory with a safe and secure work environment for the protection of employees, partners, and the public;
- Maintain EERE's science and support infrastructure through regular reinvestments determined by age, condition, risk, and DOE and industry standards, ensuring the availability of a world-class RD&D environment for ongoing EERE mission activities;
- Acquire new mission-critical science and technology capabilities, when warranted;
- Provide direct funding for operational activities for both F&I and site-wide investments; and
- Develop and steward grid modernization and broader energy systems integration capabilities supporting RD&D at the Energy Systems Integration Facility (ESIF), including its high performance computing capabilities.

Highlights of the FY 2017 Budget Request

In FY 2017, the F&I Budget supports two Departmental Crosscuts: Grid Modernization and Cybersecurity. Investments in Grid Modernization include funding for core operations and expanding capabilities of the "Peregrine" High Performance Computer (HPC) at ESIF, nearly doubling capacity to approximately 2.2 petaflops. This will meet the increased demand for computer time from researchers and Grid Modernization partners. This is the final year of the 3-year HPC upgrade effort. The Request also provides 1 megawatt of additional photovoltaic simulation and expands the Research Electrical Distribution Bus (REDB) to enable concurrent experiments on the electrical grid simulation system at ESIF. It also incorporates a large environmental chamber and mechanical controls for testing at – 40° C temperature with humidity control at ESIF. We anticipate a new HPC cycle in FY 2018, at which point we will re-evaluate usage requirements for operations to support Grid Modernization requirements.

DOE Cybersecurity crosscut investments support collaboration among National Laboratories and the 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 to the crosscut initiatives, EERE proposes in FY 2017 to consolidate NREL Site-Wide Facility Support funding in the F&I Program to eliminate NREL Site-Wide Facility Support funding from individual EERE technology program lines. Locating this funding in the F&I Program will provide clarity and transparency in communicating EERE's stewardship for NREL and will simplify planning and execution of EERE's annual budget. This consolidation into a single program line allows for better integration and coordination of operations and investments.

FY 2017 Crosscuts ($K)

	Grid	Cybersecurity	Total
Facilities and Infrastructure	**36,000**	**2,190**	**38,190**

Facilities and Infrastructure
Funding ($K)

	FY 2015 Enacted	FY 2015 Current	FY 2016 Enacted	FY 2017 Request	FY 2017 vs FY 2016
Facilities and Infrastructure					
Operations and Maintenance	26,000	26,000	26,000	26,000	0
Facility Management	30,000	30,000	36,000	36,000	0
NREL Site-Wide Facility Support	0	0	0	30,000	+30,000
Total, Facilities and Infrastructure	**56,000**	**56,000**	**62,000**	**92,000**	**+30,000**

Facilities and Infrastructure
Budget Structure Crosswalk (K)

FY 2016 Budget Structure	Proposed FY 2017 Budget Structure			Total
	Operations and Maintenance	Facility Management	NREL Site-Wide Facility Support (Facilities and Infrastructure)	
Facilities and Infrastructure				
Operations and Maintenance	26,000	0	0	**26,000**
Facility Management	0	36,000	0	**36,000**
NREL Site-Wide Facility Support	0	0	30,000	**30,000**
Building Technologies	0	0	2,500*	**0**
Federal Energy Management Program	0	0	800*	**0**
Weatherization and Intergovernmental Programs	0	0	400*	**0**
Geothermal Technologies	0	0	500*	**0**
Solar Energy Technologies	0	0	9,100*	**0**
Water Power	0	0	700*	**0**
Wind Energy	0	0	4,700*	**0**
Vehicle Technologies	0	0	3,000*	**0**
Bioenergy Technologies	0	0	6,500*	**0**
Hydrogen and Fuel Cell Technologies	0	0	1,800*	**0**
Total, Facilities and Infrastructure	**26,000**	**36,000**	**30,000**	**92,000**

***** Represent FY 2016 (non-add) contributions from EERE Technology Offices to the NREL Site-Wide Facility Support.

Facilities and Infrastructure
Explanation of Major Changes ($K)

	FY 2017 vs FY 2016 Enacted
Facilities and Infrastructure	
NREL Site-Wide Facility Support: Within EERE's overall budget, this change is "net-zero." In FY 2017, EERE proposes to move funding for the NREL Site-Wide Facility Support subprogram from individual technology programs to the Facilities and Infrastructure Program. The NREL Site-Wide Facility Support subprogram funding provides basic site services, functions, and infrastructure for site operations, which includes management, trained building operators and technicians, building and grounds maintenance, fire and emergency response, engineering and construction support, electrical safety program, utilities, facilities planning support; and activities within the Sustainability and Environmental Health and Safety portfolios. Including this funding in the Facilities and Infrastructure Program, instead of individual technology program budgets, will provide clarity and transparency in communicating EERE's stewardship of NREL, and will simplify planning and execution of EERE's annual budget. This consolidation into the F&I program enables better integration and coordination of operations and investments.	**+30,000**
Total, Facilities and Infrastructure	**+30,000**

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 real property assets at NREL. The subprogram includes General Plant Projects (GPP), General Plant Equipment (GPE), Maintenance and Repair (M&R), and Safeguards and 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. Some specific GPP projects include completion of the National Wind Technology Center power upgrade project, Field Test Laboratory Building upgrade in support of Bioenergy and Hydrogen transportation research, anti-reflective coating in the Process Development and Integration Laboratory cleanroom, and construction of a Synthetic Molecular Biology Laboratory in the Integrated Biorefinery Research Facility.

GPE investments acquire shared science and support equipment to meet research mission needs, replace outdated technology, and provide for emergent research opportunities. Some specific GPE investments include data storage devices, application software, servers, a sapphire laser, and an x-ray diffraction system.

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 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
Operations and Maintenance $26,000,000	**$26,000,000**	**$0**
• 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 Condition Index (ACI) of 0.97 (Excellent) for all NREL facilities.	• Continues with GPP and GPE activities similar to FY 2016 and maintains an excellent Asset Condition Index. Investment keeps deferred maintenance at a very low level and ensures that the NREL facilities remain in excellent condition.	• There are no significant changes from the planned activities in FY 2016.
• Provides funding for M&R and S&S at NREL for operational readiness and a secure environment.	• Maintains operational readiness for M&R and S&S activities.	• There are no significant changes from the planned activities in FY 2016.

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's primary role is to explore and enhance the integration of energy supplies from fossil fuels, renewable power, and electric systems to satisfy industrial, commercial, and consumer demand. ESIF operations are a critical part of EERE support for the DOE Grid Modernization crosscut initiative as identified by the Quadrennial Technology Review (QTR). ESIF has the diverse, specific and integrated capabilities most appropriate to address the research opportunities for "Enabling Modernization of the Electric Power Grid" identified by the QTR:

- Grid Designs and Concepts;
- Measurements, Communications, and Controls;
- Transmission and Distribution Components;
- Electric Energy Storage; and
- Grid Cyber, Physical Security Flexible and Distributed Energy Resources.

ESIF provides the technical capabilities needed to help advance the Nation's energy system into a cleaner, more intelligent and modernized infrastructure. This facility provides testing, simulation, data analysis, engineering, and evaluation techniques that address grid and broader energy system integration challenges using hardware and software in a controlled environment. EERE has continued to expand ESIF's capabilities while demonstrating that the ESIF infrastructure can effectively address the questions posed by utilities, electronic equipment manufacturers, distributed generation companies, and all other entities involved in energy systems integration.

ESIF'S HPC modeling and simulation provides critical support to the breadth of EERE's mission. Simulations conducted on the HPC have led to significant advances in clean energy technologies. Examples of research performed by the HPC include:

- Simulations of enzyme-plant cellulose interactions to reduce fuel costs.
- Model wake fields and inflow conditions in whole wind plants with realistic terrain to reduce cost of electricity.
- New techniques to predict material properties of novel alloys and design materials with prescribed physical properties.
- Multi-scale simulations of electric-drive vehicle battery systems to help make EVs market competitive.
- Optimization of Biomass Pyrolysis reactor design to reduce cost of renewable fuel production.
- Modeling of interconnections at native spatial scales under different renewable penetration scenarios.

Demand for computing, from well-established R&D efforts by the Wind Energy, Solar Energy and Bioenergy Technologies programs, has saturated the current HPC capabilities. Thus, NREL entered into a 3-year plan to expand the HPC capacity. There was a critical need to increase EERE's current HPC capabilities from one to two petaflops at NREL, to meet growing demand from traditional users and new areas including energy system integration, grid modernization, and other new program initiatives. FY 2017 is the final year of the 3-year upgrade. We anticipate a new HPC cycle in FY 2018 after re-evaluating usage requirements for operations to support grid modernization requirements. Additionally, the enhancement of REDB will incorporate a large environmental chamber and mechanical controls for testing at – 40° C temperature with humidity control.

EERE and NREL maintain an ESIF stewardship plan that includes the following success metrics:

- Availability of the high performance computer to support research by DOE and non-DOE users;
- Availability of research laboratory space to conduct renewable energy experiments;
- Number of users;
- Partner cost share commitments;
- Technical outputs to include NREL technical reports, peer-reviewed papers, Record of Invention/Patent, Intellectual Property license, R&D 100 Awards; and
- Annual publication of the market impact of ESIF-related R&D.

The table below describes the major categories funded by this subprogram.

Major ESIF Costs
ESIF Administration: ESIF operations director and administrative support. This also includes other labor and non-labor costs to implement a user program, e.g., user outreach, engagement and education; developing calls for proposal; conducting technical peer reviews of proposal; scheduling RD&D projects and reporting ESIF status and progress.
Scientific Staff: ESIF-dedicated technical staff (40 FTEs) that steward individual capabilities, including experimental and high-performance computing. Technical staff supports users in designing, setting up and conducting experiments in ESIF. In the user-facility model, peer reviewed and selected projects receive facility-funded support for equipment and experimental configuration design, set-up, problem solving and operation.
Equipment: Recapitalization based on average research and scientific computing equipment life. Initial costs address older equipment, as well as expansion of the high-performance computing capability and equipment to enable testing >1MW power systems.
Operations & Maintenance: Labor for 14 FTEs includes one dedicated ESIF building engineer and the labor associated with other NREL site operations staff or service contractors to maintain facility systems and sustain readiness. Examples include custodial services, fire & emergency systems, HVAC maintenance, and small parts. This also includes a prorated share of NREL site operating costs, such as road maintenance and snow removal as well as maintenance and calibration for all user program research equipment.
Utilities: Power, Water, Natural Gas, Dedicated Exhaust, House Nitrogen, Compressed Air, (utilities billed by service providers).

Activities and Explanation of Changes

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
Facility Management $36,000,000	**$36,000,000**	**$0**
• 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.	• Maintains expanded high performance computing capacity commensurate with number of ESIF projects. • Provides systems engineers, area supervisors, health and safety personnel, and management for ESIF research activities. • Provides for utilities, building operations, and routine maintenance. • Provides experimental connections and enhanced data collection. • Invests in a large environmental chamber and mechanical controls for testing at – 40° C temperature with humidity control.	• This is the final year of a 3-year HPC upgrade investment. • Capital funds allow enhancement of REDB services to include an environmental chamber capable of testing at – 40° C.

Facilities and Infrastructure
Capital Summary ($K)

	Total	Prior Years	FY 2015 Enacted	FY 2015 Current	FY 2016 Enacted	FY 2017 Request	FY 2017 vs FY 2016 Enacted
Capital Operating Expenses Summary (including Major Items of Equipment (MIE))[1]							
Capital Equipment > $500K (including MIE)	n/a	n/a	3,600	3,600	3,600	3,600	0
Plant Projects (GPP and IGPP)	n/a	n/a	7,800	7,800	7,800	7,800	0
Accelerator Improvement Projects (AIP) (<$5M)	0	0	0	0	0	0	0
Total, Operations and Maintenance Expenses	**n/a**	**n/a**	**11,400**	**11,400**	**11,400**	**11,400**	**0**
Capital Equipment > $500K (including MIE)							
Total Non-MIE Capital Equipment (>$500K)	n/a	n/a	3,600	3,600	3,600	3,600	0
Total, Capital Equipment (including MIE)	**n/a**	**n/a**	**3,600**	**3,600**	**3,600**	**3,600**	**0**
Plant Projects (GPP and IGPP)							
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)	**n/a**	**n/a**	**7,800**	**7,800**	**7,800**	**7,800**	**0**
Total, Capital Summary	**n/a**	**n/a**	**11,400**	**11,400**	**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.

Facilities and Infrastructure
NREL Site-Wide Facility Support

Description

In FY 2017, EERE proposes to move funding of the NREL Site-Wide Facility Support subprogram from individual technology programs to the Facilities and Infrastructure Program. Locating this funding in the Facilities and Infrastructure Program will provide clarity and transparency in communicating EERE's stewardship of NREL, and will simplify planning and execution of EERE's annual budget. This consolidation into a single program allows for better integration and coordination of operations and investments.

The NREL Site-Wide Facility Support subprogram funding provides basic site services, functions, and infrastructure for site operations, which includes management, trained building operators and technicians, building and grounds maintenance, fire and emergency response, engineering and construction support, electrical safety program, utilities, facilities planning support; and activities within the Sustainability and Environmental Health and Safety portfolios. These are core functions for site operations, safety, environmental compliance, and sustainability at NREL. These activities ensure availability of critical facilities and capabilities for the growing demand of R&D mission needs.

NREL Site-Wide Facility Support

Activities and Explanation of Changes

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
NREL Site-Wide Facility Support $0	**$30,000,000**	**+$30,000,000**
• Funding previously requested in individual program budgets. No funding requested within the Facilities and Infrastructure Budget Request.	• Instead of withdrawing funds from various program budgets, directly funding NREL Site-Wide Facility costs from this subprogram budget will provide basic site services, functions, and infrastructure for site operations. This removes the burden of funding these activities from the EERE technical programs.	• A corresponding decrease in the EERE technology program Budget Requests offsets this Request.

Crosscutting Innovation Initiatives

Overview

To accelerate clean energy innovation and commercialization in the U.S., DOE is establishing a new Crosscutting Innovation Initiatives program in FY 2017. This program will fund research, development, and demonstration activities that will strengthen regional clean energy innovation ecosystems, accelerate next-generation clean energy technology pathways, and encourage clean energy innovation and commercialization collaborations between our National Laboratories and American entrepreneurs. This program will focus initially on four specific high-impact innovation acceleration initiatives.

First, the program will support a new competition to establish regionally-focused clean energy innovation partnerships – "Regional Clean Energy Innovation Partnerships (RCEIPs)" - around the country cost-shared with State, industry, academic, and other stakeholder partners. These regionally focused and directed partnerships will support regionally relevant technology neutral clean energy research, development and demonstration (RD&D) needs and opportunities to support accelerated clean energy technology commercialization, economic development, and manufacturing. This effort will link the needs of regional industry and energy decision-makers with technical resources and expertise at universities and laboratories across the country.

Secondly, the program will accelerate next-generation clean energy technology pathways through a "Next-Generation Innovation (NGI)" funding opportunity. This funding opportunity will be open to off-roadmap RD&D projects with the greatest potential to change the trajectory of EERE core program technology pathways. Successful projects funded through NGI will be leveraged by EERE's core programs to enable a significant acceleration of innovation and could dramatically reduce the time and cost required to achieve the Nation's energy goals.

Third, the program will support a new "Small Business Partnerships (SBP)" program that will, in conjunction with the Office of Technology Transitions, competitively provide technology RD&D resources to small businesses through the DOE's National Labs to support their efforts to commercialize promising new clean energy technologies.

Fourth, the program will create a new effort, "Energy Technology Innovation Accelerators (ETIA)" that will leverage the technical assets and facilities of the National Laboratories to enable American entrepreneurs to conduct RD&D that enables the creation of new clean energy businesses. The Accelerators will couple the talent and commitment of early-stage clean energy technology entrepreneurs with the world-class tools and expertise of the National Labs through RD&D projects that encourage mentorship and network support leading to new company creation and the development of successful commercialization strategies.

Highlights of the FY 2017 Budget Request

The Crosscutting Innovation Initiatives Program will pursue the following major activities in FY 2017:

- Competitively awarded, cost-shared support for the creation of up to 10 Regional Clean Energy Innovation Partnerships. These partnerships will support targeted regionally-focused technology-neutral clean energy RD&D initiatives to address regionally relevant energy challenges and opportunities in energy innovation. ($110 million)
- Through an open, competitive process, the Next-Generation Innovation (NGI) subprogram will support the on-ramping of high-impact technologies through RD&D projects across EERE's sustainable transportation, renewable power, and energy efficiency sectors. Successful projects funded through NGI will be leveraged by EERE's core programs to enable a significant acceleration of innovation and could dramatically reduce the time and cost required to achieve EERE's and the Nation's energy goals. ($60 million)
- The Small Business Partnership (SBP) subprogram will, in conjunction with the Office of Technology Transitions, provide competitively awarded clean energy R&D funding at National Laboratories to partner with small businesses to address their critical clean energy R&D challenges and opportunities, with an emphasis on small business partners who have not worked with the National Laboratories before. Competitive evaluation and selection of small business participants performed by the National Laboratories under the supervision of EERE will support approximately 100-200 new partnerships. This effort will also be coordinated with other similar efforts within EERE. ($20 million)
- The Energy Technology Innovation Accelerators (ETIA) subprogram will leverage the technical assets and facilities of the National Laboratories to enable American entrepreneurs to conduct RD&D that enables the creation of new clean energy businesses. The Accelerators will couple the talent and commitment of early-stage clean energy technology

entrepreneurs with the world-class tools and expertise of the National Labs through RD&D projects that encourage mentorship and network support leading to new company creation and the development of successful commercialization strategies. ($25 million)

Crosscutting Innovation Initiatives
Funding ($K)

	FY 2015 Enacted	FY 2015 Current	FY 2016 Enacted	FY 2017 Request	FY 2017 vs FY 2016
Crosscutting Innovation Initiatives					
Regional Energy Innovation Partnerships	0	0	0	110,000	+110,000
Next-Generation Innovation	0	0	0	60,000	+60,000
Small Business Partnerships	0	0	0	20,000	+20,000
Energy Technology Innovation Accelerators	0	0	0	25,000	+25,000
Total, Crosscutting Innovation Initiatives	**0**	**0**	**0**	**215,000**	**+215,000**

SBIR/STTR:

- FY 2017 Request: SBIR $6,480,000; STTR $911,000

Crosscutting Innovation Initiatives
Explanation of Major Changes ($K)

	FY 2017 vs FY 2016 Enacted
Crosscutting Innovation Initiatives	
Regional Energy Innovation Partnerships	**+110,000**
Next-Generation Innovation Program	**+60,000**
Small Business Partnerships	**+20,000**
Energy Technology Innovation Accelerators	**+25,000**
Total, Crosscutting Innovation Initiatives	**+215,000**

Crosscutting Innovation Initiatives
Regional Energy Innovation Partnerships

Description

The U.S. energy system is composed of regions with unique energy needs and opportunities. To capitalize on and address this important reality, DOE will support a new competition to establish regionally-focused clean energy innovation partnerships – "Regional Energy Innovation Partnerships (REIPs)" - around the country. The goal of this subprogram is to accelerate the pace of innovation in clean energy technologies through the cost-shared formation of regional clean energy innovation partnerships that fund RD&D to address clean energy challenges specific to regional energy resources, customer needs and innovation capabilities of various regions of the country.

A regional approach to innovation is responsive to the conclusion of The National Research Council 2012 Report, Rising to the Challenge, noting that "Historically, federally funded R&D has not been connected to state and regional industrial development. Bridging that gap can create the local talent and technology base needed to convert these U.S. investments into domestic companies, industries and jobs." Regional Clean Energy Innovation Partnerships complement national level RD&D efforts with a technology-neutral approach that is specific to the clean energy needs, polices, resources and markets of individual regions. Specific benefits of this approach include:

- Leveraging existing knowledge clusters and comparative strengths of a geographic region.
- Linking the needs of industry and energy decision-makers with technical resources and expertise at universities and laboratories.
- Sharing risks and pooling resources between the public and private sector to conduct RD&D projects with sustained and predictable funding;
- Allowing for the development of new pathways for RD&D involving non-federal stakeholders and other performers not typically engaged through existing DOE programs;

Regional Energy Innovation Partnerships

Activities and Explanation of Changes

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
Regional Energy Innovation Partnerships $0	**$110,000,000**	**+$110,000,000**
• No funding requested in FY 2016.	• Solicit and competitively select up to 10 Regional Partnerships that will: ▪ Competitively select RD&D projects for financial assistance based on technical merit and, generally, connecting innovators in their regions with RD&D funding. ▪ Provide analysis, data, access to federal RD&D facilities, and project management. ▪ Support development of early prototypes. ▪ Encourage and support collaborative RD&D, regional public-private partnerships, and consortia of innovative clean energy entities. ▪ Develop in collaboration with stakeholders regional energy innovation roadmaps to facilitate RD&D planning and inform annual plans submitted to DOE. ▪ Coordinate with other Regional Partnerships on best practices and technology projects relevant to multiple regions.	• New subprogram in FY 2017 to fund regionally-focused and directed partnerships that support regionally-relevant clean energy RD&D to: ▪ Help create a bridge between the regionally developed innovative technologies and the private sector; ▪ Strengthen the links among regional services, technical resources, and demand; and ▪ Catalyze increased U.S. clean energy entrepreneurship and investment.

Crosscutting Innovation Initiatives
Next-Generation Innovation

Description

The Crosscutting Innovation Initiatives program will accelerate next-generation clean energy technology pathways through a "Next-Generation Innovation (NGI)" funding opportunity. This funding opportunity will be open to off-roadmap RD&D projects with the greatest potential to change the trajectory of EERE core program technology pathways. Successful projects funded through NGI will be leveraged by EERE's core programs to enable a significant acceleration of innovation and could dramatically reduce the time and cost required to achieve the Nation's energy goals. EERE's Next-Generation Innovation (NGI) subprogram will focus on the unaddressed RD&D needs, opportunities and spaces in the energy efficiency, sustainable transportation and renewable energy sectors. This subprogram will use two approaches to enable initial private-sector commercialization of high-promise emerging early stage technology concepts. First, DOE will identify and close gaps between cutting-edge R&D efforts developed by ARPA-E, Small Businesses, and entrepreneurs. (i.e., find previously supported technologies with untapped potential and fund the additional RD&D to make them investable). Second, the subprogram will invest in RD&D to on-ramp transformational technologies that accelerate the progress of EERE core program technology pathways. This effort will close two significant energy and economic opportunity gaps: the gap between market and technological potential and the gap between existing and evolving energy programs. The NGI program will target promising technology in areas that are not currently covered by existing EERE programs and this FOA will focus on deep decarbonization across energy services (e.g., mobility, light, heat, communication, etc.), allowing for greater integration and innovation across and within EERE's efforts within the Sustainable Transportation, Renewable Power, and Energy Efficiency sectors.

Next-Generation Innovation

Activities and Explanation of Changes

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
Next-Generation Innovation $0	**$60,000,000**	**+$60,000,000**
• No funding requested in FY 2016.	• Issue new competitive funding opportunity focus on deep decarbonization across energy services (e.g., mobility, light, heat, communication, etc.) and select 20 to 30 high-impact projects with the greatest potential to change the trajectory of EERE core program technology pathways. • Conduct a gaps assessment to identify previously supported technologies with untapped potential.	• New subprogram in FY 2017 to fund RD&D to on-ramp transformational technologies and identify previously supported technologies with untapped potential across EERE's sustainable transportation, renewable power, and energy efficiency sectors.

Crosscutting Innovation Initiatives
Small Business Partnerships

Description

Through the Small Business Partnerships (SBP) subprogram, DOE's world-class National Laboratories will partner with companies around the country that are committed to expanding the clean energy industry in the United States. While large industry partners often have better abilities to successfully engage with the National Laboratories, small businesses - the backbone of the nation's economy - often face knowledge, financial, and institutional barriers to accessing the capabilities and resources of DOE National Laboratories. The goal of the SBP program is to increase the interaction of these two critical entities through RD&D by: (1) assisting small businesses to bring next-generation clean energy technologies to the market faster by enabling them to access lab expertise and infrastructure quickly, easily, and affordably; and (2) increasing the interaction of National Labs with partners working on the most pressing and market-relevant RD&D challenges facing the industry to make them better informed and more capable moving forward.

Small businesses often lack the resources to conduct the type of rigorous technical work and validation necessary to demonstrate promising and innovative clean energy technologies. In coordination with the Office of Technology Transitions, SBP will fund RD&D to assist small businesses and connect private sector needs with corresponding national laboratory science and technology capabilities. These awards will leverage the National Lab's world-class technical and physical resources, providing critical assistance to small businesses to develop and test their technologies to prepare for deployment and market penetration and solve some of their most pressing technical challenges.

EERE will competitively award clean energy R&D funding at National Laboratories to partner with small businesses to address their critical clean energy R&D challenges and opportunities, with an emphasis on small business partners who have not worked with the National Laboratories before. The National Laboratories will conduct competitive evaluation and selection of small business participants under the supervision of EERE and in coordination with the Office of Technology Transitions. This effort will also be coordinated with other similar efforts within EERE. The Small Business Partnerships program will support approximately 100-200 new partnerships.

Small Business Partnership

Activities and Explanation of Changes

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
Small Business Partnership $0	**$20,000,000**	**+ $20,000,000**
• No funding requested in FY 2016.	• Competitively award clean energy R&D funding at National Laboratories to support approximately 100-200 new small business partnerships that connect private sector needs with corresponding national laboratory science and technology capabilities, and targets small businesses where engagement with the labs can add significant value. Collaborate with the Office of Technology Transitions to identify and evaluate best practices to encourage successful partnerships between small businesses and the national laboratories.	• New subprogram in FY 2017 to connect private sector RD&D needs with corresponding national laboratory science and technology capabilities, and targets small businesses where engagement with the labs can add significant value.

Crosscutting Innovation Initiatives
Energy Technology Innovation Accelerators

Description

The Energy Technology Innovation Accelerators (ETIA) subprogram will leverage the technical assets and facilities of the National Laboratories to enable American entrepreneurs to conduct RD&D that enables the creation of new clean energy businesses. The Accelerators will couple the talent and commitment of early-stage clean energy technology entrepreneurs with the world-class tools and expertise of the National Labs through self-directed clean energy RD&D projects that encourage mentorship and network support leading to new company creation and the development of successful commercialization strategies ($25 million).

Significant drops in early-stage clean energy innovation support from the U.S. venture capital community risk the creation of a "lost generation" of clean energy entrepreneurs from our nation's world leading research institutions. The ETIA program will competitively identify and support the next generation of these clean energy entrepreneurs by embedding them into clean energy RD&D project teams at the Nation's world class National Laboratories on a term-limited basis.

In Fiscal Year 2017, ETIA will establish Energy Technology Innovation Accelerators at approximately 5 National Laboratories and support more than 50 clean energy technology entrepreneurs through RD&D projects.

Energy Technology Innovation Accelerators

Activities and Explanation of Changes

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
Energy Technology Innovation Accelerators $0	**$25,000,000**	**+$25,000,000**
• No funding requested in FY 2016.	• Embed up to 50 clean energy entrepreneurs at participating National Labs to conduct self-directed clean energy RD&D projects that enable the creation of new clean energy businesses.	• New subprogram in FY 2017 to leveraging the technical assets of the National Laboratories and connecting them to entrepreneurs.

Crosscutting Innovation Initiatives
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. Goals and Metrics for appropriately measuring the impact of these programs on accelerating clean energy innovation are currently under development.

21st Century Clean Transportation

Overview

The President's Budget calls for major new investments in our Nation's infrastructure, beginning in the transportation system; and calls for greater collaboration between the public and private sectors to increase private investment in infrastructure and help rebuild America. The President's 21st Century Clean Transportation Plan would set America on a long-term path to achieving our economic and climate goals. As part of the 21st Century Clean Transportation Plan, the Department of Energy will:

- Scale-up clean transportation research and development (R&D) through initiatives to accelerate cutting the cost of battery technology; advanced the next generation of low carbon fuels such as biofuels, in particular for intermodal freight and fleets; and investigate system level energy implications of future mobility and intelligent transportation system technologies such as vehicle connectivity and automation;
- Ensure all Americans have access to at least one alternative fuel by 2020 by providing funding for the development of regional low-carbon fuel fueling infrastructure including charging stations for electric vehicles, advanced biofuels, hydrogen fuel cells, and other low carbon options. Additionally, the Department of Energy (DOE) will launch an Electric Vehicle Accelerators Communities program with the goal of deploying 10,000 new grid connected solar powered fast charge stations or renewable hydrogen refueling stations by 2025 through public-private partnerships; and
- Launch the Clean Fleets Competition program that will use challenge grants to drive state, tribal, and local government vehicle fleets to purchase clean transportation options and operate them on low-carbon fuels, including those for first responders.

Leveraging and building on EERE's core model, this program will expand investment in transportation technologies of the future; establish regional fueling infrastructure to support the deployment of low-carbon fuels; and accelerate the transition to a cleaner vehicle fleet.

Expand investment in transportation technologies of the future: The program will expand investment in transportation technologies of the future by scaling up clean transportation R&D:

- By launching a battery manufacturing innovation initiative that accelerates deep cost cutting of battery technology through disruptive new materials and low capital intensity, high-throughput battery manufacturing schemes which take us beyond current targets of $125/kW to below $100/kWh through development and demonstration of new novel paradigms for battery manufacturing processes and;
- By developing the technology and systems for achieving lowest carbon end-to-end intermodal transport for freight and fleets through competitive funding solicitations to form public-private partnerships. These partnerships would include consortia with industry, universities, state and local governments, ports and airports that will conduct research, development, and demonstration focused on intermodal freight transport cutting across trucking, rail, marine, aviation, material handling, etc. that leverage the full range of available alternative fueled transportation technologies and low carbon fueling options (electricity, hydrogen, biofuel including biogas) and optimize modal choices within the system.

The program will also launch a substantial investment in R&D to accelerate development and commercialization potential of drop-in low-carbon biofuels that can become direct substitutes for petroleum products in the distribution system and can be readily used in today's vehicles. Cutting-edge projects would focus on transformational developments that address technical barriers in feedstock logistics by providing innovative at-scale demos of new logistics models (depot concepts), improved conversion costs through new research into process intensification, and enhancing economics of biofuel production through focus on high value co-products.

Finally, the program will expand collaborative research programs by launching a smart mobility research center that moves beyond component research and investigates systems level implications of intelligent transportation systems such as connectivity and automation and future mobility systems and solutions related to the transport of both people and goods. The smart mobility research center will investigate the intersection of information and communication technologies (ICT), vehicle technologies, low carbon fuels, and disruptive transportation business models with the goal of reducing overall system level greenhouse gas (GHG) emissions and petroleum consumption while taking into consideration potential future increases to overall vehicle miles traveled resulting from changing trends in transportation. This effort significantly expands upon and will be informed by foundational efforts of DOE's Transportation as a System multi-lab consortium that is

developing an integrated framework to analyze the complex systems landscape of future transportation with respect to the nexus of energy and mobility. Possible areas of research, such as high performance computing and big data analytics for transportation, vehicle-powertrain optimization, ultra-light weighting, new vehicle design, sensors, system integration, vehicle-infrastructure-system telecommunications, cybersecurity, or new manufacturing processes would be identified through the SMART Mobility consortia and engagement with relevant stakeholders and then pursued through the research center.

Establish Regional Fueling Infrastructure to Support the Deployment of Low-Carbon Fuels: The program will work to ensure all Americans have access to at least one low-carbon fuel by 2020 by providing funding for the development of regional low-carbon fueling infrastructure. The program will encourage the development of regional approaches involving States, local governments, universities, and private organizations. These partners will work together to define low carbon fuel deployment proposals including charging stations for electric vehicles, advanced biofuels, hydrogen fuel cells and others low-carbon options that take into account the unique economies, resources, and development needs of different regions. Deployment strategies will be encouraged to address fueling infrastructure from a systems perspective and promote adoption of innovative technologies and solutions that will help put the regions on a path to meet the goals of a 26-28 percent reduction in GHG emissions by 2025 and a more than 80 percent reduction by 2050.

In addition, to increase the deployment of electric vehicles powered with clean sources of energy in communities across the country, we are also launching an Electric Vehicle Accelerator Communities program with the goal of deploying 10,000 new grid-connected solar powered fast charging stations or renewable hydrogen refueling stations by 2025 through public-private partnerships. These competitive grant programs would prioritize projects leveraging other sources of funding and those that take place in States with complementary Zero Emissions Vehicle mandates and communities with climate action plans (e.g., Climate Action Champions, signatories to Climate Compact).

Accelerate the Transition to a Cleaner Vehicle Fleet: In neighborhoods across the country, sources of diesel emissions are putting our children's health at risk and contribute to the warming of our planet. The Budget proposes to renew and expand the current Diesel Emission Reduction Act (DERA) clean diesel vehicle, engine, and equipment program managed by the Environmental Protection Agency, which expires in 2016. In parallel, the DOE will initiate a new Clean Fleets Competition that will use challenge grants to drive cleaner state, tribal, and local government vehicle fleets, including those for first responders. Through the program, local governments will demonstrate leadership in building out critical low and zero-emission fueling networks for public use.

Highlights of the FY 2017 Budget Request

The 21st Century Clean Transportation Program will pursue the following major activities in FY 2017:

- Clean Transportation R&D: Scale-up of R&D through initiatives to accelerate cutting the cost of battery technology and; public-private partnerships to achieve lowest carbon end-to-end intermodal transport for freight and fleets ($200 million).
- Next Generation Biofuels R&D: Competitive selection of cutting-edge projects to focus on transformational developments that address technical barriers in feedstock logistics by innovative at-scale demonstrations of new logistic models (depot concepts), decreased conversion costs through new research into process intensification, enhanced economics of biofuel production through focus on high value co-products and, certification of new fuel pathways ($100 million).
- Smart Mobility Research Center: Expand collaborative research programs by establishing a smart mobility research center that will investigate the intersection of information and communication technologies (ICT), vehicle technologies, low carbon fuels, and disruptive transportation business models with the goal of reducing overall system level GHG emissions and petroleum consumption ($200 million).
- Clean Fleets Competitions: Accelerate the transition to a cleaner vehicle fleet issuing challenge grants for a new Clean Fleets Competitions to drive cleaner state, tribal, and local government vehicle fleets ($85 million).
- Low-Carbon Fueling Infrastructure Deployment: Develop regional low-carbon fueling infrastructure including charging stations for electric vehicles, biofuels, hydrogen, and others low-carbon options in partnership with States, local governments, universities, and private organizations that take into account the unique economies, resources, and development needs of different regions ($750 million).

21st Century Clean Transportation
Funding ($K)

	FY 2015 Enacted	FY 2015 Current	FY 2016 Enacted	FY 2017 Request	FY 2017 vs FY 2016
21st Century Clean Transportation					
Clean Transportation R&D	0	0	0	200,000	+200,000
Next-Generation Biofuels R&D	0	0	0	100,000	+100,000
Smart Mobility Research Center	0	0	0	200,000	+200,000
Clean Fleets Competitions – Municipalities and First-Responders	0	0	0	85,000	+85,000
Low-Carbon Fueling Infrastructure Deployment	0	0	0	750,000	+750,000
Total, 21st Century Clean Transportation	**0**	**0**	**0**	**1,335,000**	**+1,335,000**

21st Century Clean Transportation

Energy Efficiency and Renewable Energy Research and Development

Research and Development ($K)

	FY 2015 Enacted	FY 2015 Current	FY 2016 Enacted	FY 2017 Request	FY 2017 vs FY 2016
Basic	0	0	0	0	0
Applied	0	0	0	320,000	+320,000
Development	0	0	0	180,000	+180,000
Subtotal, R&D	0	0	0	500,000	+500,000
Equipment	0	0	0	0	0
Construction	0	0	0	0	0
Total, R&D	**0**	**0**	**0**	**500,000**	**+500,000**

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 2015 Actual Cost	FY 2015 Planned Cost	FY 2016 Planned Cost	FY 2017 Planned Cost
National Renewable Energy Laboratory	10,241	11,039	10,180	10,261
Total, Direct-Funded Maintenance and Repair	**10,241**	**11,039**	**10,180**	**10,261**

Costs for Indirect-Funded Maintenance and Repair (including Deferred Maintenance Reduction) ($K)

	FY 2015 Actual Cost	FY 2015 Planned Cost	FY 2016 Planned Cost	FY 2017 Planned Cost
National Renewable Energy Laboratory	2,351*	1,948*	2,000*	2,000*
Total, Indirect-Funded Maintenance and Repair	**2,351***	**1,948***	**2,000***	**2,000***

* NREL transitioned from Indirect to Direct funding for Maintenance in FY2014. Starting in FY2015 NREL provides both direct and indirect funding for maintenance and repair.

Report on FY 2015 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 2015 to the amount planned for FY 2015, including Congressionally-directed changes.

Energy Efficiency and Renewable Energy
Total Costs for Maintenance and Repair ($K)

	FY 2015 Actual Cost	FY 2015 Planned Cost
National Renewable Energy Laboratory	12,592	12,987
Total, Maintenance and Repair	**12,592**	**12,987**

The Planned Cost is an estimate developed at the beginning of the year and is a minimum target amount. Final FY 2015 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

Research and Development ($K)

	FY 2015 Enacted	FY 2015 Current	FY 2016 Enacted	FY 2017 Request	FY 2017 vs FY 2016
Basic	0	0	0	0	0
Applied	594,019	575,776	640,428	996,235	+355,807
Development	762,546	752,411	765,705	1,111,824	+346,119
Subtotal, R&D	1,356,565	1,328,187	1,406,133	2,108,059	+701,926
Equipment	3,600	3,600	3,600	3,600	0
Construction	0	0	0	0	0
Total, R&D	**1,360,165**	**1,331,787**	**1,409,733**	**2,111,659**	**+701,926**

Energy Efficiency and Renewable Energy Research and Development

Small Business Innovative Research/Small Business Technology Transfer (SBIR/STTR) ($K)

	FY 2015 Transferred	FY 2016 Projected Transfers	FY 2017 Request Projected Transfers	FY 2017 vs FY 2016
Vehicles Technologies				
SBIR	6,568	7,244	12,400	+5,156
STTR	906	1,087	1,744	+657
Bioenergy Technologies				
SBIR	3,590	3,761	4,132	+371
STTR	495	564	581	+17
Hydrogen and Fuel Cell Technologies				
SBIR	1,907	2,149	2,427	+278
STTR	263	322	341	+19
Solar Energy				
SBIR	1,933	1,774	3,392	+1,618
STTR	267	266	477	+211
Wind Energy				
SBIR	935	652	1,621	+969
STTR	129	98	228	+130
Water Power				
SBIR	880	1,123	1,257	+134
STTR	121	168	177	+9
Geothermal Technologies				
SBIR	626	885	2,492	+1,607
STTR	86	133	350	+217
Advanced Manufacturing				
SBIR	5,119	6,000	7,408	+1,408
STTR	706	900	1,042	+142
Building Technologies				

SBIR	3,487	2,652	5,184	+2,532
STTR	360	398	729	+331
Crosscutting Innovation Initiatives				
SBIR	0	0	6,480	+6,480
STTR	0	0	911	+911
Total, SBIR	25,045	26,240	46,793	+20,553
Total, STTR	3,333	3,936	6,580	+2,644

Energy Efficiency and Renewable Energy
Safeguards and Security ($K)

	FY 2015 Enacted	FY 2015 Current	FY 2016 Enacted	FY 2017 Request	FY 2017 vs FY 2016
Protective Forces	5,200	5,200	5,200	5,200	0
Physical Security Systems	0	0	0	0	0
Information Security	200	200	200	200	0
Cybersecurity	2,190	2,190	2,190	2,190	0
Personnel Security	720	720	720	720	0
Material Control and Accountability	0	0	0	0	0
Program Management	490	490	490	490	0
Security Investigations	400	400	400	400	0
Transportation Security	0	0	0	0	0
Construction	0	0	0	0	0
Total, Safeguards and Security	**9,200**	**9,200**	**9,200**	**9,200**	**0**

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($K)

Energy Efficiency and Renewable Energy	FY 2015 Current	FY 2016 Enacted	FY 2017 Request
Ames Laboratory			
Energy Efficiency and Renewable Energy			
Hydrogen & Fuel Cell Technologies	200	400	600
Vehicle Technologies	1,900	1,900	1,900
Advanced Manufacturing	25,000	25,000	20,000
Bioenergy Technologies	0	13	0
Total, Energy Efficiency and Renewable Energy	**27,100**	**27,313**	**22,500**
Total, Ames Laboratory	**27,100**	**27,313**	**22,500**
Argonne National Laboratory			
Energy Efficiency and Renewable Energy			
Wind Energy	1,526	625	1,799
Geothermal Technologies	150	0	0
Hydrogen & Fuel Cell Technologies	8,420	9,000	9,000
Water Power	206	0	795
Solar Energy	580	589	2,358
Vehicle Technologies	38,371	43,647	43,647
Building Technologies	288	260	0
Federal Energy Management Program	900	0	0
Advanced Manufacturing	1,887	3,730	4,000
Strategic Programs	160	0	0
Bioenergy Technologies	5,661	5,271	4,919
Total, Energy Efficiency and Renewable Energy	**58,149**	**63,122**	**66,518**
Total, Argonne National Laboratory	**58,149**	**63,122**	**66,518**
Brookhaven National Laboratory			
Energy Efficiency and Renewable Energy			
Geothermal Technologies	100	500	1,328
Hydrogen & Fuel Cell Technologies	1,170	1,300	600
Vehicle Technologies	1,804	2,052	2,052
Strategic Programs	0	0	0
Total, Energy Efficiency and Renewable Energy	**3,074**	**3,852**	**3,980**
Total, Brookhaven National Laboratory	**3,074**	**3,852**	**3,980**
Chicago Operations Office			
Energy Efficiency and Renewable Energy			
Wind Energy	75	75	0
Hydrogen & Fuel Cell Technologies	2,180	2,500	0
Vehicle Technologies	139	158	158
Total, Energy Efficiency and Renewable Energy	**2,394**	**2,733**	**158**
Total, Chicago Operations Office	**2,394**	**2,733**	**158**

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($K)

Energy Efficiency and Renewable Energy	FY 2015 Current	FY 2016 Enacted	FY 2017 Request
Golden Field Office			
Energy Efficiency and Renewable Energy			
Wind Energy	50,671	52,550	83,789
Program Direction	27,919	27,394	27,085
Geothermal Technologies	3,747	15,800	28,500
Hydrogen & Fuel Cell Technologies	34,460	38,050	43,080
Water Power	31,400	45,924	44,581
Solar Energy	152,400	162,400	200,445
Vehicle Technologies	0	0	0
Building Technologies	19,327	49,135	142,720
Federal Energy Management Program	4,950	5,380	8,569
Weatherization Assistance	1,200	1,100	2,200
State Energy Program	7,289	7,215	21,340
Tribal Energy Activities	0	0	0
Advanced Manufacturing	119,424	143,663	174,225
Strategic Programs	3,155	3,200	5,950
Bioenergy Technologies	41,612	45,930	136,812
Cities, Counties and Communities Energy Program	0	0	22,000
Total, Energy Efficiency and Renewable Energy	**497,554**	**597,741**	**941,296**
Total, Golden Field Office	**497,554**	**597,741**	**941,296**
Idaho National Laboratory			
Energy Efficiency and Renewable Energy			
Wind Energy	870	297	0
Geothermal Technologies	2,807	1,900	3,874
Hydrogen & Fuel Cell Technologies	1,200	100	2,300
Vehicle Technologies	9,640	10,966	10,966
Federal Energy Management Program	237	258	410
Advanced Manufacturing	250	200	250
Strategic Programs	225	0	0
Bioenergy Technologies	15,438	14,890	13,864
Total, Energy Efficiency and Renewable Energy	**30,667**	**28,611**	**31,664**
Total, Idaho National Laboratory	**30,667**	**28,611**	**31,664**

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($K)

Energy Efficiency and Renewable Energy	FY 2015 Current	FY 2016 Enacted	FY 2017 Request
Lawrence Berkeley National Laboratory			
Energy Efficiency and Renewable Energy			
Wind Energy	1,087	1,060	1,282
Geothermal Technologies	3,975	2,804	4,993
Hydrogen & Fuel Cell Technologies	2,250	2,400	1,600
Water Power	70	0	0
Solar Energy	1,422	1,443	2,950
Vehicle Technologies	9,346	10,631	10,631
Building Technologies	22,504	28,224	19,538
Federal Energy Management Program	2,856	3,104	4,944
Weatherization Assistance	125	125	400
State Energy Program	771	780	780
Advanced Manufacturing	4,833	5,238	9,000
Strategic Programs	1,165	1,665	4,690
Bioenergy Technologies	5,926	5,678	1,263
Total, Energy Efficiency and Renewable Energy	**56,330**	**63,152**	**62,071**
Total, Lawrence Berkeley National Laboratory	**56,330**	**63,152**	**62,071**
Lawrence Livermore National Laboratory			
Energy Efficiency and Renewable Energy			
Wind Energy	949	578	1,119
Geothermal Technologies	600	110	155
Hydrogen & Fuel Cell Technologies	1,900	2,000	1,300
Vehicle Technologies	2,673	3,041	3,041
Advanced Manufacturing	6,125	6,750	7,500
Strategic Programs	225	0	0
Bioenergy Technologies	700	0	0
Total, Energy Efficiency and Renewable Energy	**13,172**	**12,479**	**13,115**
Total, Lawrence Livermore National Laboratory	**13,172**	**12,479**	**13,115**
Los Alamos National Laboratory			
Energy Efficiency and Renewable Energy			
Wind Energy	212	0	0
Geothermal Technologies	481	700	1,303
Hydrogen & Fuel Cell Technologies	6,130	6,600	7,300
Solar Energy	667	677	2,144
Vehicle Technologies	1,010	1,149	1,149
Advanced Manufacturing	0	400	400
Strategic Programs	0	0	0
Bioenergy Technologies	6,234	2,456	1,740
Total, Energy Efficiency and Renewable Energy	**14,734**	**11,982**	**14,036**
Total, Los Alamos National Laboratory	**14,734**	**11,982**	**14,036**

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($K)

Energy Efficiency and Renewable Energy	FY 2015 Current	FY 2016 Enacted	FY 2017 Request
National Energy Technology Lab			
Energy Efficiency and Renewable Energy			
Program Direction	14,195	14,834	14,876
Geothermal Technologies	410	35,600	36,042
Solar Energy	0	0	1,472
Vehicle Technologies	123,219	140,424	298,924
Building Technologies	23,989	14,000	15,000
State Energy Program	125	125	0
Advanced Manufacturing	250	400	400
Strategic Programs	150	130	300
Bioenergy Technologies	0	33	0
Total, Energy Efficiency and Renewable Energy	**162,338**	**205,546**	**367,014**
Total, National Energy Technology Lab	**162,338**	**205,546**	**367,014**
National Renewable Energy Laboratory			
Energy Efficiency and Renewable Energy			
Wind Energy	31,031	17,751	33,153
Facilities and Infrastructure	56,000	62,000	92,000
Geothermal Technologies	4,224	3,870	6,050
Hydrogen & Fuel Cell Technologies	17,590	17,800	17,220
Water Power	5,865	4,156	6,433
Solar Energy	55,704	55,052	48,715
Vehicle Technologies	23,985	27,283	27,283
Building Technologies	15,677	11,066	6,765
Federal Energy Management Program	5,216	5,670	9,029
Weatherization Assistance	750	750	600
State Energy Program	280	280	280
Tribal Energy Activities	0	0	0
Advanced Manufacturing	1,894	2,532	2,500
Strategic Programs	7,093	8,731	9,740
Bioenergy Technologies	60,367	56,327	45,486
Total, Energy Efficiency and Renewable Energy	**285,676**	**273,268**	**305,254**
Total, National Renewable Energy Laboratory	**285,676**	**273,268**	**305,254**

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Funding By Appropriation By Site

($K)

Energy Efficiency and Renewable Energy	FY 2015 Current	FY 2016 Enacted	FY 2017 Request
Oak Ridge Institute for Science & Education			
Energy Efficiency and Renewable Energy			
Geothermal Technologies	245	0	0
Vehicle Technologies	297	338	338
Building Technologies	1,318	1,767	0
Advanced Manufacturing	4,246	4,447	4,500
Strategic Programs	545	650	650
Bioenergy Technologies	442	700	0
Total, Energy Efficiency and Renewable Energy	**7,093**	**7,902**	**5,488**
Total, Oak Ridge Institute for Science & Education	**7,093**	**7,902**	**5,488**
Oak Ridge National Laboratory			
Energy Efficiency and Renewable Energy			
Wind Energy	150	0	664
Geothermal Technologies	2,402	1,748	3,519
Hydrogen & Fuel Cell Technologies	5,120	5,500	5,800
Water Power	3,074	2,800	3,625
Solar Energy	0	0	3,458
Vehicle Technologies	37,310	42,440	42,440
Building Technologies	18,584	12,406	10,903
Federal Energy Management Program	3,155	3,429	5,462
Weatherization Assistance	625	625	800
State Energy Program	0	25	25
Advanced Manufacturing	20,711	25,373	28,000
Strategic Programs	0	0	0
Bioenergy Technologies	11,515	11,317	10,509
Total, Energy Efficiency and Renewable Energy	**102,646**	**105,663**	**115,205**
Total, Oak Ridge National Laboratory	**102,646**	**105,663**	**115,205**
Oak Ridge Office			
Energy Efficiency and Renewable Energy			
Hydrogen & Fuel Cell Technologies	330	400	0
Water Power	177	0	0
Strategic Programs	0	0	0
Total, Energy Efficiency and Renewable Energy	**507**	**400**	**0**
Total, Oak Ridge Office	**507**	**400**	**0**

Department Of Energy

FY 2017 Congressional Budget

Funding By Appropriation By Site

($K)

Energy Efficiency and Renewable Energy	FY 2015 Current	FY 2016 Enacted	FY 2017 Request
Pacific Northwest National Laboratory			
Energy Efficiency and Renewable Energy			
Wind Energy	4,086	1,654	7,843
Geothermal Technologies	2,349	1,228	2,414
Hydrogen & Fuel Cell Technologies	3,530	3,800	6,100
Water Power	4,895	3,300	7,306
Solar Energy	0	0	1,399
Vehicle Technologies	8,044	9,150	9,150
Building Technologies	26,709	23,000	22,137
Federal Energy Management Program	1,455	1,582	2,519
State Energy Program	135	175	175
Advanced Manufacturing	250	450	500
Strategic Programs	545	150	230
Bioenergy Technologies	18,770	19,396	17,825
Total, Energy Efficiency and Renewable Energy	**70,768**	**63,885**	**77,598**
Total, Pacific Northwest National Laboratory	**70,768**	**63,885**	**77,598**
Sandia National Laboratories			
Energy Efficiency and Renewable Energy			
Wind Energy	6,573	4,248	7,749
Geothermal Technologies	4,180	2,790	5,922
Hydrogen & Fuel Cell Technologies	4,820	5,200	5,900
Water Power	6,759	4,620	6,763
Solar Energy	16,102	13,300	10,301
Vehicle Technologies	8,497	9,665	9,665
Federal Energy Management Program	83	90	144
Tribal Energy Activities	0	0	0
Advanced Manufacturing	225	225	225
Strategic Programs	250	130	300
Bioenergy Technologies	3,304	2,688	1,199
Total, Energy Efficiency and Renewable Energy	**50,793**	**42,956**	**48,168**
Total, Sandia National Laboratories	**50,793**	**42,956**	**48,168**
Savannah River National Laboratory			
Energy Efficiency and Renewable Energy			
Wind Energy	106	0	0
Hydrogen & Fuel Cell Technologies	2,900	3,100	1,400
Solar Energy	2,097	2,129	482
Bioenergy Technologies	370	310	0
Total, Energy Efficiency and Renewable Energy	**5,473**	**5,539**	**1,882**
Total, Savannah River National Laboratory	**5,473**	**5,539**	**1,882**

Department Of Energy

FY 2017 Congressional Budget

Funding By Appropriation By Site

($K)

Energy Efficiency and Renewable Energy	FY 2015 Current	FY 2016 Enacted	FY 2017 Request
SLAC National Accelerator Laboratory			
Energy Efficiency and Renewable Energy			
Solar Energy	0	0	1,376
Total, SLAC National Accelerator Laboratory	**0**	**0**	**1,376**
Stanford Site Office			
Energy Efficiency and Renewable Energy			
Vehicle Technologies	500	569	569
Total, Stanford Site Office	**500**	**569**	**569**
Undesignated Lab/Plant/Installation			
Energy Efficiency and Renewable Energy			
Cities, Counties and Communities Energy Program	0	0	4,000
Total, Undesignated Lab/Plant/Installation	**0**	**0**	**4,000**
Washington Headquarters			
Energy Efficiency and Renewable Energy			
Wind Energy	8,600	16,612	18,602
Program Direction	118,636	112,772	128,939
Geothermal Technologies	28,618	3,950	5,400
Hydrogen & Fuel Cell Technologies	2,630	2,800	3,300
Water Power	7,553	9,200	10,497
Solar Energy	1,828	6,010	10,000
Vehicle Technologies	5,791	6,587	6,587
Building Technologies	39,757	60,642	71,937
Federal Energy Management Program	8,148	7,487	11,923
Weatherization Assistance	190,300	212,400	226,000
State Energy Program	41,400	41,400	47,400
Tribal Energy Activities	0	0	0
Advanced Manufacturing	9,080	10,092	9,500
Strategic Programs	7,487	6,344	6,140
Bioenergy Technologies	5,576	59,991	45,283
Crosscutting Innovation Initiatives	0	0	215,000
Total, Energy Efficiency and Renewable Energy	**475,404**	**556,287**	**816,508**
Total, Washington Headquarters	**475,404**	**556,287**	**816,508**
Total, Energy Efficiency and Renewable Energy	**1,864,372**	**2,073,000**	**2,898,400**

Electricity Delivery and Energy Reliability

Electricity Delivery and Energy Reliability

Electricity Delivery and Energy Reliability

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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, **[**$206,000,000**]** *$262,300,000*, to remain available until expended: Provided, That of such amount, **[**$28,000,000**]** *$29,000,000* shall be available until September 30, **[**2017**]** *2018*, for program direction. *(Energy and Water Development and Related Agencies Appropriations Act, 2016.)*

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 2015 Enacted	FY 2015 Current[a]	FY 2016 Enacted	FY 2017 Request
146,975	143,901	206,000	262,300

Overview

The Office of Electricity Delivery and Energy Reliability (OE) leads the Department's efforts to strengthen, transform, and improve 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 enable 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 to 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.
- 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 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.

OE programs are aligned with the Administration's priorities, as documented in *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 perform the research, development, and demonstration that will result in an electric power grid that is reliable and 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, Development, and Deployment—pursuing technologies to improve grid reliability, efficiency, flexibility, functionality, and security; and making investments and sponsoring demonstrations aimed at bringing new and innovative technologies to maturity and helping them transition to market.
- Modeling and Analytics—developing 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 among infrastructure systems, such as between electricity and natural gas systems.

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

- Institutional Support and Technical Assistance—building capacity in the industry and convening stakeholders to coordinate efforts to transform the electric grid; providing 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—streamlining permits, special use authorizations, and other approvals required under Federal law to site electric transmission facilities.
- Emergency Preparedness and Response—pursuing enhancements to the reliability, survivability, and resiliency of energy infrastructure, and facilitating faster recovery from disruptions to energy supply.

Highlights and Major Changes in the FY 2017 Budget Request

The FY 2017 Budget Request reflects the Administration's priority to modernize the electric grid and boosting the resilience of the energy infrastructure. The Request accelerates ongoing efforts to support the Administration's energy strategy and emphasizes programs that increase electric grid resilience and risk assessment and management, increasing system flexibility and robustness, increasing visualization and situational awareness, and deploying advanced control capabilities. The Request continues to support the Department's international activities.

The FY 2017 Budget Request takes a significant first step toward fulfilling the U.S. pledge to seek to double federal clean energy research and development investments government-wide over the next 5 years as part of Mission Innovation, an initiative launched by the U.S. and 19 other countries to accelerate widespread clean energy technology innovation and cost reduction. The OE FY 2017 Budget Request of $262 million includes $177 million that contributes to the Mission Innovation pledge, an increase of $24 million from the FY 2016 Enacted level of $153 million. These investments will drive innovation essential for economic growth, provide clean, affordable and reliable energy, and advance energy security.

Clean Energy Transmission and Reliability ($30,300,000; -$8,700,000) is focused on ensuring the reliability and resiliency of the U.S. electric grid through research and development (R&D) on measurement and control of the electricity system and risk assessment to address challenges across integrated energy systems. The FY 2017 Request supports competitive awards to academia, national laboratories, and industry, and leverages resources of the DOE Office of Science and the National Science Foundation to advance scientific discovery. The FY 2017 Request reduces funding for cost-shared industry development and demonstration of synchrophasor applications.

Smart Grid Research and Development ($30,000,000; -$5,000,000) investments in Advanced Distribution Management System, Transactive Controls, Microgrids, and Resilience Electric Distribution Grid R&D continue to strengthen the distribution system modernization by accommodating increasing distributed energy resources (solar photovoltaics, combined heat and power, energy storage, electric vehicles, etc.), enabling higher levels of demand-side management and control practices, and enhancing reliability and resiliency during both normal operations and extreme weather events. The industry partnership projects on microgrid system designs and advanced controllers, established through a FY 2014 funding opportunity announcement, will be competitively down-selected to advance into field demonstration and implementation.

Cybersecurity for Energy Delivery Systems ($45,500,000, -$16,500,000) supports research on cutting edge cybersecurity solutions, information sharing to enhance situational awareness, and implementing tools to aid industry to improve their cybersecurity posture. The Request completes implementation of the Virtual Energy Sector Advanced Digital Forensics Platform, which will be transitioned to the private sector. Incident management activities are moved in FY 2017 to Infrastructure Security and Energy Restoration, which will provide a comprehensive response to incidents.

Energy Storage ($44,500,000; +$24,000,000) supports energy storage technology cost reductions, performance improvements, and reliability and safety validations, and works toward an equitable regulatory environment and industry acceptance. The increase includes initiation of 3–4 new highly leveraged, cost-shared demonstrations with states encompassing 5MW+ of energy storage assets and new university R&D into new energy storage chemistries and materials, power electronics, and system performance and evaluation.

Transformer Resilience and Advanced Components ($15,000,000; +$10,000,000) increases investments in the development of technologies and assessments to mitigate system vulnerabilities such as geomagnetic disturbances and electromagnetic pulses. Activities will also focus on developing next-generation transformers to fill a critical gap identified through the 2015 Quadrennial Technology Review. Research efforts will address the unique challenges associated with high power levels (voltage and current), high reliability requirements (25–40 years of field operations), and high costs of critical components.

Grid Institute ($14,000,000; +$14,000,000) supports the first year of funding for a new competitively selected Grid Clean Energy Manufacturing Innovation Institute as a part of the larger multi-agency National Network for Manufacturing Innovation (NNMI). This Institute will focus on technologies related to critical metals for grid application, and advances will

be broadly applicable in multiple industries and markets. Potential topics for the Institute include alloys, metal matrix/hybrid composites, and metal/hybrid laminates.

National Electricity Delivery ($6,500,000; -$1,000,000) focuses its efforts related to alternative ratemaking concepts and regulated utility business models to include workshops and discussions to determine topics of interest to regulatory stakeholders and other related activities. NED authorizes the export of electricity, issues permits for the construction of cross-border transmission lines, and is leading efforts to improve the coordination of Federal transmission permitting.

State Distribution-Level Reform Program ($15,000,000; +$15,000,000) is a new activity in FY 2017 that will award 5–10 cooperative agreements competitively to states, for a performance period of 2 years to utilize the grid architecture approach to address their system challenges. Achieving an effective design in any given geographic area will require governmental leadership (Federal and state), technological and analytic expertise, and collaboration among many stakeholders. The states are well positioned to play important leadership roles, and could benefit from the assistance that the proposed program could provide.

Infrastructure Security and Energy Restoration ($17,500,000; +$8,500,000) will continue stakeholder engagement, analysis, and exercise activities, and continue to deliver capabilities in support of DOE's ESF-12 responsibilities. The FY 2017 Budget Request supports enhancement of EAGLE-I, the Federal Government's situational awareness tool for national power outages to cover how outages affect other aspects of critical lifeline sectors and model potential impacts from various hazards, and other emergency response tools; a significantly expanded energy emergency preparedness all-hazards exercise program with state, local, tribal, and territorial entities; and analysis of new and emerging threats including those resulting from supply chains and electromagnetic pulses.

State Energy Assurance ($15,000,000; +$15,000,000) supports regional and state activities to improve capabilities to characterize energy sector supply disruptions, communicate among the local, state, regional, Federal, and industry partners, and identify gaps for use in energy planning and emergency response training programs. This program will assist OE's state, local, tribal, and territorial stakeholders in planning, training, and exercising in advance of energy emergencies.

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 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. OE contains the following crosscuts:

Grid Modernization (Grid): 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 building on analysis and findings of the QER; ensure the development of a secure and resilient grid; and collaborate with stakeholders to test and demonstrate combinations of promising new technologies.

Cybersecurity: DOE is engaged in two categories of cyber-related activities: protecting the DOE enterprise from a range of cyber threats that can adversely impact mission capabilities 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, Credentials, and Access Management (ICAM).

FY 2017 Crosscuts ($K)

	Grid Modernization	Cybersecurity	Total
Clean Energy Transmission and Reliability	30,300	0	30,300
Smart Grid Research and Development	30,000	0	30,000
Cybersecurity for Energy Delivery Systems	45,500	45,500	45,500[a]
Energy Storage	44,500	0	44,500
Transformer Resilience and Advanced Components	15,000	0	15,000
National Electricity Delivery	6,500	0	6,500
State Distribution-Level Reform Program	15,000	0	15,000
Total, Crosscuts	**186,800**	**45,500**	**186,800[a]**

FY 2015 Key Accomplishments

Clean Energy Transmission and Reliability

CETR's Transmission Reliability subprogram has improved the ability of electric system operators to comply with reliability standards. In FY 2015, we delivered the final version of the Frequency Response Analysis tool and supporting documentation. Electric system operators may use this synchrophasor-based tool to demonstrate compliance with the requirements of the North American Electric Reliability Corporation's Standard BAL-003, which requires operators to maintain a capacity to provide frequency response to ensure system reliability. The tool is available for download from the NASPI.org software research web page.

CETR's Energy System Risk and Predictive Capability (ESRPC) subprogram funded Los Alamos National Laboratory to examine the risk and uncertainty of the impact of geomagnetic disturbances on the electric power system. This research work, currently in peer review, developed a statistically rigorous estimate of the 100-year geo-electric field magnitude along with a method of how to scale the geomagnetic field to latitudes below 60 degrees north. This result is a statistically rigorous estimate that can be used by Power System Engineers and Planners to assess better their risk to a high impact, low frequency event; this study has been cited numerous times in the Federal Energy Regulatory Commission rulemaking on reliability standard regarding geomagnetic disturbances.

ESRPC funded a pilot study in FY 2014 that explores the feasibility of assessing the impacts of sea level rise on energy infrastructure through 2100. Initially, the study focused on the four major metropolitan statistical areas of New York City, Houston, Miami, and Los Angeles. Results of the study were published in a report entitled, "Effect of Sea Level Rise on Energy Infrastructure in Four Major Metropolitan Areas." Additional analysis were conducted in FY 2015 to further assess the effects of storm surge on top of sea level rise highlighting the impacts that a major storm could have on these metropolitan areas as well as four additional cities. The study approach is flexible and scalable, uses existing and robust data sources, accounts for global and local sea level changes, and incorporates results from regional studies.

ESRPC has funded a State Energy Risk Assessment Initiative in coordination with the National Association of State Energy Officials (NASEO), the National Association of Regulatory Utility Commissioners (NARUC), the National Conference of State Legislatures (NCSL), and the National Governors Association (NGA). In 2015, a State Energy Risk Assessment Workshop was held for State agencies and energy stakeholders from across the country. The workshop showcased methods, tools and processes for conducting energy infrastructure risk assessments. In addition, State Energy Risk Profiles were produced and published for all fifty States.

Smart Grid Research and Development

A prototype Microgrid Design Toolset (MDT) has completed development and is being used in planning for and designing community microgrids in Massachusetts and New Mexico. The MDT integrates energy assurance planning to ensure uninterrupted power delivery to all critical loads under normal and emergency conditions, economic and environmental analyses to co-optimize costs and CO_2 emissions reduction for candidate microgrid designs, and physics-based analyses to meet electric system power quality and reliability requirements. These capabilities were developed by DOE national

[a] The entire $45,500,000 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.

laboratories, and the MDT integrates the combined capabilities to meet the overall power system needs for economics, reliability and resilience, and environmental emissions reductions. The prototype tool and user manual are freely downloadable by all microgrid designers.

Cybersecurity for Energy Delivery Systems

A CEDS R&D project led by Applied Communication Sciences (ACS) developed innovative technology to provide anomaly and intrusion detection for advanced metering infrastructure and distribution automation wireless mesh networks. Piloted at a utility servicing over 600,000 accounts, this innovative technology gives the utility enhanced visibility into smart meter and distribution automation network activity. Such visibility strengthens power grid security and fosters effective partnerships among utility and energy delivery infrastructure suppliers. The intrusion detection and monitoring technology also improves network operators' situational awareness, helps validate over-the-air security controls, and mitigates supply chain cyber-threats. ACS introduced the cybersecurity intrusion detection and monitoring for field area networks under the SecureSmart managed security service across four major investor-owned and municipal utilities, in advance of and far beyond the original technology transition plan.

In January 2015, the Department of Energy's Oak Ridge National Laboratory (ORNL) executed an exclusive license agreement with a cybersecurity solutions provider, R&K Cyber Solutions LLC, for Hyperion, a software product developed by ORNL that can quickly recognize malicious software even if the specific program has not been previously identified as a threat. Hyperion further strengthens the cybersecurity of critical energy infrastructure by providing evidence of the secure functioning of energy delivery control system devices without requiring disclosure of the source code. It is a new type of malware detection program that points to the future of cybersecurity tools, in that it looks inside an executable program to determine the software's behavior without using its source code or running the program by computing and analyzing program behaviors associated with harmful intent. This advances the vision of resilient energy delivery systems designed, installed, operated and maintained to survive a cyber-incident while sustaining critical functions, as articulated in the energy sector's Roadmap to Achieve Energy Delivery Systems Cybersecurity.

Energy Storage

A 6.5kV normally-off silicon carbide (SiC) Junction Field Effect Transistor (JFET) semiconductor switch has been developed that can switch voltages four times as high and ten to twenty times as fast as competing silicon device. The higher voltage and faster switching allows power conversion systems to have much smaller passive components, such as inductors, capacitors, and cooling apparatus. The device targets next generation power converters used in energy storage devices and can increase converter density by over seven times and increase efficiency over two percent. This work was recognized as among the most innovative ideas of the year through a 2015 R&D 100 Award.

Using the OE-developed mixed acid vanadium/vanadium redox flow battery technology, UniEnergy Technology successfully deployed and commissioned a 1 MW/3.2 MWh energy storage system in Pullman, WA. In FY 2015, a 30% increase in current density was realized. R&D efforts have demonstrated the potential for a 50% reduction in system costs since the project was initiated in 2011. New aqueous soluble organic redox species have been identified which can directly replace vanadium in these systems enabling the potential for a further 50% reduction in battery costs.

OE provided technical assistance to states and regional entities to understand the potential benefits and value proposition energy storage provides. In Vermont, the Energy Storage program assisted in the design, technology selection, construction, and commissioning of 4MW's of energy storage. In Oregon, a joint RFP for energy storage systems was developed and supported. In Washington, the program is providing analysis and usage optimization for 7MW/15 MWh of energy storage and recently hosted a workshop for regional utility commissioners. In California and Hawaii, the program is working with utilities and state energy offices to evaluate the role of energy storage in supporting greater renewables integration.

Infrastructure Security and Energy Restoration

During FY 2015, DOE's Energy emergency response organization was activated by FEMA for 111 days for 10 severe weather events (7 tropical, 1 flood, and 2 winter) and a wildfire. During these events, DOE works closely with Federal, state, and local governments, and industry to protect against and mitigate threats to energy infrastructure.

Electricity Delivery and Energy Reliability
Funding by Congressional Control ($K)

	FY 2015 Enacted	FY 2015 Current[a]	FY 2016 Enacted	FY 2017 Request	FY 2017 vs FY 2016
Clean Energy Transmission and Reliability	34,262	33,336	39,000	30,300	-8,700
Smart Grid Research and Development	15,439	14,930	35,000	30,000	-5,000
Cybersecurity for Energy Delivery Systems	45,999	44,756	62,000	45,500	-16,500
Energy Storage	12,000	11,604	20,500	44,500	+24,000
Transformer Resilience and Advanced Components	0	0	5,000	15,000	+10,000
Grid Institute	0	0	0	14,000	+14,000
National Electricity Delivery	6,000	6,000	7,500	6,500	-1,000
State Distribution-Level Reform Program	0	0	0	15,000	+15,000
Infrastructure Security and Energy Restoration	6,000	6,000	9,000	17,500	+8,500
State Energy Assurance	0	0	0	15,000	+15,000
Program Direction	27,606	27,606	28,000	29,000	+1,000
Subtotal, Electricity Delivery and Energy Reliability	**147,306**	**144,232**	**206,000**	**262,300**	**+56,300**
Rescission of prior year balances	-331	-331	0	0	0
Total, Electricity Delivery and Energy Reliability	**146,975**	**143,901**	**206,000**	**262,300**	**+56,300**
Federal FTEs	**83**	**83**	**89**	**89**	**0**
Additional FE FTEs at NETL supporting OE[b]	29	29	29	29	0
Total OE-funded FTEs	112	112	118	118	0

SBIR/STTR:

- FY 2015 Transferred: SBIR: $2,702; STTR: $372
- FY 2016 Projected: SBIR: $3,825; STTR: $574
- FY 2017 Request: SBIR: $5,050; STTR: $710

[a] Funding reflects the transfer of SBIR/STTR to the Office of Science.
[b] 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 provides its customers with the necessary tools and analyses to assess risks, inform decisions, and improve system performance, planning, and policy. The CETR program is focused on ensuring the reliability and resiliency of the U.S. electric grid through research and development (R&D) focused on measurement and control of the electricity system and risk assessment to address challenges across integrated energy systems. CETR is OE's one-stop-shop for energy modeling and analysis. It also brings together energy stakeholders from government, industry, and academia to generate ideas and develop solutions to the Nation's energy infrastructure challenges.

CETR's mission manifests itself in three key areas:

- Advancing electrical engineering through applied research in measurements, models, mathematics, and computation.
- Advancing applied mathematics by developing and demonstrating software tools that allow electricity system operators and planners to improve reliability and security of the system.
- Advancing operations research through research on risk and decision science to improve methods and models used to assess the impact and response of energy infrastructure systems to natural hazards and man-made events.

CETR has funded numerous researchers at the national laboratories, academia, and private organizations to improve the reliability and security of the U.S. energy infrastructure system. These funding activities included:

- Deploying measurement and communication systems for the high-voltage electricity system; as a result of these Recovery Act investments, the number of measurement devices on the electricity transmission system increased from 200 at the start of the program to almost 2,000 today, and near real-time wide-area visibility into the grid is a reality.
- Developing innovative approaches to model the grid, successfully demonstrating computational advances that have sped computation times for certain grid planning models by more than two orders of magnitude.
- Developing new methods for assessing the risks to energy systems from hurricanes, developed state-level risk profiles, and established the State Energy Risk Assessment Initiative to adopt new risk tools for energy decision making.

CETR directly engages energy stakeholders and decision makers to disseminate research results and promote application, 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 innovation in this essential area.

Highlights of the FY 2017 Budget Request

The FY 2017 Budget Request of $30 million will support the CETR's goals to:

- Develop and test methods for validating power system models using real-time data in a real-world environment to support operations and improve reliability.
- Develop and test advanced computational capabilities for simulating power system behavior in a real-world environment.
- Advance risk and decision science for energy systems by improving the statistical characterization of two wide-area natural hazards that disrupt energy systems: damaging thunderstorm events and large ice accumulation events.

The FY 2017 Budget Request also changes CETR's process and focus. All University, laboratory, and industry-targeted applied R&D and risk and decision science activities transition to a competitive solicitation process and the scale and scope of early stage R&D is reduced. The process changes allow for more efficient evaluation of the program's progress toward major goals, send a clear message regarding program priorities, and provide on-ramps for new ideas and off-ramps for projects not meeting key milestones.

The CETR program is included in the Department's Grid Modernization Initiative crosscut.

Clean Energy Transmission and Reliability
Funding ($K)

	FY 2015 Enacted	FY 2015 Current[a]	FY 2016 Enacted	FY 2017 Request	FY 2017 vs FY 2016
Clean Energy Transmission and Reliability					
Transmission Reliability	17,424	16,849	17,000	12,300	-4,700
Advanced Modeling Grid Research	10,648	10,297	15,000	12,000	-3,000
Energy Systems Risk and Predictive Capability	6,190	6,190	7,000	6,000	-1,000
Total, Clean Energy Transmission and Reliability	**34,262**	**33,336**	**39,000**	**30,300**	**-8,700**

SBIR/STTR:

- FY 2015 Transferred: SBIR: $814; STTR: $112
- FY 2016 Projected: SBIR: $960; STTR: $144
- FY 2017 Request: SBIR: $778; STTR: $109

Clean Energy Transmission and Reliability
Explanation of Major Changes ($K)

	FY 2017 vs FY 2016
Transmission Reliability: Reduce funding targeted to industry cost-shared development and demonstration of synchrophasor applications.	-4,700
Advanced Modeling Grid Research: Refocus the portfolio toward demonstrating commercial potential of prior innovations, reducing the scale and scope of early-stage R&D.	-3,000
Energy Systems Risk and Predictive Capability: Partner with Department of Homeland Security (DHS) Office of Critical Infrastructure Analysis to provide real-time support for energy events and complete a Congressionally directed study regarding a Spare Transformer Reserve.[b]	-1,000
Total, Clean Energy Transmission and Reliability	**-8,700**

[a] Funding reflects the transfer of SBIR/STTR to the Office of Science.
[b] P.L. 114-94, Fixing America's Surface Transportation Act, Section 61004.

Description

The Transmission Reliability (TR) subprogram funds electrical engineering research at DOE national laboratories, academia, and the electricity industry to develop and deploy advanced technologies that enhance the reliability of the U.S. electricity transmission infrastructure. After the 2003 blackout across much of the Northeast, a key blackout investigation recommendation was that situational awareness across the electricity transmission system be improved to help operators mitigate the scale and scope of future blackouts. In response, TR led the deployment of sensors on the grid in collaboration with the electricity transmission industry.[a] TR also engaged in efforts to network these sensors and to develop and share best practices. Additionally, the subprogram supported R&D in characterizing the measurements from these sensors, understanding the behavior of the grid, and using the measurements to help utilities comply with standards. Other R&D looked at how wholesale electricity markets affect reliability and how large scale loads could provide services to the bulk electric system. Had phasor measurement units (PMUs) been in place, the start of the 2003 blackout would have been detected by system operators prior to the initial event as system conditions deteriorated, 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, whereas in 2003, data had to be collected from each affected utility; investigators completed their work in weeks in 2011 versus eight months in 2003.

The measurements from the sensors on the grid are an essential part of a modern transmission system. Retirements of coal-fired power plants, abundant low-cost natural gas, the integration of large wind plants and distributed solar technologies, and increased and expanded wholesale market operations are transforming the nature and character of electricity generation and causing the grid to be used in ways for which it was not designed. TR funds the development of cyber-secure applications employing synchrophasor data to enhance the flexibility, reliability, and resilience of the Nation's power system.

TR has a long history of supporting the outreach, industry participation, and analysis that ensure that the Department's grid-related R&D is relevant to the problems that need to be solved. TR continues to build a user community for synchrophasor data and to support joint industry-government-university problem solving in this area, including support of the North American Synchrophasor Initiative (NASPI), participation of national laboratory experts in industry working groups, and analyses supporting the development and dissemination of synchrophasor-based tools.

In FY 2017, TR completes a restructuring that begins in FY 2016, refocusing efforts from initial application development and efforts promoting industry acceptance of the technology to supporting the use of measurements in real-time system and market operations. 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; examples of key value added areas include condition- and performance-based asset management, detection of geomagnetically induced currents, event and event-precursor detection, and intelligent alarming for operators.

The focus of TR-sponsored R&D in FY 2017 will be in two key areas. The first area will be "big data" applications of grid measurements. This will be competed as an open solicitation, and will require all proposers to have utility partners. The second area will be empirical-based modeling of the transmission systems and loads. Modern electrical loads, from computers to light-emitting diode lights, behave differently from the large rotating machines that characterized the electric system in the past. These loads interact with the electric system and can create widespread problems in power quality. This new focus extends upon work supported by the AMGR subprogram in FY 2016 on new mathematical models of loads.

TR continues to fund university research in FY 2017, with R&D grants to study future needs for electricity system operators in the areas of human cognition and decision making. The research will blend computer science, gaming, psychology, and decision sciences to characterize how the emerging automatic control systems of the grid will interact with human system operators in the future. These grants will be competitively awarded to universities and other research organizations, with a

[a] The sensors are known as phasor measurement units (PMUs) and their measurements become synchrophasors when aggregated together with a common timestamp.

requirement that the university have a utility partner to ensure the relevance of the research to electricity system operations.

Transmission Reliability activities directly support the Grid Sensing and Measurement pillar and Design and Planning Tools pillar of the Grid Modernization Initiative. Success in this program is also essential to achieve the System Control and Power Flow goals of the Initiative.

Centers[a]

CETR continues support for the Center for Ultra-Wide-Area Resilient Electric Energy Transmission Networks (CURENT), which is jointly funded by the National Science Foundation (NSF) and the Department and based at the University of Tennessee, Knoxville. CURENT seeks fundamental breakthroughs and investigates enabling technologies needed to achieve a resilient transmission network on a continental scale, while educating a new generation of electric power and energy systems engineering leaders with a global perspective coming from diverse backgrounds. The FY 2017 budget request continues support for CURENT at $2,134,000 in TR, the same as in FY 2016. Additional activities may be considered depending on programmatic needs in related research areas and the Center's unique capabilities for effectively addressing them. In FY 2015, for example, the AGMR subprogram supported supplemental research in advanced model-based data analytics in alignment with the Center's overall objectives. CURENT's programmatic and technical goals are to develop new systems methodologies to take advantage of advancements in wide-area measurement and communication; flatten the control and information structure so it is less hierarchical and can replace, at all levels of the power grid, traditional inflexible operations strategies; draw on high performance computing capability to realize large-scale and faster-than-real-time simulation for predictive control (and fast response) to ensure secure and reliable operation; and investigate use of widely allocated high power electronic actuator coupled with transmission level energy storage.

[a] As required by the guidance on inclusion of centers in future budget justifications in H.Rpt. 113–135, the House report for the FY 2014 Energy and Water Development appropriations.

Activities and Explanation of Changes

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
Transmission Reliability $17,000,000	**$12,300,000**	**-$4,700,000**
• Install PMU-based technology to perform on-line generator model validation that is required by NERC for all large generators. • Continue support of NASPI to advance information sharing and joint problem-solving among utilities, vendors, universities, and the government, including two annual workgroup sessions. • Co-fund National Science Foundation CURENT Engineering Research Center. • 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.	• Follow-up R&D in synchrophasor data applications and analysis tools with utility deployment and commissioning assistance. • Continue to support NASPI as a mechanism for joint problem solving and information exchange. • Continue CURENT support as recommended by the NSF peer review panel. • Perform R&D on the next-generation phasor measurement unit. • Sponsor R&D on data-driven human cognition and decision making for electricity systems. • Continue university-based R&D on power systems focused on measurement and data.	• Reduce funding targeted to industry cost-shared development and demonstration of synchrophasor applications.

Clean Energy Transmission and Reliability
Advanced Modeling Grid Research

Description

The Advanced Modeling Grid Research (AMGR) subprogram supports R&D in analytical tools necessary for effective planning and operations of the electric system, and is poised in FY 2017 to transition its research innovations into industry application. AMGR continues to complement Transmission Reliability R&D, which uses measurements to feed operational decisions and system control. AMGR R&D 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. Investments will increase the operational efficiency of the electric system, improve reliability, enhance resilience, and facilitate control across the electricity transmission and distribution systems.

The program supports R&D in three major areas:

- **Data Management and Analytics.** These activities advance methods for data collection, usage, storage, and archiving to facilitate the use of large datasets in concert with real-time measurements to support operations.
- **Mathematical Methods and Computation.** These activities develop the foundation of the next generation of tools that operators and operational planners will use to manage the electric system. AMGR develops new algorithms and software libraries for use on high performance computing platforms, leveraging the investments of the Advanced Scientific Computing Research program in the Office of Science and optimization work by the Advanced Research Projects Agency-Energy (ARPA-E).
- **Models and Simulations.** These activities perform R&D on new system models, integrated modeling approaches, and simulations that incorporate real-time high-resolution operational data and guide operational decision making; this is a significant advancement over existing system models.

Together, the three research areas will help to ensure continued reliable operation in a large-scale, dynamic, and uncertain environment.

AMGR is aligned with the core initiatives of the Department. R&D supports the QER recommendation to "provide grid modernization research and development, analysis, and institutional support" and key conclusions of the QTR, which noted the need for advanced algorithms to support grid operations. [a] It is a core component of the Grid Modernization Initiative, supporting system operations, control, and power flow, as well as design and planning tools.

The FY 2017 Request supports the following R&D activities.

- Research translating innovations in applied mathematics to grid applications. This builds off the work of DOE's Office of Science, the National Science Foundation (including the Division of Mathematical Sciences and the Engineering Research Centers), and the success of the Grid Science Winter School, led by Los Alamos National Laboratory in January 2015. These research opportunities will engage the next generation of leaders in the electric power industry and catalyze a community of world-class, multidisciplinary researchers. These activities include competitively awarded grants to universities.
- Developing software libraries providing the foundation of energy management systems, the software that manages electricity systems.
- Developing a capability through the Grid Modernization Laboratory Consortium (GMLC) to test mathematical and modeling breakthroughs in a real-time operator-based simulation environment. This is a unique national laboratory capability and essential for demonstrating the viability of AMGR innovations.

AMGR will also issue a solicitation targeted to industry for cost-shared cooperative agreements to develop a capability for using models to assess evolving operational situations and recommend actions to operators. This work will be coordinated with Transmission Reliability R&D in human cognition and decision making.

[a] Quadrennial Energy Review, April 2015, p. 3-29.

Advanced Modeling Grid Research

Activities and Explanation of Changes

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
Advanced Modeling Grid Research $15,000,000	**$12,000,000**	**-$3,000,000**
• Expand mathematics and computational research to include uncertainty quantification, model formulation and reduction, and controls. • Continue efforts in architecture and data analytics. • Assess performance of open source mathematical methods and solvers (from the software repository) in prototype power system application. • 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.	• Sponsor Grid Science Winter School • Enhance software library of mathematical methods and solvers for energy management systems • Develop capability for grid software testing through the GMLC • Issue an industry solicitation for developing tools based on past innovation from programs which recommend actions to operators under dynamic and abnormal conditions	• Refocus the portfolio toward demonstrating commercial potential of prior innovations, reducing the scale and scope of early-stage R&D.

Clean Energy Transmission and Reliability
Energy Systems Risk and Predictive Capability

Description

The Energy Systems Risk and Predictive Capability (ESRPC) subprogram's objective is to advance risk informed decision making for energy systems by characterizing how current and future threats (natural and man-made) impact energy system planning and operations. The goal is to enable risk-informed decisions regarding energy systems to be made by Federal, state, and local officials, thus improving the response to disruptions to energy systems and investments in systems. ESRPC funds research activities to improve predictive modeling and risk and decision science regarding interdependent energy infrastructure systems.

The products developed by ESRPC are intended to inform a large range of energy industry and government stakeholders regarding how energy systems operate and respond to disturbances as well as provide an analytical benchmark upon which further modeling can be performed by stakeholders to support long-term planning and investment.

In FY 2017, ESRPC will focus on continuing to enhance 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 leveraging the scientific and engineering expertise of the national laboratories.

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.

ESRPC products generally will fall in one of three categories:

- **Analytical and predictive modeling products supporting emergency response.** Activities aim to measurably improve the preparation for, response to, and recovery from disruptions to U.S. energy systems by providing quantitative 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 and supports the development of high resolution risk failure curves. Products developed under this area are intended to support infrastructure system planning decisions. However, because infrastructure system decisions may last for at least 30 years or longer, appropriately characterizing and 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.
- **Analytical tools supporting contingency planning from non-traditional events.** ESRPC 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. FY 2017 funding will also be used to transition computation and distribution of hazard results from desktop computing infrastructure to cloud based infrastructure.

ESRPC directly supports the Grid Security and Resilience pillar of the Grid Modernization crosscut by assessing and communicating risks to energy infrastructure systems.

Energy System Risk and Predictive Capability

Activities and Explanation of Changes

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
Energy System Risk and Predictive Capability		
$7,000,000	**$6,000,000**	**-$1,000,000**
• Advance predictive analytics on interconnected energy infrastructure systems to include understanding of how historical performance predicts future system performance. • Begin connecting research data from the Transmission Reliability and Advanced Modeling Grid Research subprograms to the ESRPC analytical platform. • Advance real-time predictive analytics to enhance Federal, state, local, and industry knowledge for events. • Continue to enhance and strengthen partnerships to ensure the program delivers value to all stakeholders. • Begin wide-scale deployment of a program to educate stakeholders on how to understand, assess, and communicate risk to the energy system. • Provide real time analysis support for all high profile events. • Deploy a capability to assess risks to interdependent energy infrastructure.	• Continue connecting research data from the TR and AMGR subprograms to support ESRPC risk assessments and energy infrastructure analysis. • Advance risk and decision science for energy systems to enhance Federal, state, local, and industry knowledge for events. • Continue to enhance and strengthen partnerships to ensure the program delivers value to all stakeholders. • Develop a capability with the national laboratories to assess risks to interdependent energy infrastructure.	• Partner with DHS Office of Critical Infrastructure Analysis to provide real-time support for energy events. • Complete a Congressionally directed study regarding a Spare Transformer Reserve.[a]

[a] P.L. 114-94, Fixing America's Surface Transportation Act, Section 61004.

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 2015	FY 2016	FY 2017
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 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.	Develop and test methods for validating power system models using real-time data in a real-time environment to support operations and improve reliability.
Result	Met	Not Applicable	Not Applicable
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) 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.	Develop and test advanced computational capabilities for simulating power system behavior in a real-world environment.
Result	Met	Not Applicable	Not Applicable
Endpoint Target	Realization of advanced modeling capabilities, including dynamic operation, real-time analysis, and predictive response.		

	FY 2015	FY 2016	FY 2017
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	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.	Deploy initial analytical products assessing risk and improving decisions for energy infrastructure systems.
Result	Met	Not Applicable	Not Applicable
Endpoint Target	This subprogram develops tools and robust predictive analytic products which assist decision makers in assessing current and future risks to inter-dependent energy systems.		

Smart Grid Research and Development

Overview

The Smart Grid program focuses primarily on the development of innovative 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, resiliency, and faster outage recovery, building upon previous and ongoing grid modernization efforts, including the 2009 Recovery Act's 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 evolving electricity needs. These needs include accommodating increasing customer-owned distributed generation including solar photovoltaics (PV); supporting the shift towards the electrification of transportation such as electric vehicles; 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 focus within the Smart Grid program. New approaches and technologies will also be investigated, including Resilient Electric Distribution Grid R&D enhancing the Nation's electric distribution grid to withstand and recover from disruptions caused by extreme weather events, the Advanced Distribution Management System (ADMS), enabling a whole new level of visibility and control across a utility's entire service territory, transformative approaches in Transactive Control paradigms relying partially on customer-owned and controlled assets to support performance of the distribution system, and 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.

The planned FY 2017 Smart Grid investments in ADMS, Transactive Controls, Microgrids, and Resilient 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. Microgrid R&D is also a strategy element in DOE's 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 a pillar, empowering consumers and enabling them to make informed decisions, of the Administration's report "*A Policy Framework for the 21st Century Grid: Enabling Our Secure Energy Future*" by the National Science and Technology Council.[a]

Highlights of the FY 2017 Budget Request

The FY 2017 request includes a continued investment in the Grid Modernization Initiative, which includes development of an ADMS. Despite ADMS advantages, deployment is lagging because of the challenges associated with integrating multiple toolsets across various platforms and vendors. Because of the complexity of integration, the solutions generally are expensive and time consuming and so are difficult for most utilities to justify; especially mid-sized and small utilities. Leveraging the initial work in FY 2016, ADMS activities will work with industry to develop the means of tangibly quantifying and demonstrating that the benefits of deploying an ADMS system justify the complexities of its deployment. Additionally, a

[a] http://www.whitehouse.gov/sites/default/files/microsites/ostp/nstc-smart-grid-june2011.pdf.

framework to accelerate the integration of ADMS technologies will be developed. Benefits will be examined from the perspectives of both a utility and a regulatory authority.

An ADMS system, composed of vendor tools and information systems representing the diversity of suppliers common in distribution utilities, will be assembled and integrated into a fully functional control room environment. The ADMS reference environment will be based on a reference implementation of a published interoperability standard. Once the reference environment is established, operator-in-the-loop exercises will be conducted to verify and quantify the benefits of ADMS versus traditional operational environments. The results of standard test cases, developed by the program, will be broadly dispersed to utilities and regulators. The results of these test cases will show the incremental benefit of transitioning from a traditional distribution management systems to an ADMS.

Smart Grid investments will continue to explore transactive controls (previously called market-based controls) in FY 2017. Coupling transactive control signals with electric distribution operations, generally known as transactive controls, will create value for both utilities and customers, as well as additional flexibility in the system. Depending on the results of R&D, transactive controls should allow energy use to be far more predictable, and could allow utilities to procure some control services rather than buying all the necessary equipment and exerting control through an increasingly expensive asset base. If the current electric grid were an automobile factory, every part of every car built would be made inside the factory. They would purchase every tool and piece of equipment necessary to make every part of the car, from metal to plastic to tires to fabric to radio. It makes for a reliable, but very expensive and inefficient factory. With transactive controls, the utility will perform some activities with assets it owns and operates, and accomplish additional functions through out-sourcing, much the way any modern automobile manufacturer operates today with factories and an extensive supplier network. The difference between the car manufacturing metaphor and the electric grid is that the product (electricity) is made, controlled and distributed every second of every day, which presents unique challenges pursued through this R&D program. This new control paradigm will enable utilities to balance supply and demand at all levels of the grid, by actively seeking 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.

Transactive Control Signal activities in FY 2017 include enhancing simulation tools and generating test cases, as well as validating tools using the initial test cases that were developed under Recovery Act 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. Transactive control approaches are being considered as potential solutions to grid challenges in California, New York, Texas and the Northwest. R&D in this area will help guide early pilots and expand their applicability to additional areas of the country.

Smart Grid will expand investments in activities to achieve the DOE 2020 microgrid performance targets and community-specific objective for electric system resiliency. Quantitative microgrid performance targets in reliability, emissions reduction, energy system efficiency, and cost effectiveness, as well as associated R&D needs, were formulated with engagement of a broad range of stakeholder groups.[a] FY 2017 Microgrid R&D activities will continue foundational R&D by national laboratories, including integrating microgrid controllers with distribution management systems to advance microgrid/grid system functionalities in energy management, protection and control, resiliency, ancillary services, and data management. An FY 2017 Funding Opportunity Announcement (FOA) will competitively award those among the industry partnership projects (established through the FY 2014 FOA on Microgrid Research, Development, and System Design) to advance into the field demonstration/implementation phase. Ongoing partnerships with Massachusetts and New York on

[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.

microgrid deployment will continue. In aggregate, these activities aim toward achieving the end state of having an integrated network of multiple microgrids as a building block for the smarter grid of the future.

Finally, resilient Electric Distribution Grid R&D activities in FY 2017 continue to support the Department's crosscutting Grid Modernization Initiative, which contributes to achieving the Initiative's outcome of a 10 percent reduction in the economic costs of power outages by 2025. Two multi-year national laboratory projects were awarded through the FY 2015 Grid Modernization Laboratory Consortium (GMLC) Research Call to develop decision support tools for use by distribution utilities, with one in system design/planning and the other in system restoration. The design/planning tool prototype will advance into the testing and demonstration phase in FY 2017 and the restoration tool will expand its capabilities to provide optimal recovery from all known extreme weather hazards. Also, through the Local Electricity Delivery Infrastructure FOA, FY 2017 awards will build upon the previous Resilient Electricity Delivery Infrastructure FOA to establish partnerships with U.S. cities and utilities to deploy smart grids and microgrids for climate preparedness and resilience that use multiple generation sources, storage, electric vehicles, distributed resources, etc., with the goal of maximizing resilience and other technical and financial benefits by taking advantage of multiple value streams.

The Smart Grid program is included in the Department's Grid Modernization Initiative crosscut.

Smart Grid Research and Development
Funding ($K)

	FY 2015 Enacted	FY 2015 Current[a]	FY 2016 Enacted	FY 2017 Request	FY 2017 vs FY 2016
Smart Grid Research and Development	**15,439**	**14,930**	**35,000**	**30,000**	**-5,000**

SBIR/STTR:

- FY 2015 Transferred: SBIR: $448; STTR: $61
- FY 2016 Projected: SBIR: $1,050; STTR: $158
- FY 2017 Request: SBIR: $960; STTR: $135

Smart Grid Research and Development
Explanation of Major Changes ($K)

	FY 2017 vs FY 2016
The FY 2016 appropriations included Congressional direction of $5,000,000 for development of advanced, secure, low-cost sensors that measure, analyze, predict, and control the future grid during steady state and under extreme conditions. Work related to low-cost sensors is completed using funding provided in FY 2016.	**-5,000**

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

Activities and Explanation of Changes

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
Smart Grid Research and Development $35,000,000	**$30,000,000**	**-$5,000,000**
• Award new projects in networked microgrid R&D through a laboratory call to achieve full integration of a network of multiple microgrids with distribution systems. • 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; prototyping design support tools for remote off-grid microgrids (AC and DC); and utilizing microgrids as a grid resource for reliability and resilience. • Support national laboratory R&D projects awarded through the Grid Modernization laboratory call for development of a design tool and system restoration tool to enhance distribution grid resilience against extreme weather hazards. • Continue to support the Resilient Electricity Delivery Infrastructure projects by providing technical assistance from national labs to awarded U.S. cities and tribal communities. • Develop the specifications for an open source ADMS platform for interconnection and interoperability with various systems and applications. • 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.	• Integrate microgrid controllers with distribution management systems to meet the functional requirements defined in the DOE guidelines document. • Competitively down select projects, among the seven awarded through the FY 2014 FOA, to proceed to field demonstrations of microgrid system designs with advanced controllers to verify and validate achievement of the DOE 2020 microgrid performance targets under real-world conditions. • Competitively down-select a national laboratory project, from the two projects awarded through the FY 2015 research call, to test and validate the performance of the developed design support tool and provide technical assistance to a remote community in Alaska (up to $1,000,000) on the use of the tool. • Support national labs to conduct laboratory testing of resilient distribution grid tools (one for system design and planning, and one for system restoration) that were developed through the FY 2015 Grid Modernization lab call.	• The reduction reflects one-time funding in FY 2016 to develop advanced, secure, low-cost sensors that measure, analyze, predict, and control the future grid during steady state and under extreme conditions.

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
• 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. • Establish a standard means of quantifying the value of various grid services and determining the net value provided by the distributed assets. • Develop control algorithms for end-use devices (water heaters, refrigerators, clothes dryers, and variable speed drives) to respond to transactive control signals for the provision of ancillary services. • Evaluate transactive approaches developed by research organizations and industry, and enhance existing simulation and modeling tools to attain stable, predictable response with increased efficiency. • Supports one-time funding to develop advanced, secure, low-cost sensors that measure, analyze, predict, and control the future grid during steady state and under extreme conditions.	• Based on the specifications established in FY 2016, develop an integration platform, based on open source interoperability standards and advanced mathematical models at the distribution and transmission levels, to integrate the applications, test cases, and local inputs (e.g., weather, power flow, and asset conditions) to form a fully functional ADMS environment. ▪ Utilize the environment to validate the benefits of ADMS capabilities that vendors can use to accelerate bringing ADMS to the market, that utilities can use to justify investments, and as the basis for training exercises for operators. ▪ Improve the ability to model and run simulations of distributed controls and distributed (local) markets that leverage locational time-varying values. ▪ Ensure that emerging distributed energy resources (DER) and distribution control standards are being developed with the necessary attributes to embrace market-based options as they mature, including security. ▪ Employ advanced simulations to evaluate stability of transactive control solutions in high DER scenarios, on time scales that are supported by existing technology.	

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 2015	FY 2016	FY 2017
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	Complete development of a prototype Microgrid Design Toolset that is used by at least one A&E firm for microgrid design analysis.	Release the first generation of a microgrid controller (i.e., Complete System-Level Efficient and Interoperable Solution for Microgrid Integrated Controls, also known as CSEISMIC 1.0) with full documentation of the architecture, device controllers, and a use case with a distribution management system.	Complete development of a design support tool that is used by at least one remote community for designing an AC or DC microgrid for off-grid applications
Result	Met	Not Applicable	Not Applicable
Endpoint Target	Achievement of a self-healing and resilient distribution grid, with integration of networked microgrids and transactive 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 nation-state level threats to the United States. Reliable and resilient energy infrastructure is essential to our economy, health, safety, and national security. Energy delivery system cybersecurity is 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. 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 (of activities such as data exfiltration) and information sharing to reduce cyber risk. 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 energy sector utility owners, operators, and vendors 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 activities with four key objectives:

- researching technologies to improve energy reliability and resilience;
- accelerating information sharing to enhance situational awareness;
- expanding implementation of the Cybersecurity Capability Maturity Models and Risk Management Process;[b] and
- developing innovative solutions for reconstitution after a large-scale cyber event.

OE's mission to modernize the electric grid cannot be achieved without the research, development, demonstration, and integration of secure energy delivery control systems. The FY 2017 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. This roadmap is being updated in FY 2016.

CEDS maintains a research, development, and demonstration portfolio that includes long-, mid-, and short-term efforts that address the energy sector's Roadmap milestones. 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 transition of long-term innovative

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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

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 2017 Budget Request

The FY 2017 request reflects the critical need to accelerate and expand efforts to strengthen the energy infrastructure against cyber threats and mitigate vulnerabilities. Working closely with the Energy Sector and our government partners, the request includes a continued focus in the following key areas:

- Researching, developing, and demonstrating cutting-edge cybersecurity solutions.

  DOE works in partnership with the energy sector toward the Roadmap vision of resilient energy delivery systems designed, installed, operated and maintained to survive a cyber-incident while sustaining critical functions.

  - ✓ The FY 2017 request supports a competitive solicitation for energy sector-led R&D that strengthens energy delivery control system cybersecurity, addressing legacy energy delivery control system infrastructure as well as the continuing introduction of new power system technologies; a competitive research call for national laboratory high-risk/high-payoff energy delivery control system cybersecurity research, and mid-term R&D that will also strengthen and maintain core capabilities for the energy sector. Research areas could include technologies or techniques that identify, encapsulate, and remove undesired functionality that has been inserted into an energy control system or component at some point along the supply chain.

- Accelerating information sharing to enhance situational awareness.

  In partnership with industry, OE supports the Cybersecurity Risk Information Sharing Program (CRISP), a collaborative effort with private energy sector partners to facilitate the timely sharing of threat information and the deployment of situational awareness tools to enhance the sector's ability to identify threats and coordinate the protection of critical infrastructure. In August 2014, the North American Electric Reliability Corporation (NERC) and the Electricity Subsector Coordinating Council (ESCC) agreed to manage CRISP for its sector. As of summer 2015, 20 companies have signed contracts with NERC and 8 more are scheduled to join by the end of the year.

  - ✓ The FY 2017 request supports the next CRISP Operational Pilot, focused on improving the enrichment of the participant data with U.S. Government information and increasing the speed of near-real-time sharing.

- Expanding implementation of the Cybersecurity Capability Maturity Models and Risk Management Process.

  DOE worked with the Department of Homeland Security, the National Institute of Standards and Technology, and industry to develop the Cybersecurity Capability Maturity Model (C2M2) to encourage adoption of best practices and to inform cybersecurity investment decisions. The Department also worked with industry on the creation of a Risk Management Process (RMP), which enables organizations to apply effective and efficient risk management processes and tailor them to meet their organizational requirements.

  - ✓ The FY 2017 request supports expanding the implementation of the C2M2 and RMP. The program will continue to expand the utility volunteers to demonstrate C2M2 data analytics and benchmarking methodologies, building on existing benchmarking work and laying the foundation for the C2M2 web portal.

- Developing innovative solutions for reconstitution after a large-scale cyber event.

  The Department will be leading an effort to develop an effective, timely, and coordinated reconstitution capability in the energy sector. In collaboration with the government and industry partners, DOE will be leveraging governmental and non-governmental resources to create solutions that will support the continuity of essential operations for the energy sector under a large-scale cyber event focused on restoration.

  - ✓ In FY 2017, the program will begin the development of innovative solutions to use for reconstitution after a large-scale cyber event.

- Completing implementation of the Virtual Energy Sector Advanced Digital Forensics Analysis Platform.

  The platform is a virtual collaborative environment for conducting real-time, advanced digital forensics analysis for the energy sector. Sometimes referred to as a sandbox, it is often used to execute untested code and programs from unverified third-parties, suppliers, untrusted users, and websites without allowing the software to harm the host device. This two-year project, starting in FY 2016, will create a virtual environment that allows analysts to safely execute and inspect malware, zero-day vulnerabilities, and advanced threats. A fair and open competitive procurement process will be followed.

  - ✓ In FY 2017, the program will complete implementation of and participation in the project, after which it will be transitioned to the private sector, with a goal to become self-sustaining.

The CEDS program is included within the Department's Grid Modernization Initiative and Cybersecurity crosscuts.

Cybersecurity for Energy Delivery Systems
Funding ($K)

	FY 2015 Enacted	FY 2015 Current[a]	FY 2016 Enacted	FY 2017 Request	FY 2017 vs FY 2016
Cybersecurity for Energy Delivery Systems	**45,999**	**44,756**	**62,000**	**45,500**	**-16,500**

SBIR/STTR:

- FY 2015 Transferred: SBIR: $1,092; STTR: $151
- FY 2016 Projected: SBIR: $1,050; STTR: $158
- FY 2017 Request: SBIR: $960; STTR: $135

Cybersecurity for Energy Delivery Systems
Explanation of Major Changes ($K)

	FY 2017 vs FY 2016
• The Virtual Energy Sector Advanced Digital Forensics Analysis Platform is reduced from $10,000,000 to $5,000,000 in FY 2017. In FY 2017, the program will complete implementation and begin transitioning to the private sector.	-16,500
• Incident management is moved to Infrastructure Security and Energy Restoration (ISER) in FY 2017, a $1,500,000 decrease. ISER will provide a comprehensive response to incidents.	
• The $5,000,000 provided in FY 2016 is the third and final year of funding for development of the industry-scale electric grid test bed.	
• The $5,000,000 provided in FY 2016 to develop cyber and cyber-physical solutions for advanced control concepts for distribution and municipal utility companies is one-time funding that is not continued in FY 2017.	

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

Activities and Explanation of Changes

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
Cybersecurity for Energy Delivery Systems		
$62,000,000	**$45,500,000**	**-$16,500,000**
Research & Development		
• 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. • 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.	• Issue a competitive solicitation for energy sector-led R&D that strengthens energy delivery control system cybersecurity, addressing legacy energy delivery control system infrastructure as well as the continuing introduction of new power system technologies. • Issue a competitive research call for National Laboratory high-risk/high-payoff energy delivery control system cybersecurity research, and mid-term R&D that will also strengthen and maintain core capabilities for the energy sector. Research areas could include technologies or techniques that identify, encapsulate and remove undesired functionality that has been inserted into an energy control system or component at some point along the supply chain.	• R&D funding is unchanged from FY 2016.

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
Cybersecurity Operations (C2M2, CRISP and Incident Management)		
• Continue to fund the CRISP classified analytic and reporting functions. • Issue a competitive solicitation to identify commercially available technologies and services to enhance CRISP capabilities. • Expand online access to the C2M2 and RMP tools and conduct benchmarking and data analytics. • Enhance situational awareness with relevant local and Federal agencies and informational analysis centers through information sharing development and practicing regional cybersecurity incident response communications.	• Expand the utility volunteers to demonstrate C2M2 data analytics and benchmarking methodologies, building on existing benchmarking work and laying the foundation for the C2M2 web portal. • Establish another CRISP Operational Pilot focused on improving the enrichment of the participant's data with U.S. Government information and increase the speed of real-time sharing. • Begin the development of innovative solutions to use for reconstitution after a large-scale cyber event.	• Incident management is moved to ISER in FY 2017 to provide a more comprehensive response to incidents.
Virtual Energy Sector Advanced Digital Forensics Analysis Platform		
• 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 2017 is the second year of a planned two-year implementation, after which the platform will be transitioned to the private sector, with a goal of it becoming self-sustaining.
Wireless Testbed		
• Continue development of the industry-scale electric grid test bed.	• No activities.	• This effort is completed in FY 2016.
Advanced Control Concepts		
• Develop cyber and cyber-physical solutions for advanced control concepts for distribution and municipal utility companies.	• No activities.	• This one-time funding is not continued in FY 2017.

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 2015	FY 2016	FY 2017
Performance Goal (Measure)	**Cybersecurity**—Demonstrate new protective measures to reduce risks from cyber incidents.		
Target	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	Demonstrate a tool that establishes a tailored trustworthy space for one substation control system component
Result	Met	Not Applicable	Not Applicable
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 develop 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 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 grid 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 need for grid-scale energy storage projects throughout the country is growing. 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.

To maximize the benefits of energy storage, research and development will address four areas:

- Cost Competitive Energy Storage—Develop material and system enhancements to resolve key cost and performance challenges with respect to novel flow, lithium, sodium, magnesium, and thermo-electrochemical 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 safer and 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, 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.

Highlights of the FY 2017 Budget Request

Energy storage is a key component for the development of a clean and cost-effective future grid. The FY 2017 request supports work on materials research, device development, demonstrations, and grid analysis. Efforts, in collaboration with industry, states, and other Federal agencies, align with the needs identified in the Quadrennial Energy Review and Quadrennial Technology Review. Activities are also planned under the Grid Modernization Initiative cross cutting technical areas focusing on design and planning tools and institutional support. The development of new models for industry standard planning tools that can optimize the size, location, and use of energy storage assets can speed adoption of energy

[a] Grid Energy Storage:
http://energy.gov/sites/prod/files/2013/12/f5/Grid%20Energy%20Storage%20December%202013.pdf

storage by providing a quantifiable revenue return. The Energy Storage program will initiate 3–4 highly leveraged collaborative demonstration projects with states, regional entities, and utilities through a funding opportunity announcement (FOA). Detailed cost-benefit analyses will be conducted in order to provide end users a complete value proposition under local use conditions. These studies will also provide owners with optimal control strategies to ensure the most cost effective deployment of the storage assets.

Storage system R&D, which has been successful in developing technology for reducing costs while improving performance and lifetimes, will focus on new electrochemical systems and improved power conversion technologies. In particular, the Energy Storage program will focus on the identification and development on a new aqueous soluble organic (ASO) redox-flow chemistry that can replace vanadium-based electrolytes, reducing system costs by half. Additional redox flow battery research efforts will support the continued development of organic and inorganic based multi-valent redox couples, novel separator materials, and zinc-iodine hybrid flow systems. Promising new laboratory electrochemical systems based on low-cost iron and sodium metal chemistries will be demonstrated in commercially relevant storage systems that meet the safety and cost targets required for wider scale deployment. A new FOA will be issued to support early stage university research aimed at discovering the next generation of chemistries and systems, facilitating a continued development pipeline leading to lower cost, safer, and more reliable energy storage systems. Finally, the re-use of electric and plug-in hybrid vehicle batteries for grid-scale energy storage will be evaluated in field-deployed stationary applications.

Power conversion systems (from direct current to alternating current) are considered a key enabling technology for grid-connected energy storage systems. The program will continue to develop advanced semiconductor switches, magnetics, capacitors, thermal management, and packaging that allow for considerable reduction in size as well as expanded operating range to increase the overall power conversion efficiency and power density by 30 percent. New R&D activities will be initiated to integrate and test advanced semiconductor devices and passive materials in prototypical energy storage systems

Safety and reliability are cornerstones to the acceptance of new technologies. The 2014 Energy Storage Safety Strategic Plan identified the key developmental areas required for the safe deployment of energy storage, leading to the formation of an Energy Storage Safety Working Group composed of utilities, vendors, regulatory agencies, and underwriters.[a] In FY 2017, the Energy Storage program's goals will expand to include reliability efforts focused on development of accelerated testing metrics for energy storage and power conditioning systems. With DOE's leadership, an annual Energy Storage Safety and Reliability Forum will be initiated with key stakeholders to accelerate the safe and reliable deployment of energy storage. This effort will support a coordinated series of projects to assess potential failure modes, prepare mitigation measures, and develop guidelines for operation and incident preparedness. In addition, OE will continue to establish and test grid energy storage standards for performance and grid interconnection, and to promulgate these standards internationally to facilitate deployment of U.S. storage technologies domestically and abroad.

To facilitate a more equitable regulatory environment for energy storage, the program will support new efforts with utility regulators and industry to develop analysis tools for integrated resource planning that accurately value the services energy storage can provide. Critical to this effort is the development of analytic tools and uniform model standards for energy storage that can accommodate regional diversity and risk attributes of energy storage along with primary, secondary and tertiary value stream recognition.

Optimal use of energy storage technologies, validation of performance, and analysis of regional use-cases are critical to enable further deployment of energy storage and accelerate acceptance of these new technologies by industry. The Energy Storage program will continue to support collaborative test-bed and field trial evaluation of new storage technologies in conjunction with states, utilities, and storage providers in order to elucidate energy storage benefits, understand integration challenges and opportunities, and build confidence in the safety and performance of deployed technologies. The new FY 2017 demonstration projects will provide a more comprehensive analysis of regional use-cases and value recognition for energy storage systems. Information from these highly leveraged demonstrations projects will help guide new design tools for utilities, regulators, and developers.

The Energy Storage program is included within the Department's Grid Modernization Initiative crosscut.

[a] Energy Storage Safety Strategic Plan:
http://energy.gov/sites/prod/files/2014/12/f19/OE%20Safety%20Strategic%20Plan%20December%202014.pdf

Energy Storage
Funding ($K)

	FY 2015 Enacted	FY 2015 Current[a]	FY 2016 Enacted	FY 2017 Request	FY 2017 vs FY 2016
Energy Storage	**12,000**	**11,604**	**20,500**	**44,500**	**+24,000**

SBIR/STTR:

- FY 2015 Transferred: SBIR: $348; STTR: $48
- FY 2016 Projected: SBIR: $615; STTR: $92
- FY 2017 Request: SBIR: $1,424; STTR: $200

Energy Storage
Explanation of Major Changes ($K)

	FY 2017 vs FY 2016
The FY 2017 Request will expand technical assistance and collaborative activities with states and regions to include initiating 3–4 new highly leveraged, cost-shared demonstrations (DOE's share is approximately $2 million per demonstration, with a 50% cost-share requirement); facilitating adoption of energy storage valuation models into commercial grid planning tools; and refining techno-economic valuation models.	**+24,000**
The Request will also support new university R&D activities targeted toward new, more cost-effective chemistries and materials, advanced power electronics, and conduct system performance and evaluation. $2,000,000 is planned for this effort.	

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

Activities and Explanation of Changes

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
Energy Storage $20,500,000	**$44,500,000**	**+$24,000,000**
• Accelerate development of next generation redox flow batteries (RFBs), with significant potential to provide lower cost systems. • 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. • Provide enhanced tools and data to U.S. industry for development and use of grid-scale batteries. • Organize a Stationary Energy Storage Reliability workshop with industry, developer, and utility stakeholders. • Demonstrate various capabilities and optimization of Distributed Energy Storage System aggregation in large-scale electrical distribution model. • Develop characterization methods, test procedures, and understanding of failure and degradation phenomena enabling improved design and accelerated aging tests. • Develop industry standards for safety, reliability, testing and evaluation, and promulgation to international standards bodies. • Support and organize quarterly Energy Storage Safety Forum meetings for the energy storage community to increase acceptance of storage technologies. • Continue development of power conversion systems (primarily power electronics) specifically for grid energy storage applications.	• Continue development and accelerate validation of next generation RFBs through industrial partnering with enhanced safety and reliability testing. • Support regional grid-scale testing and field evaluations with states, utilities, and storage providers to elucidate energy storage economic and technical benefits, understand grid integration and performance issues, and implement safety and performance protocols. • Incorporate and validate enhanced planning and evaluation tools for energy storage into commercially relevant distribution level planning models. Assess strategies for incorporation of storage tools for transmission planning. • In collaboration with industry, establish an Energy Storage Reliability and Safety Initiative to support accelerated testing, characterization, and analysis of commercially relevant, grid-scale energy storage systems. • Working with utilities, regulators and industry, develop analysis tools for integrated resource planning to accurately value the services energy storage can provide. Development of analytic tools and uniform model standards for energy storage which can accommodate regional diversity and risk attributes of energy storage along with primary, secondary and tertiary value stream recognition	• Supports the transition of selected energy storage technologies from R&D to industrially relevant scales, safety, and costs. • Focuses R&D efforts on prototyping new aqueous soluble organic flow battery chemistries capable of halving the cost relative to the current vanadium/vanadium (V/V) technology. • Initiates 3–4 new highly leveraged, cost-shared demonstrations encompassing 8MW+ of energy storage assets. Working with states, utilities, and storage providers, detailed cost benefit relationships for storage under local market conditions will be determined and disseminated in public reports. • Supports initial development of energy storage valuation models into commercial grid planning tools • Expands the Energy Storage Safety Forum to include reliability efforts focused on development of accelerated testing metrics for energy storage and power conditioning systems. The expanded Forum will include national and international energy storage communities to facilitate adoption of U.S. codes, standards, and technologies. • Refines techno-economic valuation models for energy storage and offers enhanced tools to regulators, utilities, and developers. • Develops energy storage valuation tools for regulators.

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
• Perform analysis to select best carbon fiber product for flywheel production and application. • Conduct a technical and economic feasibility study for a load-leveling energy storage system, partnering with the city of Cordova, Alaska, and the Alaska Center for Energy and Power ($250,000)	• Conduct preliminary techno-economic analysis on potential demonstration sites for aggregated distributed energy storage systems. • Demonstrate potential for 2nd use lithium-ion battery systems for residential and commercial applications. • Develop industry standards for safety, reliability, testing and characterization of various energy storage technologies, and promulgation to international standards. • Continue to support Energy Storage Safety Forum meetings for the energy storage community nationally and internationally to increase acceptance of energy storage technologies and deployment. • Increase power conversion system performance for grid-tied energy storage systems applications. • Support industrial deployment of next generation flywheel technology with new carbon fiber reinforced nanoparticles.	• Develops standards for characterization, testing, safety, and reliability for advanced flywheel and electrochemical capacitors. • Furthers secondary battery use in a socially responsive application with potential for extensive replication. • Increased R&D activities include system performance evaluation using advanced semiconductor and passive materials. • Initiates transfer of carbon fiber reinforcement technology development at the national labs to industry.

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 2015	FY 2016	FY 2017
Performance Goal (Measure)	**Energy Storage**—Lower the cost of grid-scale (over 1 MW) energy storage technologies.		
Target	325 $/kWh for a 4 hour system (vanadium/vanadium electrolyte)	300 $/kWh for a 4 hour system (vanadium/vanadium electrolyte)	Target will transition to new aqueous soluble organic flow systems. $350/kWh for a 4 hour system (aqueous soluble organic electrolyte)
Result	Met	Not Applicable	Not Applicable
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 **R**esilience and Advanced Components (TRAC) program supports modernization and resilience of the grid by addressing the unique challenges facing transformers and other critical components (i.e., grid hardware) that are responsible for carrying and controlling 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. Development of advanced components will provide the physical capabilities required in the future grid and help avoid infrastructure lock-in with outdated technologies that are long-lived and expensive.

Transformers, power lines, and substation equipment are often exposed to the elements and are vulnerable to an increasing number of natural and man-made threats. To ensure a reliable and resilient electric power system, next-generation grid hardware needs to be designed and built to withstand and recover from the impact of lightning strikes, extreme terrestrial or space weather events, electrical disturbances, accidents, equipment failures, deliberate attacks, and other unknowns. Approximately 70 percent of large power transformers (LPTs) are 25 years or older, 60 percent of substation 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 critical components can lead to widespread outages and long recovery times.

Expanding on concerns of ground-induced currents (GIC) from solar flares, the TRAC program addresses challenges associated with geomagnetic disturbances (GMD), electromagnetic pulses (EMP), and other physical stresses on transformers and grid components in a systematic and comprehensive manner, in close cooperation with equipment manufacturers and electricity asset owners and operators. Greater deployment of distributed generation and distributed energy resources is introducing new challenges with reversed power flows, increased harmonics, and larger fault currents that can impact the reliability and lifetimes of current-generation grid hardware. The TRAC program will increase the resilience of aging grid assets, identify requirements for next-generation grid hardware, and accelerate the development, demonstration, and deployment of advanced components.

Highlights of the FY 2017 Budget Request

FY 2017 activities support the Administration's strategy on resilience and physical security, and align with the outcomes of the 2015 Quadrennial Technology Review (QTR). Following FY 2016 work on improving the understanding of transformer vulnerabilities to GMD and EMP, OE will examine failure mechanisms and characterize risks to a broader set of critical grid components and technologies, such as circuit breakers and relays, from these threats through multi-physics modeling and physical testing. Assessment and development of stress mitigation options, such as improved asset monitoring capabilities, will enhance the portfolio of solutions needed to increase system security, reliability, and resilience.

Activities will also support the development of next-generation transformer prototypes based on design work and simulations conducted in FY 2016. Next-generation transformer designs, such as hybrid and solid-state concepts, can provide power flow control capabilities and increase system resilience. These advanced transformers will enable more flexible and adaptable designs that are interoperable with legacy systems and facilitate transformer sharing between utilities in the event of component failures. Development of these systems can reduce the criticality of substations, optimize power flows, and enable buffering of local grids for higher reliability.

The TRAC program is included within the Department's Grid Modernization Initiative crosscut.

Transformer Resilience and Advanced Components
Funding ($K)

	FY 2015 Enacted	FY 2015 Current[a]	FY 2016 Enacted	FY 2017 Request	FY 2017 vs FY 2016
Transformer Resilience and Advanced Components	**0**	**0**	**5,000**	**15,000**	**+10,000**

SBIR/STTR:

- FY 2016 Projected: SBIR: $150; STTR: $22
- FY 2017 Request: SBIR: $480; STTR: $68

Transformer Resilience and Advanced Components
Explanation of Major Changes ($K)

	FY 2017 vs FY 2016
The increase reflects a more comprehensive approach to assessing system vulnerabilities to GMD and EMP and the development of mitigation solutions. Additionally, activities will focus on next-generation transformers to fill a crucial gap identified through the 2015 QTR. Research efforts will address the unique challenges associated with the high power levels (voltage and current), high reliability requirements (25–40 years of field operations), and high costs associated with these critical components. Federal investment will enable greater system efficiency and support higher penetration of renewables by providing inherent power flow capabilities and increase the security and resilience of the grid through new transformer designs that are more interoperable between systems.	**+10,000**

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

Activities and Explanation of Changes

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
Transformer Resilience and Advanced Components $5,000,000	**$15,000,000**	**+$10,000,000**
• Begin modeling and testing of transformers to evaluate vulnerability to GMD/EMP. • Evaluate next-generation transformer designs that are more resilient.	• Expand modeling and testing of vulnerabilities to GMD/EMP by including other critical components and technologies such as circuit breakers and relays. Increasing grid security and resilience will require a more comprehensive understanding of system vulnerabilities beyond transformers due to component interconnectivity. • Develop prototypes of next-generation transformers with enhanced flexibility and functionality. Utilities have limited ability to share transformers in the event of an emergency due to large degrees of customization; more adaptable solutions are needed.	• Increase reflects a more extensive portfolio of research and development activities to increase transformer and grid resilience.

Grid Institute

Overview

In FY 2017 the Office of Electricity Delivery and Energy Reliability will establish a Grid Clean Energy Manufacturing Innovation Institute focused on projects that facilitate the transition of innovative material processes and production technologies for grid application to industry. This institute is part of the larger multi-agency National Network for Manufacturing Innovation (NNMI). The NNMI model promotes collaboration, complements university research, and supports innovation to increase the competitiveness of U.S. manufacturers. Manufacturing Institutes are a partnership among government, industry, and academia, supported with cost-share funding from Federal and non-Federal sources. Within 5 years of its launch, the Grid Institute is expected to be financially independent and sustainable using only private-sector and other sources without further federal funding.

Industry estimates that approximately $1.1 trillion will be needed to expand, upgrade, and, as necessary, replace, the U.S. electric delivery infrastructure through 2040.[a] As the grid modernizes and aging assets are replaced, there is an opportunity to develop and deploy next-generation grid hardware that has higher performance and possesses the capabilities needed in the future grid. However, successful commercialization of advanced grid components will require materials with new physical properties and enhanced functionality. For example, the magnetic core of a solid state transformer will need to operate at higher frequencies and sustain performance at higher temperatures.

Industrial metals such as aluminum, iron, and copper are the fundamental raw materials used to build out the Nations' electricity delivery infrastructure. These metals are used in the production of underground cables, overhead conductors, transformers, and other assets that are critical to the grid. Depending on the application, various physical properties (e.g., electric, magnetic, thermal, and mechanical) must be balanced simultaneously along with cost to satisfy grid component requirements. Advances in metallurgy, nanotechnology, and materials science have enabled better control and optimization of the various properties of metals. Leveraging these advances present enormous opportunities to enhance the performance of grid components and enable future applications.

Manufacturing technologies, processes, and techniques have a direct impact on the performance and cost of metal-based materials. Improvements and connectivity to end-use applications are critical to achieving the desired properties and price points required for grid components. Technical challenges associated with adopting materials innovation to grid applications include the control of physical properties (e.g., composition, chemistry, microstructures, trade-offs, stability, and reliability) and the control of manufacturing processes (e.g., defects, strain, uniformity, anisotropy, repeatability, and scalability). There is also a large opportunity to improve the sustainability of manufacturing processes (e.g., energy consumption, input materials, waste materials, and disposal), especially with the recycling of old grid assets.

Manufacturing is critical to future U.S. innovation, global economic competitiveness, and job growth. Application of new and improved materials, technologies, and processes in the manufacturing of grid components can drive forward U.S. leadership in the development of these products, while achieving energy, environmental, and economic benefits across the economy. Advances made through the Grid Institute will be spread broadly across multiple industries and improve U.S. competitive advantage, especially for small- and medium-sized enterprises. Further, investments with universities and small- and medium-sized enterprises contribute to developing national capabilities that enable future global leadership. Supporting innovations in manufacturing also helps ensure that technologies invented in the U.S. ultimately are produced in the United States.

Highlights of the FY 2017 Budget Request

The FY 2017 request provides the first year of funding for the new Grid Institute that will be competitively selected through a funding opportunity announcement (FOA). This Institute is designed to focus on technologies related to industrial metals for grid application, but advances will be broadly applicable in multiple industries and markets. Topics on materials and

[a] "2015 Quadrennial Technology Review Technology Assessment: Transmission and Distribution Components," http://energy.gov/sites/prod/files/2015/09/f26/QTR2015-3F-Transmission-and-Distribution_1.pdf, November 2015

manufacturing innovations for grid components were informed through DOE workshops and engagement with industry stakeholders.[a] Potential topic areas for the Grid Institute include:

- Alloys (homogeneous structures)—Covetics are a relatively new class of alloy that involve nano-carbon particles fused into metal systems (e.g., aluminum, copper, gold, silver, zinc, tin, lead, and iron). These materials have enhanced properties such as lower electrical resistivity, improved thermal conductivity, and enhanced mechanical strength compared to their base metals. Electrical conductors made from copper covetics could reduce energy losses by more than 40%.
- Metal Matrix/Hybrid Composites (heterogeneous structures)—Cobalt-rich nano-composite steel has tunable magnetic properties, improved corrosion resistance, and better mechanical strength. Magnetic cores made from these materials can produce transformers that are more efficient (less core losses), more reliable (less corrosion), and possibly more compact (operation at higher frequencies).
- Metal/Hybrid Laminates (structures in discrete layers)—Laminates of different metals, alloys, and composites (metallic or non-metallic) can exhibit properties such as enhanced strength, toughness, or functionality. Large power transformers already use magnetic cores with electrical steel laminates to reduce eddy current losses. Laminates could also be applied to the housing of transformers to reduce noise, reduce weight, and increase resilience (i.e., withstand ballistic attacks).

Requests for information and additional workshops with industry, academia, and other government organizations will be used to refine the topics for the Institute, including development of quantitative technical goals and metrics. OE will work with the Office of Energy Efficiency and Renewable Energy's Advanced Manufacturing Office (AMO) to ensure consistency in the development and execution of Clean Energy Manufacturing Innovation Institutes across the Department.

[a] "Manufacturing Innovation Multi-Topic Workshop" http://www.energy.gov/eere/amo/downloads/manufacturinginnovation-multi-topic-workshop, October 2014 and "Materials Innovation for Next-Generation T&D Grid Components: Workshop Summary Report," http://info.ornl.gov/sites/publications/files/Pub59578.pdf, October 2015.

Grid Institute
Funding ($K)

	FY 2015 Enacted	FY 2015 Current	FY 2016 Enacted	FY 2017 Request	FY 2017 vs FY 2016
Grid Institute	**0**	**0**	**0**	**14,000**	**+14,000**

SBIR/STTR:

- FY 2017 Request: SBIR: $448; STTR: $63

Grid Institute
Explanation of Major Changes ($K)

	FY 2017 vs FY 2016
The Grid Institute is new in FY 2017.	**+14,000**

Grid Institute

Activities and Explanation of Changes

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
Grid Institute $0	**$14,000,000**	**+$14,000,000**
	• Establish and fund the first year of the Grid Institute as part of the National Network for Manufacturing Innovation.	• This is a new activity in FY 2017.

National Electricity Delivery

Overview

The National Electricity Delivery (NED) program helps state, regional, and tribal entities to develop, refine, and improve their programs, policies, and laws related to electricity while mitigating market failures. The scope of this activity includes facilitating the development and deployment of reliable and affordable electricity infrastructure, whether generation, transmission, storage, distribution, or demand-side electricity resources. In addition, NED implements a number of legal authorities, such as coordination of transmission permitting by Federal agencies, periodic transmission congestion studies, permitting of cross-border transmission lines, and authorization of electricity exports.

The electric industry, together with its state and Federal regulators, is currently responding to several major new challenges and opportunities, including a changing electric generation mix; new environmental rules; aging infrastructure; adoption of new technologies, such as information technologies, from generation to end-use; updating communication networks (e.g., analog to digital); accommodating new end-use technologies such as distributed resources; planning for increased interdependencies among natural gas, water, and electricity systems; and adopting new regulatory and market regimes that manage these challenges and opportunities in providing reliable and affordable electricity service. All of this must be balanced against the need for cost effectiveness, improved or sustained reliability and resiliency (physical security and cybersecurity), and system flexibility.

Highlights of the FY 2017 Budget Request

NED's electricity policy technical assistance (e.g., electricity delivery system, energy market modeling, and planning tool development) to states, regions, and tribes, which is available upon their request, helps identify high level or generally applicable approaches that encourage their development and deployment of reliable and affordable electricity infrastructure, whether generation, transmission, storage, distribution, or demand-side electricity resources, while respecting their decision-making sovereignty.

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 lower growth in electricity sales, in part due to increasing 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 new regulatory and market regimes that link utility revenues to other performance indices, but this is a complex and controversial subject that will require attention and analysis over the next several years. In FY 2017, efforts in this area include workshops and discussions to determine topics of interest to regulatory stakeholders and other related activities.

OE completed a very successful program under the American Recovery and Reinvestment Act to conduct long-term (e.g., 15–20 year) transmission plans in each of the three interconnections. The Eastern Interconnection Planning Collaborative and the Eastern Interconnection States' Planning Council, the Western Electricity Coordinating Council and the Western Governors' Association, and the Electric Reliability Council of Texas will continue to inform future transmission plans that will shape the future of the electricity grid in their respective interconnections. These activities highlighted a number of areas where technical assistance, such as planning tool development and iterative scenario gaming, is required to move the plans forward to incorporate changes identified above in the industry. The FY 2017 request includes analytical support to energy system planning and state decision-making entities to improve the quality of the plans moving forward. This work will include consideration of a number of system elements such as interdependencies (e.g., energy/water and natural gas), environmental compliance, and coordination between neighboring systems.

Additional technical and policy expertise provided to states, regions, localities, and tribal entities spans a wide variety of current and future electricity-related issues, such as:

- integration of new technologies (e.g., variable generation, smart grid, demand response, and distributed generation) into electric utility planning, operations, and regulation;
- effects of increasing shale gas production and reducing base load coal and nuclear generation on utility resource planning and transmission requirements;
- implications of complex interdependencies (e.g., gas/electric and energy/water) germane to electric utility planning, operations, and regulation;

- state mandates for clean energy and energy efficiency;
- new approaches to transmission planning;
- implications relating to how utilities operate in response to evolving markets;
- grid architecture (including not only wire but the communication and control systems necessary to maintain and operate the electricity delivery systems), valuation, and distribution system planning
- management of risks (e.g., electricity policy uncertainty, changing markets, and extreme weather) by state electricity regulators and other state officials; and
- potential effects of Environmental Protection Agency regulations on electricity system reliability.

These activities will result in the development of relevant tools as an important enabler for state regulators, utility executives, and other stakeholders to make better informed decisions about their respective elements of the electricity system.

Analytical tools that can inform regulatory decisions fall into several broad areas: grid architecture, resource adequacy, system planning, grid operations and interactions, valuation of technologies in context of a given system, finance, and markets, including rate designs. Wherever possible, development of new tools should build on what is currently available and familiar to decision-makers and stakeholders.

In FY 2017, NED will continue to work with stakeholders to identify tools and other resource needs and then work with experts, including from the national laboratories, industry, and universities, to develop and/or enhance tools and other resources to help facilitate better-informed decision-making.

To implement OE's legal responsibilities surrounding the Nation's electricity infrastructure, NED carries out a range of activities that include:

- preparing and publishing DOE's annual *Transmission Data Review*
- conducting environmental review and technical analyses needed for Federal authorization of transmission projects that cross the U.S. international borders;
- coordinating Federal permitting by other agencies of new transmission infrastructure that involves Federal authorizations, 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.

NED will continue to support DOE's efforts associated with the Quadrennial Energy Review (QER). Since the release of the QER 1 report in April 2015, NED has participated in multiple workshops to develop legal, regulatory, and policy roadmaps for harmonizing regulations across international borders.

The NED program is included within the Department's Grid Modernization Initiative crosscut.

National Electricity Delivery
Funding ($K)

	FY 2015 Enacted	FY 2015 Current	FY 2016 Enacted	FY 2017 Request	FY 2017 vs FY 2016
National Electricity Delivery	**6,000**	**6,000**	**7,500**	**6,500**	**-1,000**

National Electricity Delivery
Explanation of Major Changes ($K)

	FY 2017 vs FY 2016
The decrease in funding results in fewer states and tribes receiving technical assistance.	**-1,000**

National Electricity Delivery

Activities and Explanation of Changes

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
National Electricity Delivery $7,500,000	**$6,500,000**	**-$1,000,000**
• Expand suite of tools for grid scenario discussions at the Federal, state and local levels. • Provide technical assistance on electricity-related topics, upon request, to states, public utility commissions, tribes, and other regional and Federal entities. • Conduct studies related to Performance Based Regulation (by states) and grid planning in the Eastern and Western Interconnections. • Implement Integrated Interagency Pre-application process to improve Federal permitting of transmission infrastructure pursuant to section 216(h). • Conduct activities leading to publishing the triennial *National Transmission Congestion Study*.	• Maintain the suite of tools for grid scenario discussions at the Federal, state, and local levels. • Provide technical assistance on electricity-related topics, upon request, to states, public utility commissions, tribes, and other regional and Federal entities. • Implement statutory requirements pursuant to section 216(h) of the Federal Power Act • National review of transmission plans and assess barriers to their implementation • Produce white papers on key subjects relating to Regulated Utility Business Models	• Tool development is delayed • Fewer states and tribes receive technical assistance • Congestion study activities are not required in FY 2017

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 2015	FY 2016	FY 2017
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	40 states/tribes assisted	50 states/tribes assisted	45 states/tribes assisted
Result	Met	Not Applicable	Not Applicable
Endpoint Target	Increased access to reliable, affordable and sustainable energy sources.		

State Distribution-Level Reform Program

Overview

There is broad recognition today that the electricity sector is undergoing a major transformation. Much of this change is occurring at the distribution level where utilities and other entities are working at the consumer-utility intersection to offer consumers products and services to help them reduce their electricity costs and obtain new kinds of benefits from the use of electricity. Several states have embarked on major efforts to reform the regulatory frameworks for their distribution sectors, leveraging OE support. The common theme among their efforts is the need to "unlock new sources of value" that are latent in the existing framework, while preserving or enhancing traditional values such as reliability and affordability.

This program will assist states, through competitive awards, with identifying and addressing issues related to undertaking reforms whether they are structural, policy, or regulatory in nature. While OE already provides high-level policy and technical expertise to states, this support will allow state officials to utilize DOE's national laboratories, associated academic institutions, and other subject matter experts to develop targeted solutions to discrete issues that are too situation specific to be addressed as part of OE's core functions.

The awards will be competitively awarded based upon criteria to be established in the associated funding opportunity announcement. Subject to the requested funding being available, each executed agreement will be fully funded at the time of execution with an associated performance period of two years.

Highlights of the FY 2017 Budget Request

State legislators and regulators looking to transition from traditional to future grid designs may need to examine not only the wire portion of the electricity delivery system but the control and communication systems that are necessary to achieve its reliable operation. Grid architecture includes identifying how market participants communicate and are coordinated, determining the data sharing and system control requirements, examining requirements for regulations and rules as the distribution grid becomes a platform for multi-directional power flow and financial transactions, and examining the role of a distribution systems operator (DSO) and how a DSO would interface with the bulk system operator. The technical assistance provided by OE will involve system analysis to ensure that the integration of distribution energy resources and new markets is accommodated through appropriately designed business and regulatory processes.

The states that are currently wrestling with distribution-level reform will likely find themselves addressing a wide range of challenges:

- rate design—how to send more informative price signals to consumers and other sector participants;
- rules to ensure consumer access to technologies and services—what is the appropriate (state) government role;
- distribution system planning—the utility has to lead the process, but it must be open and inclusive; analytic methods and tools are needed for dealing with uncertainties and how to deal with externalities (climate, environmental, and other);
- optimizing linkages between wholesale and retail markets;
- new regimes and protocols for data access and data sharing, as an essential enabler for achievement of many potential benefits;
- development of broadly-accepted benefit/cost methodologies;
- development of a platform for competition among non-regulated or loosely-regulated grid-edge companies;
- new or updated regulatory compacts for utilities; and
- protections for low/moderate income customers and other vulnerable groups.

The Distribution-Level Reform program will competitively award 5–10 awards to states for a two-year performance period to address these system challenges.

The State Distribution-Level Reform Program is included within the Department's Grid Modernization Initiative crosscut.

Benefits

In the new paradigm that is emerging at the distribution level, the distribution utility may have a more active role on the consumer-side of the meter as well as planning, building, and operating the distribution network. The utility would also provide price signals and other indicators to consumers and companies working at the consumer-utility intersection about where various kinds of non-utility-owned technological devices would add value to the functioning of the grid. The

components of this grid would be highly interactive, and this data-informed interactivity would enable higher levels of asset utilization than is achievable in today's networks.

Achieving an effective design in any given geographic area will require governmental leadership (Federal and state), technological and analytic expertise, and collaboration among many stakeholders. The states are well positioned to play important leadership roles, and would benefit from the assistance that the proposed program could provide.

State Distribution-Level Reform Program
Funding ($K)

	FY 2015 Enacted	FY 2015 Current	FY 2016 Enacted	FY 2017 Request	FY 2017 vs FY 2016
State Distribution-Level Reform Program	**0**	**0**	**0**	**15,000**	**+15,000**

State Distribution-Level Reform Program
Explanation of Major Changes ($K)

	FY 2017 vs FY 2016
The State Distribution-Level Reform Program is new in FY 2017.	**+15,000**

State Distribution-Level Reform Program

Activities and Explanation of Changes

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
State Distribution-Level Reform Program $0	**$15,000,000**	**+$15,000,000**
	• 5–10 awards (awarded competitively for a two-year performance period). • State application of grid architecture to understand the interactions of market designs, regulated utility business models, regulations, and control and coordination mechanisms to ensure a successful transformation in grid design. • Examining methods and sharing tools to assist in distribution system planning, especially to enable the integration of distributed energy resources into the grid. • Developing and sharing approaches to enable the valuation of grid resources that can be used in distribution markets. • Conducting studies that examine approaches for incentivizing performance and applying alternative rate designs.	• This is a new activity in FY 2017.

Infrastructure Security and Energy Restoration

Overview

The Infrastructure Security and Energy Restoration (ISER) program enables the security and resilience of the Nation's energy infrastructure (electricity, petroleum, and natural gas) through implementation of the National Preparedness System to assist the whole of government to achieve the National Preparedness Goal: a secure and resilient Nation with the capabilities required across the whole community to prevent, protect against, mitigate, respond to, and recover from the threats and hazards that pose the greatest risk.

OE/ISER is the DOE office responsible for executing DOE's Energy Sector Specific Agency (SSA) role, executing DOE's Emergency Support Function-12 (ESF-12) (Energy) role, and providing DOE's support to the Infrastructure Systems Recovery Support Function (IS-RSF).[a] ISER facilitates the creation of a favorable security and resilience environment by delivering analysis, training, data (which includes situational awareness and modeling data), tools, and validation exercises to assist our partners with executing Preparedness activities across the five mission areas specified in Presidential Policy Directive 8: National Preparedness.

ISER's development and delivery of these capabilities is informed by coordination with energy infrastructure stakeholders by virtue of our SSA authorities and through active participation with our sister agencies. This allows ISER to serve as a point of entry for energy infrastructure security and resilience stakeholders at all levels, including the private sector, to DOE and the Federal Government. Through this mechanism, the sector stakeholders are able to develop a common understanding of risks, inform preparedness capability requirements, help build and sustain these capabilities at all levels, and develop plans for their use, validation and refinement.

The ISER program derives its authorities and mandates from:

- Presidential Policy Directive – 21 (PPD-21): Critical Infrastructure Security and Resilience
- Presidential Policy Directive – 8 (PPD-8): National Preparedness
- The National Infrastructure Protection Plan (NIPP)
- The National Preparedness System
- The National Planning Frameworks

Highlights of the FY 2017 Budget Request

The FY 2017 budget request reflects ISER's commitment to expand Energy Sector security and resilience through full coordination with our government and industry partners in the delivery of analysis, training, data, tools and exercises to sector stakeholders.

Build Emergency Support Function 12 Capacity: ISER will focus on developing and implementing a DOE training model focused on the delivery of training to state, local, tribal, and territorial entities, interagency and private sector partners in order to create a nation-wide ESF-12 trainer cadre. This model will efficiently expand our ability to respond and recover by creating a nation-wide cadre of ESF-12 responders. To facilitate our ability to collect information and respond to disasters, ISER will develop training modules and implement a strategy for substantially improving the number, and energy sector knowledge-base of the volunteers available to the interagency community and the regions in the event of emergency.

Exercising Energy Sector Preparedness: Per the National Response Framework (NRF), DOE is responsible for conducting energy emergency exercises with the energy industry, Federal partners, and local, state, tribal, and territorial governments. To this end, ISER seeks to establish an exercise program in order to meet the NRF requirements and ensure the energy sector is prepared. ISER has conducted and participated in a few exercises in the past, but has not developed an established annual program. The exercise program will evaluate and validate DOE's capabilities to respond to energy emergencies and facilitate the restoration of energy system with industry, Federal, state, local, tribal, and territorial partners.

Improve Energy Sector Situational Awareness Capabilities: ISER is home to EAGLE-I, the Federal Government's situational awareness tool for national power outages. EAGLE-I's awareness of distribution outages has been growing, but it lacks the abilities to illustrate how outages affect other aspects of critical lifeline sectors or model potential impacts of various hazards, and would benefit from increased access to more varied sources of data. The FY 2017 request will transform

[a] The Infrastructure Systems Recovery Support Function is described at https://www.fema.gov/pdf/recoveryframework/infrastructure_system_rsf.pdf.

EAGLE-I into a system for data acquisition, collection, modeling, analysis, and visualization services. This will establish a collaborative platform for historic and real time data collection, assimilation, integration, and curation across the public and private sectors. It will be the Federal focal point for collecting and sharing energy infrastructure information, linked with other Federal efforts. Additionally, it will assess the significance and credibility of novel and emerging data resources and analytics for possible integration in the ESF-12 activities and services.

Cybersecurity Incident Management: ISER will lead an effort to develop an effective, timely, and coordinated cyber incident management capability as part of its all-hazards approach to incident response for the energy sector. In collaboration with the Department of Homeland Security (DHS), the Federal Energy Regulatory Commission (FERC), the Electricity Sector Information Sharing and Analysis Center (ES-ISAC), industry, and international stakeholders, and in concert with work performed under the CEDS program, ISER will develop and formalize incident management processes and procedures (e.g., communications and coordination of activities, roles, and responsibilities) which align with the National Incident Management System and National Response Framework. These processes and procedures include establishing and managing relationships with cyber-assistance fly-away teams and coordination with the intelligence community and law enforcement. In FY 2017, ISER will conduct a series of cybersecurity incident management capability exercises to test enhanced coordination procedures and support sector preparedness and resilience.

Infrastructure Security and Energy Restoration
Funding ($K)

	FY 2015 Enacted	FY 2015 Current	FY 2016 Enacted	FY 2017 Request	FY 2017 vs FY 2016
Infrastructure Security and Energy Restoration	**6,000**	**6,000**	**9,000**	**17,500**	**+8,500**

Infrastructure Security and Energy Restoration
Explanation of Major Changes ($K)

	FY 2016 vs FY 2017
The FY 2017 ISER budget proposal supports on-going FY 2016 efforts and allows for increased capability in three primary areas: developing a national energy infrastructure situational awareness visualization capability for EAGLE-I and other emergency response tools; a significantly expanded energy emergency preparedness all-hazards exercise program with state, local, tribal, and territorial entities; and analysis of new and emerging threats including those resulting from supply chains and electromagnetic pulses (EMP).	**+8,500**

Infrastructure Security and Energy Restoration

Activities and Explanation of Changes

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
Infrastructure Security and Energy Restoration **$9,000,000**	**$17,500,000**	**+$8,500,000**
• ESF-12 Responsibilities: 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.	• ESF-12 Responsibilities: Establish enhanced annual training on regional energy infrastructure for volunteer energy responders and significantly increase the number of available responders without increasing budgetary outlay. Address outstanding emergency communication needs. Establish an information sharing system with State Energy and Emergency Response Offices and exercise these through progressive regional exercises (see below, in Exercises) culminating in a national effort. Create a national energy critical energy infrastructure training program/ curriculum.	• Expand ISER's ability to help the Nation respond to energy emergencies by expanding the Department's core response capabilities, formalizing our connections with state, local, tribal, and territorial representatives, addressing unmet emergency communication needs, and establishing more robust annual training programs.

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
• SSA Responsibilities: Continue implementation of National Preparedness and Critical Infrastructure Security and Resilience mandates and the coordination of other national energy preparedness policies; develop a Physical Security Capability and Maturity Model (P2CM2) and perform PSCM2 Assessments; support NERC Reliability Standard to Enhance Physical Security Measures; continue development of technical specifications for security systems for high valued, critical energy assets; and facilitate the necessary actions to expand the Oil and Natural Gas ISAC from cyber-focus to all-hazards focus.	• SSA Responsibilities: Continue implementation of National Preparedness and Critical Infrastructure Security and Resilience mandates and the coordination of other national energy preparedness policies. Maintain and strengthen relationships with the Energy Sector by chairing the Electricity Sector Coordinating Council (ESCC) and the Oil and Natural Gas Coordinating Council (ONGSCC). Work across the Federal Government to facilitate the energy sector's access to needed support for preparedness, response, and recovery.	
• Exercises: 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.	• Exercises: ISER will establish an exercise program in order to meet the requirements established in the NRF and to validate and evaluate the ability of DOE's capabilities to respond to energy emergencies and facilitate the restoration of energy system with industry, Federal, state, local, tribal, and territorial partners.	• Move from participating in a limited number of exercises in a limited way to establishing an annual exercise program focused on DOE's ESF-12 role and capabilities. This would complement our State Energy Assurance program, which focuses on building state, local, tribal, and territorial partners' capabilities to prepare, respond and recover for energy emergencies. The program will include one national-level exercise and multiple regional, state, local, tribal, and territorial exercises, addressing all threats and hazards (including cyber).

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
• Situational Awareness and Emergency Response Tools: Increase the ability for the monitoring and visualization technology to rapidly adapt, when possible, to new emerging threats.	• Situational Awareness and Emergency Response Tools: Building on EAGLE-I, the Federal Government's situational awareness tool for national power outages, develop national energy infrastructure situational awareness visualization capability that incorporates novel data sources and leading-edge visualization technologies. Identify existing capabilities resident at DOE national laboratories that can be leveraged to provide new or enhanced emergency response capabilities (e.g., cyber capabilities at INL and alternative grid control at PNNL.)	• Establish a national energy infrastructure situational awareness visualization capability, building on EAGLE-I, that incorporates novel sources data and leading-edge visualization technologies and the identification of existing capabilities resident at DOE national laboratories that can be harnessed/leveraged to provide new or enhanced emergency response capabilities.
	• Cyber Incident Response: Build cyber protections into DOE's all-hazard incident response plan and incorporate applicable national policies and directives.	• Cyber incident response activities are funded within the Cybersecurity for Energy Delivery Systems (CEDS) program in FY 2016.
• New and Emerging Threats: Identify strategies and conduct analysis on methods to improve the resilience of critical energy infrastructure components, e.g., the potential impacts of geomagnetic disturbances (GMD) and electromagnetic pulses (EMP) on the electric grid.	• New and Emerging Threats: Continue identifying strategies and conducting analysis on methods to improve the resilience of critical energy infrastructure components, e.g., identify critical companies from an incident-response standpoint.	• Develop an implementation strategy with industry to address potential impacts of GMD and EMP on the electric grid; identify other emerging threats to and needs of the energy sector, such as how to measure improvements is resilience, how to address national black start capability, domestic fuel industry resilience given increased domestic production, and appropriate analysis.

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 2015	FY 2016	FY 2017
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	60% situational awareness capability availability	70% situational awareness capability availability	90% situational awareness capability availability
Result	Met	Not Applicable	Not Applicable
Endpoint Target	Maintain the availability to near-real time energy situational awareness tools to interagency partners at greater than 90%.		

State Energy Assurance

Overview

State Energy Assurance is a new program in FY 2017 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 program will provide funds via competitive regional cooperative assistance awards that would support continual energy assurance plan improvement, exercise regional and state capabilities to characterize energy sector supply disruptions, communicate among the local, state, regional, Federal, and industry partners, and identify gaps for use in energy planning and emergency response training programs.

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. Through support of state energy assurance planning improvement and regional resilience exercises, the Federal Government will partner with states and local governments—who are ultimately responsible for responding to disasters and disruptions—to build and maintain preparedness and assurance capabilities.

The funds will be used to support several activities relevant to short- and long-term energy assurance preparedness and planning:

- Conducting regional energy emergency exercises 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.
- 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, through regional exercises.
- 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).
- Ensuring lessons learned from regional exercises are incorporated in 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).
- 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.

Highlights of the FY 2017 Budget Request

The FY 2017 budget request proposes a $15,000,000 competitive regional cooperative assistance program that would exercise regional and state capabilities to characterize energy sector supply disruptions, communicate among the local, state, regional, Federal, and industry partners, and identify gaps for use in energy planning and emergency response training programs.

Approximately 10 awards are planned, competitively allocated to teams of local, state, regional, tribal, and territorial entities on the basis of a combination of criteria including need (the likelihood of energy disruptions), size (to ensure a combination of large and small states), and desire (the extent of endorsement and support from participating Governors

and participation by emergency management and state energy offices). The portfolio would also reflect a mix of energy producing and energy consuming states/regions.

Project objectives will include:

- Identifying and establishing a core set of requirements linked to measurable results (for example, developing metrics that would allow states and regions to assess the strength of their plans).
- Focusing on identifying critical gaps (for example, cybersecurity, liquid and delivered fuels).
- Focusing on integrating new and evolving system risks and threats (for example, advances in intelligent grid controls, increased distributed generation, and changes in petroleum product flows and rail constraints).
- Clarifying and highlighting regional interdependencies (for example, natural gas infrastructure expansion needs and opportunities).

With this program, DOE will in part meet its responsibilities as outlined in Presidential Policy Directives 21 and 8, and as recommended by the Quadrennial Energy Review and the National Petroleum Council, to address the present and future U.S. energy needs through the implementation of a strong national energy program consistent with overall national, economic, environmental and social goals. DOE will bring efficiencies of scale and scope to the assistance of the state, local, tribal, and territorial community, which otherwise would have neither the incentive nor, in many instances, the resources to participate as they should.

State Energy Assurance
Funding ($K)

	FY 2015 Enacted	FY 2015 Current	FY 2016 Enacted	FY 2017 Request	FY 2017 vs FY 2016
State Energy Assurance	0	0	0	15,000	+15,000

State Energy Assurance
Explanation of Major Changes ($K)

	FY 2017 vs FY 2016
State Energy Assurance is a new activity in FY 2017.	**+15,000**

State Energy Assurance

Activities and Explanation of Changes

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
State Energy Assurance $0	**$15,000,000**	**+$15,000,000**
	• Support regional and state activities to improve capabilities to characterize energy sector supply disruptions, communicate among the local, state, regional, Federal and industry partners, and identify gaps for use in energy planning and emergency response training programs. • The expertise and capability developed by the national laboratories would also be available to the awardees as well as for use in real-world energy emergencies.	• This is a new activity in FY 2017.

Program Direction

Overview

Program Direction provides for 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 118 full-time equivalent employees (FTEs) that provide executive management, programmatic oversight, and analysis for the effective implementation of the OE program. Of these, 89 FTEs are planned for Headquarters and 29 FTEs are planned at the National Energy Technology Laboratory (NETL). While OE funds 29 FTEs at NETL within its budget, the FTEs are considered Fossil Energy employees.

OE provides FTEs to support Federal Emergency Management Agency (FEMA) Emergency Support Function 12 (ESF-12) mission events and all required ESF-12 training activities. During FEMA mission events, OE FTE base pay is funded by Program Direction funding, while OE is reimbursed by FEMA for overtime and travel expenses. OE also provides FTE support for international energy issues at the request of the Department of State, which reimburses OE for all salary and benefit expenses associated with the work.

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 through NED; 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 by providing ESF-12 and readiness training for DOE emergency responders, who are coordinated through ISER. The Department of State and the private sector reimburse OE for all travel related to their tasks.

Support Services includes contractor support directed by the Federal staff to perform administrative tasks and provide analysis to management. These efforts include 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., American Association for the Advancement of Science [AAAS] fellows) and Intergovernmental Personnel Act (IPA) assignments.

Other Related Expenses includes corporate IT support (DOE's Energy Information Technology Services [EITS] desktop services) and working capital fund (WCF) 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 2017 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 Funding ($K)				
	FY 2015 Enacted	FY 2015 Current	FY 2016 Enacted	FY 2017 Request	FY 2017 vs FY 2016
Program Direction Summary					
Washington Headquarters					
Salaries and Benefits	13,092	13,092	13,562	14,068	+506
Travel	650	650	650	650	0
Support Services	2,905	2,905	2,864	3,120	+256
Other Related Expenses	4,214	4,214	4,004	4,060	+56
Total, Washington Headquarters	**20,861**	**20,861**	**21,080**	**21,898**	**+818**
National Energy Technology Laboratory					
Salaries and Benefits	5,700	5,700	5,720	5,750	+30
Travel	300	300	300	300	0
Support Services	500	500	550	602	+52
Other Related Expenses	245	245	350	450	+100
Total, National Energy Technology Laboratory	**6,745**	**6,745**	**6,920**	**7,102**	**+182**
Total Program Direction					
Salaries and Benefits	18,792	18,792	19,282	19,818	+536
Travel	950	950	950	950	0
Support Services	3,405	3,405	3,414	3,722	+308
Other Related Expenses	4,459	4,459	4,354	4,510	+156
Total, Program Direction	**27,606**	**27,606**	**28,000**	**29,000**	**+1,000**
Federal FTEs	**83**	**83**	**89**	**89**	**0**
Additional FE FTEs at NETL supporting OE[a]	29	29	29	29	0
Total OE-funded FTEs	112	112	118	118	0

[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 2015 Enacted	FY 2015 Current	FY 2016 Enacted	FY 2017 Request	FY 2017 vs FY 2016
Support Services and Other Related Expenses					
Support Services					
Technical Support	1,318	1,318	1,384	1,513	+129
Management Support	2,087	2,087	2,030	2,209	+179
Total, Support Services	**3,405**	**3,405**	**3,414**	**3,722**	**+308**
Other Related Expenses					
Other Services	855	855	600	500	-100
EITS Desktop Services	500	500	603	612	+9
WCF	3,104	3,104	3,151	3,398	+247
Total, Other Related Expenses	**4,459**	**4,459**	**4,354**	**4,510**	**+156**

Program Direction

Activities and Explanation of Changes

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
Program Direction $28,000,000	**$29,000,000**	**+$1,000,000**
Salaries and Benefits $19,282,000	**$19,818,000**	**+$536,000**
Salaries and Benefits support 118 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 118 FTEs at HQ and NETL that provide executive management, programmatic oversight, and analysis for the effective implementation of the OE program.	Increase reflects cost of living increases.
Travel $950,000	**$950,000**	**$0**
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.	Travel funding is unchanged from FY 2016.
Support Services $3,414,000	**$3,722,000**	**+$308,000**
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 Intergovernmental Personnel Act (IPA) assignments.	The increase in Support Services is due to anticipated contractual price increases over FY 2016.
Other Related Expenses $4,354,000	**$4,510,000**	**+$156,000**
Other Related Expenses includes EITS desktop services and WCF 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 EITS desktop services as well as equipment upgrades and replacements, commercial credit card purchases using the simplified acquisition procedures to the maximum extent possible, and other needs. This category also includes WCF estimates for FY 2017, which have increased over the FY 2016 estimates to fund the third year of OPM credit monitoring and projected inflation increases in existing WCF programs including corporate business systems, building occupancy, interagency transfers, and telecommunications.	The increase is primarily associated with the Working Capital fund charges.

Electricity Delivery and Energy Reliability

Research and Development ($K)[a]

	FY 2015 Enacted	FY 2015 Current	FY 2016 Enacted	FY 2017 Request	FY 2017 vs FY 2016
Basic	7,644	7,428	5,844	8,376	+2,532
Applied	66,813	64,929	78,424	81,096	+2,672
Development	40,258	39,122	55,244	68,600	+13,356
Total, R&D	114,715	111,479	139,512	158,072	+18,560

[a] R&D reporting includes a proportional share of program direction funding in addition to direct R&D funding. Program direction funding was not included in the R&D reporting in the FY 2016 and prior year budget justifications.

Small Business Innovative Research/Small Business Technology Transfer (SBIR/STTR) ($K)

	FY 2015 Transferred	FY 2016 Projected Transfer	FY 2017 Request Projected Transfer	FY 2017 vs FY 2016 Projected
Clean Energy Transmission and Reliability				
SBIR	814	960	778	-182
STTR	112	144	109	-35
Smart Grid Research and Development				
SBIR	448	1,050	960	-90
STTR	61	158	135	-23
Cybersecurity for Energy Delivery Systems				
SBIR	1,092	1,050	960	-90
STTR	151	158	135	-23
Energy Storage				
SBIR	348	615	1,424	+809
STTR	48	92	200	+108
Transformer Resilience and Advanced Components				
SBIR	0	150	480	+330
STTR	0	22	68	+46
Grid Institute				
SBIR	0	0	448	+448
STTR	0	0	63	+63
Total, SBIR	2,702	3,825	5,050	+1,225
Total, STTR	372	574	710	+136

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($K)

Electricity Delivery and Energy Reliability	FY 2015 Current	FY 2016 Enacted	FY 2017 Request
Ames Laboratory			
Electricity Delivery and Energy Reliability			
Clean Energy Transmission and Reliability	100	100	0
Cybersecurity for Energy Delivery Systems	50	0	0
Total, Electricity Delivery and Energy Reliability	**150**	**100**	**0**
Total, Ames Laboratory	**150**	**100**	**0**
Argonne National Laboratory			
Electricity Delivery and Energy Reliability			
Clean Energy Transmission and Reliability	2,075	6,230	0
Smart Grid	2,369	1,773	1,658
Cybersecurity for Energy Delivery Systems	1,000	1,909	1,500
National Electricity Delivery	357	250	250
Total, Electricity Delivery and Energy Reliability	**5,801**	**10,162**	**3,408**
Total, Argonne National Laboratory	**5,801**	**10,162**	**3,408**
Brookhaven National Laboratory			
Electricity Delivery and Energy Reliability			
Infrastructure Security & Energy Restoration	50	0	0
Cybersecurity for Energy Delivery Systems	950	0	1,000
Total, Electricity Delivery and Energy Reliability	**1,000**	**0**	**1,000**
Total, Brookhaven National Laboratory	**1,000**	**0**	**1,000**
Chicago Operations Office			
Electricity Delivery and Energy Reliability			
Clean Energy Transmission and Reliability	75	75	0
Total, Chicago Operations Office	**75**	**75**	**0**
Idaho National Laboratory			
Electricity Delivery and Energy Reliability			
Clean Energy Transmission and Reliability	100	0	0
Energy Storage	50	0	0
Cybersecurity for Energy Delivery Systems	1,149	181	254
National Electricity Delivery	50	50	50
Transformer Resilience and Advanced Components	0	300	1,000
Total, Electricity Delivery and Energy Reliability	**1,349**	**531**	**1,304**
Total, Idaho National Laboratory	**1,349**	**531**	**1,304**
Idaho Operations Office			
Electricity Delivery and Energy Reliability			
National Electricity Delivery	150	25	0
Total, Idaho Operations Office	**150**	**25**	**0**

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($K)

Electricity Delivery and Energy Reliability	FY 2015 Current	FY 2016 Enacted	FY 2017 Request
Lawrence Berkeley National Laboratory			
Electricity Delivery and Energy Reliability			
Clean Energy Transmission and Reliability	3,895	3,875	400
Smart Grid	1,090	1,775	1,775
Infrastructure Security & Energy Restoration	50	0	0
Energy Storage	50	0	0
Cybersecurity for Energy Delivery Systems	0	90	117
National Electricity Delivery	2,645	3,000	2,300
Total, Electricity Delivery and Energy Reliability	**7,730**	**8,740**	**4,592**
Total, Lawrence Berkeley National Laboratory	**7,730**	**8,740**	**4,592**
Lawrence Livermore National Laboratory			
Electricity Delivery and Energy Reliability			
Clean Energy Transmission and Reliability	900	0	0
Infrastructure Security & Energy Restoration	4	0	0
Cybersecurity for Energy Delivery Systems	0	316	295
Total, Electricity Delivery and Energy Reliability	**904**	**316**	**295**
Total, Lawrence Livermore National Laboratory	**904**	**316**	**295**
Los Alamos National Laboratory			
Electricity Delivery and Energy Reliability			
Clean Energy Transmission and Reliability	1,644	3,750	0
Smart Grid	252	970	1,020
Infrastructure Security & Energy Restoration	50	0	0
Cybersecurity for Energy Delivery Systems	50	0	100
Total, Electricity Delivery and Energy Reliability	**1,996**	**4,720**	**1,120**
Total, Los Alamos National Laboratory	**1,996**	**4,720**	**1,120**
National Energy Technology Lab			
Electricity Delivery and Energy Reliability			
Program Direction	6,590	6,970	7,102
Clean Energy Transmission and Reliability	3,797	13,191	24,500
Smart Grid	3,614	9,645	7,500
Infrastructure Security & Energy Restoration	528	1,000	1,944
Cybersecurity for Energy Delivery Systems	30,061	44,000	32,000
National Electricity Delivery	1,340	1,500	1,500
Transformer Resilience and Advanced Components	0	1,500	8,000
Total, Electricity Delivery and Energy Reliability	**45,930**	**77,806**	**82,546**
Total, National Energy Technology Lab	**45,930**	**77,806**	**82,546**

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FY 2017 Congressional Budget

Funding By Appropriation By Site

($K)

Electricity Delivery and Energy Reliability	FY 2015 Current	FY 2016 Enacted	FY 2017 Request
National Renewable Energy Laboratory			
Electricity Delivery and Energy Reliability			
Program Direction	7	0	0
Clean Energy Transmission and Reliability	400	0	0
Smart Grid	675	3,350	3,050
Infrastructure Security & Energy Restoration	50	0	0
Cybersecurity for Energy Delivery Systems	50	109	109
National Electricity Delivery	195	125	125
Transformer Resilience and Advanced Components	0	0	1,000
Total, Electricity Delivery and Energy Reliability	**1,377**	**3,584**	**4,284**
Total, National Renewable Energy Laboratory	**1,377**	**3,584**	**4,284**
Oak Ridge Institute for Science & Education			
Electricity Delivery and Energy Reliability			
Program Direction	7	0	0
Clean Energy Transmission and Reliability	4	0	0
Infrastructure Security & Energy Restoration	75	0	0
Total, Electricity Delivery and Energy Reliability	**86**	**0**	**0**
Total, Oak Ridge Institute for Science & Education	**86**	**0**	**0**
Oak Ridge National Laboratory			
Electricity Delivery and Energy Reliability			
Clean Energy Transmission and Reliability	2,321	2,000	100
Smart Grid	600	950	800
Infrastructure Security & Energy Restoration	50	100	195
Energy Storage	768	1,243	2,698
Cybersecurity for Energy Delivery Systems	50	227	268
National Electricity Delivery	115	50	50
Transformer Resilience and Advanced Components	0	2,200	1,000
Total, Electricity Delivery and Energy Reliability	**3,904**	**6,770**	**5,111**
Total, Oak Ridge National Laboratory	**3,904**	**6,770**	**5,111**
Pacific Northwest National Laboratory			
Electricity Delivery and Energy Reliability			
Clean Energy Transmission and Reliability	6,870	3,050	1,000
Smart Grid	2,769	11,671	11,671
Infrastructure Security & Energy Restoration	65	1,620	3,150
Energy Storage	4,477	7,619	16,539
Cybersecurity for Energy Delivery Systems	1,042	1,178	1,350
National Electricity Delivery	170	100	100
Transformer Resilience and Advanced Components	0	800	1,000
Total, Electricity Delivery and Energy Reliability	**15,393**	**26,038**	**34,810**
Total, Pacific Northwest National Laboratory	**15,393**	**26,038**	**34,810**

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($K)

Electricity Delivery and Energy Reliability	FY 2015 Current	FY 2016 Enacted	FY 2017 Request
Richland Operations Office			
Electricity Delivery and Energy Reliability			
Infrastructure Security & Energy Restoration	879	0	0
Total, Richland Operations Office	**879**	**0**	**0**
Sandia National Laboratories			
Electricity Delivery and Energy Reliability			
Clean Energy Transmission and Reliability	700	300	0
Smart Grid	861	600	600
Energy Storage	6,029	10,400	22,576
Cybersecurity for Energy Delivery Systems	155	52	52
National Electricity Delivery	460	250	250
Transformer Resilience and Advanced Components	0	0	1,000
Total, Electricity Delivery and Energy Reliability	**8,205**	**11,602**	**24,478**
Total, Sandia National Laboratories	**8,205**	**11,602**	**24,478**
Savannah River National Laboratory			
Electricity Delivery and Energy Reliability			
Clean Energy Transmission and Reliability	50	0	0
Energy Storage	50	0	0
Cybersecurity for Energy Delivery Systems	50	0	0
Total, Electricity Delivery and Energy Reliability	**150**	**0**	**0**
Total, Savannah River National Laboratory	**150**	**0**	**0**
Washington Headquarters			
Electricity Delivery and Energy Reliability			
Program Direction	21,002	21,030	21,898
Clean Energy Transmission and Reliability	10,405	6,429	4,300
Smart Grid	2,700	4,266	1,926
Infrastructure Security & Energy Restoration	4,199	6,280	12,211
Energy Storage	180	1,238	2,687
Cybersecurity for Energy Delivery Systems	10,149	13,938	8,455
National Electricity Delivery	518	2,150	1,875
Transformer Resilience and Advanced Components	0	200	2,000
State Distribution-level Reform	0	0	15,000
Grid Institute	0	0	14,000
Energy Assurance	0	0	15,000
Total, Electricity Delivery and Energy Reliability	**49,153**	**55,531**	**99,352**
Total, Washington Headquarters	**49,153**	**55,531**	**99,352**
Total, Electricity Delivery and Energy Reliability	**144,232**	**206,000**	**262,300**

Nuclear Energy

Nuclear Energy

Nuclear Energy

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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, **[**$986,161,000**]** and the purchase of no more than three emergency service vehicles for replacement only, *$993,896,000*, to remain available until expended, of which *$61,040,000* shall be derived from the Nuclear Waste Fund: Provided, That of such amount, **[**$80,000,000**]** *$88,700,000* shall be available until September 30, **[**2017**]** *2018*, for program direction **[**including official reception and representation expenses not to exceed $10,000**]**. *(Energy and Water Development and Related Agencies Appropriations Act, 2016.)*

Public Law Authorizations
42 U.S.C. 10101, Nuclear Waste Policy Act of 1982

Nuclear Energy
($K)

FY 2015 Enacted[1]	FY 2015 Current[1]	FY 2016 Enacted	FY 2017 Request
913,500	902,004	986,161	993,896

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. Nuclear power has reliably and economically contributed almost 20% of electrical generation in the United States over the past two decades. It remains the single largest contributor (more than 60%) of non-greenhouse-gas-emitting electric power generation in the United States.

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. Efforts to ensure NE research capabilities are available to US universities, industry and small businesses are focused through the Nuclear Science User Facilities, the public-private research initiative Gateway for Accelerated Innovation in Nuclear (GAIN), vouchers to assist small businesses seeking access to the knowledge and capabilities at the national laboratories, and the Office of Technology Transition's Technology Commercialization Fund.

The Nuclear Energy program will support implementation of the Civil Nuclear Cooperation aspects of the Iran Joint Comprehensive Plan of Action (JCPOA) to ensure that Iran's nuclear program will be exclusively peaceful.

Within the FY 2017 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; 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. Working more closely with industry, the Department will explore improvements to light water reactor systems and fuel forms to further enhance safety and reliability of the existing fleet and support the development of advanced nuclear technologies role in reducing carbon emissions while providing high density energy (electricity and high temperature process heat) to address rising global energy needs. 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 into our facilities operations and R&D programs 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 2017, the Budget requests $76.3 million, including $61.0 million from the Nuclear Waste Fund and $15.3 million in defense funding, for the Integrated Waste Management System. This effort will lay the ground work for one or more facilities for spent fuel management under a consent-based siting program and prepare for large-scale transport of used fuel. The Budget also requests $74.3 million for related generic used fuel and high-level waste disposition R&D.

[1] FY 2015 Enacted and Current columns do not reflect the rescission of $80,121,000 of prior year appropriations as identified in Public Law 113-235.

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 2017 Budget request includes a proposal to implement such reform. Discretionary appropriations are included and continue for the duration of the effort. In FY 2017, these funds are found in the Integrated Waste Management System 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 2018, to fund the balance of the annual program costs for managing commercial used nuclear fuel. The Department is currently exploring options for managing defense high-level waste with the goal of a separate, permanent repository. The sooner that legislation enables progress on implementing a nuclear waste management program, the lower the ultimate cost will be to the taxpayers.

Highlights and Major Changes in the FY 2017 Budget Request

The FY 2017 Request continues ongoing emphasis on researching responses to Nuclear Energy fuel safety and waste streams (Fuel Cycle Research and Development, +$46.1 million), including funding to continue implementation of the Administration's Strategy through the Integrated Waste Management System, and maintaining the schedule for selecting and certifying accident tolerant fuel.

The FY 2017 Request for the Small Modular Reactor Licensing Technical Support (SMR LTS) program (+$27.1 million) completes DOE's commitment to the cost-shared awards to NuScale Power for Design Certification, the site licensing activities with Utah Associated Municipal Power Systems (UAMPS), and the award to Tennessee Valley Authority (TVA) for site permitting and licensing activities. Support for these site permitting and licensing activities is expected to incentivize a growth pattern for new SMR customers by establishing the reference blueprint for SMR Combined License Application that will improve confidence in and lower the cost of subsequent licensing activities.

In FY 2017 the Idaho Facilities Management (IFM) program (+$4.0 million) includes funding to support Department infrastructure initiatives to resurface, reconstruct, and seal major primary roads at the Idaho National Laboratory (INL) to improve the safety for all vehicle traffic (+$12.0 million), and to disposition Nuclear Energy excess contaminated facilities at INL (+$4.6 million). The FY 2017 Request for IFM also invests in reducing deferred maintenance at the Advanced Test Reactor (ATR) and Advanced Test Reactor Critical Facility (ATRC) (+$6.5 million) to improve reliability and availability of the ATR in order to meet research customer demands. These ATR investments are based on a strategy, jointly developed with Naval Reactors (NR) that will increase efficiency and irradiation days by prioritizing the plant, equipment, and experimental loop investments necessary to assure ATR operational viability beyond 2050.

In FY 2017, the International Nuclear Energy Cooperation program (+$1.5 million) will initiate efforts to develop a program for international nuclear energy education outreach, modeled after the Department of State's International Military Education and Training program. The goal of the new program is to support diplomatic, nonproliferation, climate, and international economic objectives for the safe and secure use of peaceful uses of nuclear technology in emerging countries developing nuclear energy programs.

Starting in the FY 2017 Budget Request, working capital fund business lines previously funded in part or total with program funds will be funded exclusively within Program Direction. Two business lines, CyberOne and Financial Statement Audits will continue to be funded with program dollars.

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 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 justifications for the Programs in which the crosscuts are funded. The Nuclear Energy program contains the following crosscuts:

Advanced Materials (Adv Mat): Affordable, reliable, and high-performance materials are critical for clean energy applications and for global manufacturing competitiveness in the 21st century. The new Advanced Materials crosscut, identified as a priority in both the 2015 Quadrennial Technology Review and Quadrennial Energy Review, will employ advanced synthesis, modeling, and characterization to accelerate and reduce the cost of materials qualification in a wide variety of clean energy applications, from discovery through deployment. While materials RD&D underpins much of DOE's historic and current portfolio across both basic science and applied offices, this newly formed crosscut focuses on a subset of materials R&D that will involve close coordination among the participating offices in forming a cohesive network with the following capabilities: (1) materials design and synthesis, (2) functional (applied) design, (3) process scale-up, (4) qualification, and (5) digital data and informatics.

Supercritical CO_2 (sCO_2): The supercritical carbon dioxide (sCO_2) based power generation initiative is a technology-focused crosscut that will facilitate industry's transition to realize power cycles based on sCO_2 as the working fluid. 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 FY 2017 Request builds on industry outreach and focused R&D efforts in FY 2015, and the development of more detailed conceptual plans, technical approach, and cost and schedule estimates relevant to a 10 MWe pilot test facility in FY 2016. These inputs will inform the development of the Supercritical Transformational Electric Power Generation (STEP) solicitation, to be issued and awarded in FY 2016, for the design, construction and operation of a 10 MWe pilot test facility. Initiation of design and construction of the STEP facility would begin in early FY 2017. Recognizing that the near-term deployment and potential market applications for commercial sCO_2 power cycles are primarily in the fossil energy area, the STEP project is being managed by the Office of Fossil Energy.

Subsurface Technology and Engineering RD&D (Subsurface): 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 will address identified challenges in the subsurface through highly focused and coordinated research in Wellbore Integrity, Subsurface Stress State and Induced Seismicity, Permeability Manipulation, and New Subsurface Signals to enhance renewable energy supply, ensure material impact on climate change via CO_2 storage, and significantly mitigate environmental impacts from energy-related subsurface activities and operations.

Cybersecurity: DOE is engaged in two categories of cyber-related activities: protecting the DOE enterprise from a range of cyber threats that can adversely impact mission capabilities 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, Credentials, and Access Management (ICAM).

FY 2017 Crosscuts ($K)

	Adv Mat	sCO_2	Subsurface	Cyber Security	Total
Reactor Concepts RD&D	400	6,000	0	0	**6,400**
Fuel Cycle R&D	0	0	30,500	0	**30,500**
Nuclear Energy Enabling Technologies	2,000	0	0	3,000	**5,000**
INL Sitewide S&S	0	0	0	16,258	**16,258**
Total, Crosscuts	**2,400**	**6,000**	**30,500**	**19,258**	**58,158**

Nuclear Energy
Funding by Congressional Control ($K)

	FY 2015 Enacted	FY 2015 Current[1]	FY 2016 Enacted	FY 2017 Request	FY 2017 vs FY 2016
Integrated University Program	**5,000**	**5,000**	**5,000**	**0**	**-5,000**
STEP R&D	**5,000**	**4,835**	**5,000**	**0**	**-5,000**
SMR Licensing Technical Support	**54,500**	**54,500**	**62,500**	**89,600**	**+27,100**
Reactor Concepts Research, Development and Demonstration	**133,000**	**128,611**	**141,718**	**108,760**	**-32,958**
Fuel Cycle Research and Development	**197,000**	**191,242**	**203,800**	**249,938**	**+46,138**
Nuclear Energy Enabling Technologies	**101,000**	**97,666**	**111,600**	**89,510**	**-22,090**
Radiological Facilities Management	**25,000**	**25,000**	**24,800**	**7,000**	**-17,800**
Idaho Facilities Management					
Operations & Maintenance	200,631	200,631	220,582	220,585	+3
13-D-905, Remote Handled Low-Level Waste Disposal Project, INL	5,369	5,369	0	0	+0
16-E-200, Sample Preparation Laboratory	0	0	2,000	6,000	+4,000
Total, Idaho Facilities Management	**206,000**	**206,000**	**222,582**	**226,585**	**+4,003**
Idaho Sitewide Safeguards and Security	**104,000**	**104,000**	**126,161**	**129,303**	**+3,142**
International Nuclear Energy Cooperation	**3,000**	**3,000**	**3,000**	**4,500**	**+1,500**
Program Direction	**80,000**	**80,000**	**80,000**	**88,700**	**+8,700**
Department of State Transfer	**0**	**2,150**	**0**	**0**	**+0**
Subtotal, Nuclear Energy	**913,500**	**902,004**	**986,161**	**993,896**	**+7,735**
Rescission of Prior Year Balances	-80,121	-80,121	0	0	+0
Total, Nuclear Energy	**833,379**	**821,883**	**986,161**	**993,896**	**+7,735**
Federal FTEs	394	373	372	380	+8

SBIR/STTR:

- FY 2015 Transferred: SBIR $11,992; STTR $1,654
- FY 2016 Projected: SBIR $13,129; STTR $1,969
- FY 2017 Request: SBIR $11,901; STTR $1,674

[1] Funding reflects the SBIR/STTR amounts transferred to the Office of Science.

Integrated University Program

Overview

Consistent with the Administration's science, technology, engineering, and mathematics (STEM) reorganization efforts, no funding is being requested in FY 2017 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 2015 Enacted	FY 2015 Current	FY 2016 Enacted	FY 2017 Request	FY 2017 vs FY 2016
Integrated University Program					
Integrated University Program	**5,000**	**5,000**	**5,000**	**0**	**-5,000**
Total, Integrated University Program	**5,000**	**5,000**	**5,000**	**0**	**-5,000**

Integrated University Program
Explanation of Major Changes ($K)

	FY 2017 vs FY 2016
Integrated University Program: Consistent with the Administrations STEM reorganization efforts, no funding is being requested to continue this program in FY 2017.	**-5,000**
Total, Integrated University Program	**-5,000**

Integrated University Program

Activities and Explanation of Changes

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
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 2017.	• No funding is requested to continue this program in FY 2017.

SMR Licensing Technical Support

Overview

Reflecting the Administration's policy to use every appropriate tool to combat climate change, 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) research and development strategy. As a part of this strategy, the Department has placed a high priority on accelerating commercialization and deployment timelines for small modular reactor (SMR) technologies. The SMR Licensing Technical Support (LTS) program supports first-of-a-kind costs associated with design certification and licensing activities for SMR technologies and site licensing activities for SMRs 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 support the industry first-movers as they complete the design development, certification, and licensing for SMR deployment in the early to mid-2020s. The Department's cost-shared agreements awarded under this program will reduce the risk of domestic development of commercial SMRs. It is expected that this effort will result in strengthening American manufacturing capabilities and the associated nuclear supply chain, therefore improving the domestic job outlook, and creating important export opportunities for the U.S. FY 2017 will be the final year of funding for SMR LTS activities.

The FY 2017 budget request supports the continued development of the NuScale Power SMR design under the SMR LTS program established in December 2013 and will fulfill the Department's funding commitment to this project. This 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 completed milestones that could lead to the submittal of a design certification application (DCA) to the Nuclear Regulatory Commission (NRC) in early FY2017. To date, this award has been implemented consistent with program goals. NuScale Power is expected to expend its remaining Government allotment of funding toward the approval of the design certification by the NRC, especially focusing on any Requests for Additional Information.

The establishment of SMR-specific site licensing methodologies and processes is an important aspect in the development of commercialization potential of SMR technologies. Consistent with agreements between the Department and its two utility partners to pursue site permitting and licensing activities, the FY 2017 President's Budget completes the Department's commitments for site permitting and related licensing activities. In FY 2015, the Department entered into a cost-shared Interagency Agreement with the Tennessee Valley Authority (TVA) to support its efforts to develop an Early Site Permit Application for an SMR to be built at TVA's Clinch River Site near Oak Ridge, Tennessee; submit it to the NRC; support its review; and be granted a site permit, as well as to continue forward with a Combined License Application (COLA) for an SMR to be built at the Clinch River Site. The Department also entered into a cost-shared Cooperative Agreement with NuScale and its utility partner, the Utah Associated Municipal Power Systems (UAMPS), to perform site selection, site characterization, and license application development activities to site an SMR in the Western U.S., possibly on or near the Idaho National Laboratory. UAMPS will develop Combined License Application (COLA) documentation in FY 2017. Funding provided for these site permitting and licensing activities in FY 2017 should provide adequate incentive and create the momentum for our industry partners to continue the COLAs through to completion.

Highlights of the FY 2017 Budget Request

This request fulfills DOE's commitment to the cost-shared awards to NuScale Power for Design Certification and for the site licensing activities with Utah Associated Municipal Power Systems (UAMPS), and the award to Tennessee Valley Authority (TVA) for site permitting and licensing activities. Support for these site permitting and licensing activities is expected to incentivize a growth pattern for new SMR customers by establishing the reference blueprint for SMR COLAs that will improve confidence in and lower the cost of subsequent licensing activities.

Following the DCA submittal in early FY 2017 by NuScale Power, rigorous engagement with the NRC on the review of the DCA, as well as conducting resource-intensive engineering, analysis, and testing activities in support of first-of-a-kind-engineering leading to design finalization is expected. The SMR LTS FY 2017 request also includes funding for site permitting and related licensing activities for TVA and UAMPS through their NuScale partnership. NuScale, with their utility partner UAMPS, is expected to be conducting site characterization activities at their selected site and continuing to prepare license application documentation. Through TVA, the Department is supporting the NRC review of TVA's Early Site Permit

application, as well as preparation of COLA documentation. In FY 2017, the program will also complete ongoing studies and analysis.

SMR Licensing Technical Support
Funding ($K)

	FY 2015 Enacted	FY 2015 Current	FY 2016 Enacted	FY 2017 Request	FY 2017 vs FY 2016
SMR Licensing Technical Support					
SMR Licensing Technical Support	54,500	54,500	62,500	89,600	+27,100
Total, SMR Licensing Technical Support	**54,500**	**54,500**	**62,500**	**89,600**	**+27,100**

SMR Licensing Technical Support
Explanation of Major Changes ($K)

	FY 2017 vs FY 2016
SMR Licensing Technical Support: The increase from $62,500,000 to $89,600,000 is consistent with the increased funding requirements to fulfill the Department's commitments for the NuScale SMR design, associated siting licensing work, Nuclear Regulatory Commission (NRC) review processes, and first-of-a-kind engineering activities, as well as analyses that promote generic SMR commercialization potential and completes the Department's funding commitment for the Combined License Application (COLA) for Tennessee Valley Authority's (TVA) Clinch River Site to allow for submittal of the application to the NRC.	**+27,100**
Total, SMR Licensing Technical Support	**+27,100**

SMR Licensing Technical Support

Activities and Explanation of Changes

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
SMR Licensing Technical Support $62,500,000	**$89,600,000**	**+$27,100,000**
• **NuScale Power** – NuScale Power continues activities to design, engineer, and develop certification documentation for early FY 2017 submission to the Nuclear Regulatory Commission (NRC), including: • Submitting final fuel design information (Design Certification Application (DCA) chapter 4.2) to the NRC. • Completing final draft of DCA. • Completing safety analysis and probabilistic risk assessment. • Completion of integral systems testing at the *NuScale Integral Systems Test* Facility in Corvallis, Oregon. • **mPower America** – No additional government cost-share is planned. • **Site Permitting and Licensing** • Tennessee Valley Authority (TVA) completes Early Site Permit Application for the Clinch River Site, submits it to the NRC, and supports its review. • TVA completes a small modular reactor (SMR) technology down-selection and begins development of a Combined License Application (COLA). • NuScale / Utah Associated Municipal Power Systems (UAMPS) will secure water and land use rights for sites in Idaho, and if a "go decision" is reached, will down-select an appropriate SMR site.	• **NuScale Power** – NuScale Power continues activities to design, engineer, and develop their reactor design leading to submittal of the design certification application to NRC and support the subsequent NRC review process. Key technical activities supported in FY 2017 include: • Submit a Design Certification Application to the NRC. • Respond to requests for additional information on the Design Certification Application. • Complete Fuel Testing. • Complete Reactor Module inspection demonstrations. • Conduct primary system thermal-hydraulic and code verification testing. • Conduct helical coil steam generator and other primary system manufacturing and fabrication demonstrations. • Complete human factors engineering and testing. • **Site Permitting and Licensing** • TVA will continue to support the NRC review of their Early Site Permit Application, including conducting activities required to respond to requests for additional information. • TVA will begin development of a COLA to site the selected SMR technology at the Clinch River Site. • NuScale / UAMPS will continue site characterization activities on the selected site. • NuScale / UAMPS will continue development of COLA documentation, including: - Security plan	• Funding increase is consistent with fulfilling the Department's commitments for NuScale SMR design, associated ongoing site licensing work, NRC review processes, and first-of-a-kind engineering activities, as well as analyses that promote generic small modular reactor commercialization potential and completes the Department's funding commitment for the COLA for TVA's Clinch River Site to allow for submittal of the application to the NRC.

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
• NuScale / UAMPS will perform site characterization activities on the selected site. • NuScale / Utah Associated Municipal Power Systems (UAMPS) will begin development of Combined License Application (COLA) documentation. • **Program Management** – DOE will continue analyses and studies important to improving small modular reactor (SMR) licensing and commercialization potential.	- Emergency plan - Environmental report - Geological and geotechnical investigations • **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 2015	FY 2016	FY 2017
Performance Goal / Measure	**SMR - Licensing Technical Support Program - Enable submission of license application documentation to the Nuclear Regulatory Commission by SMR vendor and utility partners by supporting design, engineering, certification, and licensing efforts for selected SMR project. Annual measures are to complete planned milestones.**		
Target	Complete FY 15 planned milestones	Complete FY 16 planned milestones	Complete FY 17 planned milestones
Result	All quarterly milestones were completed on time with the exception of the third quarter (Complete the seismic analysis for TVA's Clinch River site in support of the ESPA). However, TVA completed their analysis in support of the ESPA in September 2015.	N/A	N/A
Endpoint Target	Provide financial 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 engages with industry, and the broader stakeholder community, to develop an effective public-private cost-shared sCO_2 Brayton cycle 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 energy strategy to use every appropriate tool to combat climate change. 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 effort 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 project, while continuing to leverage the technical expertise and capabilities of the national laboratories. In FY 2017, the STEP project is being managed by FE to better align with near-term commercial potential. Funding for STEP in NE can be found in the Reactor Concepts Research, Development and Deployment (RD&D) program. The STEP project will focus on sCO_2 components and technologies common to solar, nuclear, fossil, and geothermal heat sources to secure end-user confidence for commercial sCO_2 power cycles and technology specific R&D will be performed in the corresponding programs.

Highlights of the FY 2017 Budget Request

Nuclear Energy research on advanced sCO_2 Brayton cycle energy conversion technology is currently supported in the Advanced Reactor Technologies (ART) subprogram of Reactor Concepts RD&D. In FY 2017, NE is consolidating these research efforts within ART. FY 2017 efforts will focus on the development and operational performance testing of high efficiency Brayton cycle turbo-machinery and conduct of experiments to explore liquid metal/sCO_2 heat exchanger performance. NE will continue to use expertise gained from previous sCO_2 research to support FE with the sCO_2 project.

Supercritical Transformational Electric Power Research and Development
Funding ($K)

	FY 2015 Enacted	FY 2015 Current[1]	FY 2016 Enacted	FY 2017 Request	FY 2017 vs FY 2016
Supercritical Transformational Electric Power Research and Development					
Supercritical Transformational Electric Power Research and Development	5,000	4,835	5,000	0	-5,000
Total, Supercritical Transformational Electric Power Research and Development	**5,000**	**4,835**	**5,000**	**0**	**-5,000**

SBIR/STTR:

- FY 2015 Transferred: SBIR $145; STTR $20
- FY 2016 Projected: SBIR $150; STTR $23
- FY 2017 Request: SBIR $0; STTR $0

[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 2017 vs FY 2016
Supercritical Transformational Electric Power Research and Development: Funding is reduced to reflect the consolidation of the sCO_2 activities into the Advanced Reactor Technologies (ART) program for the development and operational performance testing of high efficiency Brayton cycle turbo-machinery and the conducting of experiments to explore liquid metal/sCO_2 heat exchanger performance.	**-5,000**
Total, Supercritical Transformational Electric Power Research and Development	**-5,000**

Supercritical Transformational Electric Power Research and Development

Activities and Explanation of Changes

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
Supercritical Transformational Electric Power Research and Development $5,000,000	**$0**	**-$5,000,000**
• Support Fossil Energy's (FE) implementation of the Supercritical Transformational Electric Power (STEP) pilot scale project. • Evaluate options to reduce technical risks and reduce cost for the STEP project. • Conduct specific research and development (R&D) and technology development activities.	• No funding is being requested.	• Within the Reactor Concepts Research, Development and Deployment (RD&D) program Supercritical CO2 is supported by the Advanced Reactor Technologies (ART) subprogram. In FY 2017, funding in ART will be for the development and operational performance testing of high efficiency Brayton cycle turbo-machinery and the conducting of experiments to explore liquid metal/sCO2 heat exchanger performance.

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;
- Management of nuclear waste;
- Minimizing proliferation risks of nuclear materials; and
- Further enhancing safety and incorporating lessons learned from Fukushima.

Finally, the Reactor Concepts RD&D program will support implementation of the Civil Nuclear Cooperation aspects of the Iran Joint Comprehensive Plan of Action (JCPOA) to ensure that Iran's nuclear program will be exclusively peaceful.

Highlights of the FY 2017 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 starting around 2018. Research in the Safety Margin Characterization and Instrumentation and Controls areas will help address economic barriers to continued operation. 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 supporting industry efforts to improve response to potential severe accidents and working with international partners in preparation and planning efforts in support of eventual examination of the damaged Fukushima 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, supporting the Nuclear Regulatory Commission (NRC) with development of an advanced reactor licensing framework and other initiatives for licensing of advanced reactors, liquid metal reactor component testing, TRISO fuel development and graphite material qualification, advanced materials development and codification, continued international collaborations and continued engagement with industry on cost-shared R&D collaborations. The ART subprogram will also perform activities to implement the results of the Advanced Test/Demonstration Reactor Study pending completion and findings. 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.

Within the Reactor Concepts RD&D program Supercritical CO_2 is supported by the Advanced Reactor Technologies (ART) subprogram. Supercritical CO_2 research was previously funded under both ART and STEP; however, consolidation of the funding under ART in FY 2017 better reflects the program's scope of research. In FY 2017, ART will fund approximately $6 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.

Reactor Concepts Research, Development and Demonstration
Funding ($K)

	FY 2015 Enacted	FY 2015 Current[1]	FY 2016 Enacted	FY 2017 Request	FY 2017 vs FY 2016
Reactor Concepts Research, Development and Demonstration					
Light Water Reactor Sustainability	35,000	33,845	40,000	35,260	-4,740
Advanced Reactor Technologies	98,000	94,766	101,718	73,500	-28,218
Total, Reactor Concepts Research, Development and Demonstration	**133,000**	**128,611**	**141,718**	**108,760**	**-32,958**

SBIR/STTR:

- FY 2015 Transferred: SBIR $3,857; STTR $532
- FY 2016 Projected: SBIR $4,252; STTR $637
- FY 2017 Request: SBIR $3,480; STTR $490

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

Reactor Concepts Research, Development and Demonstration
Explanation of Major Changes ($K)

	FY 2017 vs FY 2016
Light Water Reactor Sustainability: The decrease from $40,000,000 to $35,260,000 reflects a focus on the highest priority research activities in the Materials Aging and Degradation area consistent with the LWRS program plan to support the first subsequent license renewal applications expected to be submitted by industry to the Nuclear Regulatory Commission in 2018.	**-4,740**
Advanced Reactor Technologies: The decrease from $101,718,000 to $73,500,000 reflects completion of the fabrication and preparation activities for the AGR-5/6/7 experiment irradiation; reduced efforts in the areas of advanced reactor materials development and component development applicable to advanced reactor systems; and does not include funding for two ongoing industry cost-shared awards made in early calendar year 2016 to further the development of two performance based advanced reactor concepts.	**-28,218**
Total, Reactor Concepts Research, Development and Demonstration	**-32,958**

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 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 Light Water Reactor Sustainability (LWRS) program is also helping the industry to address current economic challenges by introducing new technologies through its Pilot Plant programs that helps to gain efficiencies and improve safety.

LWRS has partnered with industry and the Nuclear Regulatory Commission (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 to ensure industry pull for new technologies. 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 (EPRI) as documented in a joint research and development plan. Cost sharing with other industry partners is documented in project work agreements.

Since the Fukushima Daiichi accident, the nuclear community has been reassessing safety assumptions and nuclear plant safety performance. As a part of this, Nuclear Energy 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.

Activities and Explanation of Changes

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
Light Water Reactor Sustainability $40,000,000	**$35,260,000**	**-$4,740,000**
• Materials Aging and Degradation – Complete progress report on mechanistic testing for Irradiation Assisted Stress Corrosion Cracking (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. • Safety Margin Characterization – In collaboration with industry, complete a full-	• Materials Aging and Degradation – Develop the scientific basis for understanding and predicting long-term environmental degradation behavior of materials in nuclear power plants. This work will provide data and methods to assess the performance of systems, structures, and components essential to safe and sustained nuclear power plant operations. The research and development (R&D) products will be used to define operational limits and aging mitigation approaches for materials in nuclear power plant systems, structures, and components subject to long-term operating conditions, providing key input to both regulators and industry. This includes research on concrete; RPV embrittlement; cable degradation; weld repair for core internals; mechanisms of IASCC; cracking in nickel-based alloys; swelling, phase transformations and computational thermodynamic techniques for core internals; and harvesting of baffle bolts and RPV materials from decommissioned Zion plant. Continue the development NDE techniques for concrete and cable insulation. Conduct testing of irradiated concrete. • Safety Margin Characterization – Develop and deploy approaches for managing uncertainty in safety margins quantification to improve decision-making for nuclear power plants. This includes developing and demonstrating a risk-assessment method tied to safety margins quantification and creating advanced tools for safety assessment that enable more accurate representation of nuclear power plant safety margins and their associated impacts on operations and economics. The R&D products will be used to produce state-of-the-art nuclear power plant safety analyses that yields new insights on actual plant safety margins and permits cost effective management of these margins during periods of	• The decrease reflects a focus on the highest priority research activities in the Materials Aging and Degradation area consistent with the LWRS program plan to support the first subsequent license renewal applications submitted by industry to the Nuclear Regulatory Commission, expected in 2018.

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
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 Risk-informed Safety Margin Characterization (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 performance to evaluate the reliability of proposed industry Boiling Water Reactor (BWR) hardened venting systems. Complete the initial verification and validation of the RELAP-7 code. Extend the Risk Analysis and Virtual Control Environment (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. • 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	extended operation. Planned funding would support modeling development for external events such as flooding and seismic; external event equipment failure testing to validate physics-based models; development of margins analysis methods; and further RAVEN (simulation controller software) development. Continue the development of the Grizzly tool to simulate component aging and damage evolution of reactor components. • Instrumentation and Controls – Address long-term aging and modernization of current instrumentation and control technologies through development, demonstration, and testing of new instrumentation and control technologies and advanced condition monitoring technologies for more automated and reliable plant operation. This research will be used by industry to design and deploy new instrumentation and control technologies and systems in existing nuclear power plants that enhance understanding of plant operating conditions and available margins and improved response strategies and capabilities for operational events. Planned funding would support continued work on five pilot plant projects: Advanced Hybrid control Room; Automated Work Packages; Digital Architecture for an automated Plant; Outage Risk Management; and Automating Manual Plant Activities along with a new pilot plant project to develop a comprehensive plant physics-based model as the foundation of a Computerized Operator Support System (COSS). It would also support the development of on-line monitoring capabilities for passive components (both concrete and cables) as well as the integration of on-line monitoring capability into other plant automated systems. • Systems Analysis and Emerging Issues – Address emerging issues that could influence the continued viability of existing plants, such as the potential limited supply of Lithium-7 needed for water chemistry control.	

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
collaboration to develop an on-line monitoring capability for passive components. • 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. • 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 (severe accident analysis software tools) 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 Safety Technologies – Develop scientific and technical insights, data, analysis and methods to support industry efforts to enhance nuclear reactor safety for beyond design basis events. Support severe accident modeling uncertainty impacts on SAMGs and Fukushima reactor inspection planning and coordination with international partners.	

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 efforts to reduce long-term technical barriers for advanced nuclear energy systems. In addition, the subprogram supports identification of potential regulatory questions for advanced reactors and engages with Nuclear Regulatory Commission (NRC) to highlight any potential concerns. 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, research and development (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.

Advanced reactor technologies pursued through this program reside at different maturity levels. R&D efforts are mainly focused on three advanced concepts: fast reactors using liquid sodium coolant (SFRs), and two high temperature reactors: the more mature high temperature gas-cooled reactors (HTGRs), and the less mature reactors using liquid salt coolants. High temperature reactor R&D includes qualification of TRISO coated particle fuel and graphite used in HTGRs and salt cooled reactors. R&D is also 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 including supercritical CO_2, and instrumentation and controls). In addition to the R&D activities, initiatives focused on addressing licensing questions specific to non-light water cooled reactors are being conducted in coordination with the NRC and the nuclear industry. ART will continue to solicit and evaluate new ideas in order to encourage innovation, support technology advances, and enhance the safety and performance of advanced reactor systems. The ART Technical Review Panel (TRP) process will continue to be used for engagement with industry to evaluate advanced reactor technologies, identify R&D opportunities and inform future cost-shared R&D investment decisions with a view toward long-term commercialization. Other significant efforts include preliminary planning to implement the direction resulting from the completion of the test/demonstration reactor study.

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.

Activities and Explanation of Changes

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
Advanced Reactor Technologies $101,718,000	**$73,500,000**	**-$28,218,000**
• Fast Reactor Technologies – Complete Mechanism Engineering Test Laboratory (METL) construction and commissioning. Continue testing of gear-on-gear test assembly in water, in preparation for testing in METL. Evaluate concepts for liquid sodium (SFR) control rod drive mechanisms. • High Temperature Reactor Technologies – Continue post-irradiation examination (PIE) of the AGR-3/4 fuel experiment for fission product transport data. Complete Advanced Gas Reactor (AGR)-5/6/7 experiment preparations for final TRISO fuel tests. Continue PIE of Advanced Graphite Creep (AGC)-2 and -3 graphite experiments and continue irradiation of AGC-4 experiment in Advanced Test Reactor (ATR). Complete reconfiguration of Argonne National Laboratory (ANL) Natural Circulation Shutdown Heat Removal Test Facility (NSTF) from air cooled to water cooled to test alternative configuration effectiveness. Perform severe accident analytical methods validation using the Oregon State High Temperature Test Facility. • Advanced Reactor Generic Technologies – Continue the American Society of Mechanical Engineers (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	• Fast Reactor Technologies – Continue METL operations and maintenance for Liquid Metal Reactor (LMR) experiments. Safety analysis code improvements and validation and verification (V&V). Thermal hydraulic and neutronic code development for LMRs. SFR and Lead-Cooled Fast Reactor – Generation IV International Forum (LFR GIF) support and other bilateral international collaborations. • High Temperature Reactor Technologies - Continue TRISO fuel development and qualification. AGR-5/6/7 irradiation begins. Continue AGC graphite qualification. Experimental V&V of models for severe accident heat removal at the ANL NSTF and for core thermal hydraulics using the Oregon State High Temperature Test Facility. High Temperature Reactor (HTR) international activities through GIF, as well as bilateral collaborations. • Advanced Reactor Generic Technologies - Continue development of advanced structural materials for fast reactors including Alloy 709 Code Qualification. Resolve regulatory issues for high temperature materials and develop SiC/SiC for HTR use. Continue experiments on sodium coolant properties. Investigate process heat exchanger development. Continue development of instrumentation and controls specific to advanced reactor concepts. Continue bilateral and multi-lateral (e.g., Generation IV International Forum) efforts on advanced reactor safety, thermal hydraulics, facilities, and other collaborative research. • Activities in support of sCO_2 Crosscut – Perform experiments using the sCO_2 Brayton Cycle Test Article. Finalize scale-up activities for higher power and larger systems. Develop Advanced sCO_2 Recuperators. Continue tests on Small Leak Phenomena. • Advanced Reactor Regulatory Framework – Pursue various initiatives to address licensing questions specific to non-	• The decrease reflects completion of the fabrication and preparation activities for the AGR-5/6/7 experiment; reduced efforts in the areas of advanced reactor materials development and component development applicable to advanced reactor systems; and does not include funding for two ongoing industry cost-shared awards made in early calendar year 2016 to further the development of two performance based advanced reactor concepts.

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
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. • Advanced Reactor Regulatory Framework – Continue engagement with the Nuclear Regulatory Commission (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. • Advanced Reactor System Studies – Complete advanced test/demonstration reactor planning study and begin examining steps to implement identified options. Continue economic analysis study including capital, operations, and fuel costs. • Space and Defense Power Systems - Conduct stewardship activities for legacy special nuclear materials (SNM) and system assets resulting from National Security projects.	light water cooled reactors. Some activities will be performed jointly with the NRC, such as NRC Policy and Key Technical Issue Resolution. Continue support of the International Atomic Energy Agency (IAEA) Coordinated Research Project on High Temperature Gas-Cooled Reactors (HTGR) Safety Design Criteria. Implement research and development (R&D) activities delineated in the ART Regulatory Technology Development Plan. • Advanced Reactor System Studies – Perform activities to implement the results of the Advanced Test/Demonstration Reactor Study pending completion and findings. • Space and Defense Power Systems - Continue stewardship activities for legacy special nuclear materials (SNM) and system assets resulting from National Security projects.	

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 2015	FY 2016	FY 2017
Performance Goal / Measure	**Advanced Reactor Technologies - Complete 90% of annual program milestones to support research to develop technologies and subsystems that are critical for advanced reactor concepts.**		
Target	90%	90%	90%
Result	91%	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 - This program is developing the scientific basis to extend existing nuclear power plant operating life beyond the current 60 year limit. The scientific basis will assist the NRC in making life-extension regulatory decisions.**		
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 receive 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 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 implementing the Administration's *Strategy for the Management and Disposal of Used Nuclear Fuel and High-Level Radioactive Waste (Strategy).* Advancements in fuel cycle technologies and solutions support the enhanced availability, affordability, safety, and security of nuclear-generated electricity in the United States. The FCR&D program also provides technical support for the Department's uranium management policies to mitigate negative impacts on domestic producers from Departmental actions. This includes technical support in developing Secretarial Determinations for the sale or transfer of uranium.

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 also participates in projects sponsored by the International Atomic Energy Agency and the Organization for Economic Cooperation and Development/Nuclear Energy Agency.

Highlights of the FY 2017 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. In FY 2017, the program will progress from the feasibility phase to the development and qualification phase, provided there are feasible accident tolerant fuel concepts that are identified in FY 2016. The program continues to follow the long-term development plan that was provided to Congress in FY 2015.

In January 2013, the Administration released its *Strategy.* Full implementation of the *Strategy's* principles and components requires new legislation; however, the Department continues to implement elements of the Strategy where possible within existing authorities. In March 2015, President Obama authorized the Energy Department to move forward with planning for a separate repository for high-level radioactive waste resulting from atomic energy defense activities. The Secretary announced three specific actions that the Department will undertake – 1) planning for a defense-only repository; 2) planning for interim storage of commercial spent fuel; and 3) moving forward with a consent-based siting process for both types of facilities. In December 2015, the Secretary detailed near-term steps the Department will take on a consent-based siting process, including a series of public meetings and other actions designed to solicit feedback from states, tribal and local governments, and others on the design of a consent-based siting process. In FY 2017, DOE will move forward with the implementation of a consent-based process.

In FY 2016, the Used Nuclear Fuel Disposition subprogram had two components: (1) R&D and (2) Integrated Waste Management System (IWMS). In FY 2017, IWMS activities expand and IWMS becomes a stand-alone subprogram alongside of Used Nuclear Fuel Disposition R&D. Used Nuclear Fuel (UNF) Disposition R&D continues in FY 2017 to conduct generic R&D associated with storage, transportation, and disposal of used nuclear fuel and wastes generated by existing and future fuel cycles. IWMS expands to include all of the activities associated with laying the groundwork to site, design, construct, and operate specific waste management facilities for commercial and defense nuclear waste.

In FY 2017, IWMS consists of two components: (1) Storage & Transportation, and (2) Consent Based Siting. Storage & Transportation pertains to the pilot and consolidated interim storage facilities for commercial used nuclear fuel and a permanent repository for defense high-level waste. Consent Based Siting pertains to the activities required to support the siting of all of the waste management facilities: storage and disposal, commercial and defense.

FCR&D's UNF Disposition R&D subprogram will continue to conduct scientific research and technology development to enable storage, transportation, and disposal of UNF. Because of the evolution of the domestic UNF inventory, special emphasis is placed on understanding the behavior of high-burnup fuels during storage and transportation. In FY 2017, significant funding levels support continuation of R&D on the concept of waste disposal in deep boreholes in crystalline basement rock.

Over the next 10 years, the IWMS subprogram focus will be on the siting, design, licensing, construction, and operation of a pilot interim storage facility with an initial focus on accepting used nuclear fuel from shut-down reactor sites; development of transportation capabilities to facilitate the acceptance of used nuclear fuel at a pilot interim storage facility; and advancing toward the siting and licensing of a larger interim storage facility that will have sufficient capacity to provide flexibility in the waste management system and allows for acceptance of enough used nuclear fuel to reduce expected government liabilities.

In FY 2017, in the IWMS subprogram, the Department is requesting $76.3 million ($61.04 million from Nuclear Waste Fund; $15.26 defense funding) to support preliminary generic process development and other non-R&D activities related to storage, transportation, and consent-based siting; including support for development of a separate repository for defense high-level waste within the Storage and Transportation and Consent-based Siting subprograms. In addition, for the UNF disposition R&D subprogram, the Department requests $74.3 million for storage, transportation, and disposal related research and development.

To support the nuclear waste management program over the long term, reform of the current funding arrangement is necessary 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 2017 Budget Request includes a proposal to implement such reform. Discretionary appropriations are included for the duration of the effort. These funds would be used to fund expenses that are regular and recurring, such as program management costs, including administrative expenses, salaries and benefits, studies, and regulatory interactions. In FY 2017, these funds will be for ongoing studies and outreach efforts associated with transportation and storage through the UNF Disposition waste management system integration subprogram. Discretionary funds will also be used for the separate, permanent repository for defense waste. Mandatory appropriations in addition to the discretionary funding are proposed to be provided annually beginning in 2018 to fund the balance of the annual program costs for managing commercial used nuclear fuel.

Fuel Cycle Research and Development
Funding ($K)

	FY 2015 Enacted	FY 2015 Current[1]	FY 2016 Enacted	FY 2017 Request	FY 2017 vs FY 2016
Fuel Cycle Research and Development					
Material Recovery and Waste Form Development	35,300	33,165	32,950	23,300	-9,650
Advanced Fuels	60,100	58,070	62,100	59,000	-3,100
Systems Analysis and Integration	16,900	17,380	10,500	5,000	-5,500
Materials Protection, Accounting & Control Technology	7,600	7,142	8,050	7,000	-1,050
Used Nuclear Fuel Disposition R&D	49,000	47,724	62,500	74,338	+11,838
Integrated Waste Management System	22,500	22,500	22,500	76,300	+53,800
Fuel Resources	5,600	5,261	5,200	5,000	-200
Total, Fuel Cycle Research and Development	**197,000**	**191,242**	**203,800**	**249,938**	**+46,138**

SBIR/STTR:

- FY 2015 Current: SBIR $5,061; STTR $698
- FY 2016 Request: SBIR $5,439; STTR $816
- FY 2017 Request: SBIR $5,556; STTR $781

[1] Funding reflects the transfer of SBIR/STTR to the Office of Science

Fuel Cycle Research and Development
Explanation of Major Changes ($K)

	FY 2017 vs FY 2016
Materials Recovery and Waste Form Development: The decrease from $32,950,000 to $23,300,000 supports focused near term research including the ongoing US-ROK Joint Fuel Cycle Study, advanced actinide recovery with a focus on co-extraction processing, and waste form development related to iodine-129 and glass corrosion.	**-9,650**
Advanced Fuels: The decrease from $62,100,000 to $59,000,000 the development of enhanced accident tolerant fuel for existing and future light water reactors. The proposed funding supports the transition into Phase 2, Development and Qualification.	**-3,100**
Systems Analysis and Integration: The decrease from $10,500,000 to $5,000,000 supports analyses and evaluations of fuel cycle options of topics that are necessary to guide R&D Campaigns in the near-term. Program assessment and coordination activities will continue to ensure FCR&D is executed effectively.	**-5,500**
Materials Protection, Accounting & Control Technology: The decrease from $8,050,000 to $7,000,000 reflects the narrowing of the scope of R&D for advanced instrumentation to focus on the most promising technologies. Support to electrochemical processing and the used fuel security continue to be priorities of this subprogram.	**-1,050**
Used Nuclear Fuel Disposition R&D: The increase from $62,500,000 to $74,338,000 reflects an increase in funding to support activities to design and certify rail cars for use with anticipated transportation casks, and for activities for testing of high burnup fuel and post-irradiation examination of spent fuel rods for the high burn-up demonstration.	**+11,838**
Integrated Waste Management System: This increase from $22,500,000 to $76,300,000 allows significant progress to be made in working with communities to design and potentially site one or more interim storage facilities for commercial nuclear waste and a permanent repository for defense high-level nuclear waste. Funding will also be used to accelerate the development of a transportation capability to move the commercial spent fuel and defense high-level waste from its current storage location.	**+53,800**
Fuel Resources: The decrease from $5,200,000 to $5,000,000 focuses on the marine testing efforts to speed up the technology development beyond lab scale demonstration.	**-200**
Total, Fuel Cycle Research and Development	**+46,138**

Fuel Cycle Research and Development
Material Recovery and Waste Form Development

Description

The primary mission of the Material Recovery and Waste Form Development (MRWFD) subprogram is to develop advanced material recovery as well as advanced waste form development technologies that improve current fuel cycle performance with minimal processing, waste generation, and potential for material diversion. In addition, MRWFD is increasingly applying the expertise and technical capabilities it has established over the years to a wider array of applications than just separations, including providing solutions for environmental remediation, national security missions, as well as civilian nuclear applications.

Regarding civilian nuclear applications, future ability to achieve sustainably, economically, and non-proliferation attributes for recycle light water reactor fuels and advanced reactor fuels will depend in part on the ability to separate the various elements from the used nuclear fuel into material for reuse and material 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. Its mission is to assess jointly with the Republic of Korea the technical and economic feasibility and nonproliferation acceptability of electrochemical recycling and other options for managing used nuclear fuel. JFCS is divided into three phases and extends over ten years. In FY 2017, JFCS will continue its second phase, known as the Integrated Recycling Test (IRT). The IRT combines the individual process steps to optimize the electrochemical recycling demonstration.

Material Recovery and Waste Form Development

Activities and Explanation of Changes

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
Material Recovery and Waste Form Development		
$32,950,000	**$23,300,000**	**-$9,650,000**
• 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. • 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. • Investigate thermodynamics and kinetics of case study process(es) such as co-extraction of Neptunium/Technetium to better characterize operating window (e.g. optimizing the acidity, temperature) and optimize process performance (understand if extraction of heptavalent technetium will impede the process conditions). • Continue development of U/TRU recovery technologies on solid electro-refining cathode. Fabricate equipment for solid cathode demonstration at kg scale with actual fuel following Joint Fuel Cycle Studies (JFCS) Integrated Recycling Test (IRT) testing. • Perform lab-scale testing with simulants of candidate aqueous processes. • Continue to develop solvent degradation (radiolysis and hydrolysis) evaluations. • Provide software tools and analysis for the	• Pursue advance material recovery technologies under the Sigma Team for Advanced Actinide Recovery of two-step process (heterogeneous) separation with a focus on co-extraction processing. • Continue work under the Sigma Team for Off-Gas with a focus on iodine-129 capture and immobilization. • Pursue the development and demonstration of the efficacy of solid-cathode U/TRU recovery as an alternative to liquid cadmium cathode in electro-refining operations. • Continue the international engagement on glass corrosion rate for reference glass. • Develop advanced on-line monitoring to enable better operation, faster upset recovery and to allow validation of dynamic models. • Provide the design, fabrication, qualification, and installation of the remote sampling/casting system in Hot Fuel Examination Facility (HFEF). It includes subsequent equipment for the loading, welding, and weld inspection of rodlets in the Fuel Manufacturing Facility. • Continue the Phase II IRT in the JFCS, to demonstrate the integration of key unit operation in electrochemical recycling.	• The decrease supports focused near-term research including the ongoing US-ROK Joint Fuel Cycle Study, advanced actinide recovery with a focus on co-extraction processing, and waste form development related to iodine-129 and glass corrosion.

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
tracking of material at risk during operations of the IRT in the Hot Fuel Examination Facility (HFEF). • Provide for the design, fabrication, qualification, and installation of remote, kilogram-scale process equipment in the HFEF. • Investigate critical technical topics (related to fuel fabrication) to enable the success of the IRT, or to enable determination of the long-term technical and economic feasibility and non-proliferation acceptability of electrochemical recycling. • Establish the technical basis for an international consensus glass corrosion rate for reference glass. Explore advanced on-line process monitoring at H-Canyon.		

Fuel Cycle Research and Development
Advanced Fuels

Description

The development of advanced nuclear fuels is a major objective for both existing light water reactors (LWR) and the entire spectrum of advanced nuclear energy systems. The development of advanced fuels is an essential part of certain future 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) development over the long term of transmutation fuels with enhanced proliferation resistance and resource utilization. The Advanced Fuels subprogram sustains core fuel development and experimental capabilities that also support the nuclear reactor technologies described in the Office of Nuclear Energy's Reactor Concepts Research, Development, and Demonstration program.

In FY 2017, the program continues aggressive support of high-priority accident tolerant fuel (ATF) and clad concepts that are capable of achieving the objective of irradiating test rods or an assembly in a commercial power reactor by 2022. This requires an increased level of fuel fabrication and testing, including irradiations in the U.S. and foreign reactors (Advanced Test Reactor (ATR), Halden), steam environments, furnaces, and mechanical property testing. A lower-level of feasibility research will continue on longer-term concepts that, while unable to achieve the 2022 objective, show significant promise of improving beyond current LWR fuels. These activities, for both near-term and longer-term concepts, also include establishing modeling capability for these new concepts (largely developed from existing models) 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 major activity in 2017 will be initiating the second phase of fuel development, including utilization of the pressurized loop testing capability in the Advanced Test Reactor developed in 2016 and preparing for transient testing in the TREAT transient experiment facility once operational.

Furthermore, in FY 2017, development of the long term transmutation fuel also continues with irradiations, development of fabrication techniques, material testing capability enhancement, associated model development, and coordination with the NE nuclear modeling and instrument development programs. As always, major cooperation with U.S. universities through the Nuclear Energy University Program and Integrated Research Project programs will be pursued in a way that supports all of our priority advanced fuel development activities.

Activities and Explanation of Changes

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
Advanced Fuels $62,100,000	**$59,000,000**	**-$3,100,000**
• Initiate post irradiation examination (PIE) on first set of industry-led ATF-1 fuel-clad samples. • Select and prioritize ATF technologies for phase 2 development and qualification towards lead fuel rod or lead fuel assembly irradiation. • Continue planning for a Halden reactor irradiation test on ATF-related FeCrAl cladding material to start in late 2016. • Continue development of remote casting of metallic fuel samples. • Initiate PIE on PHENIX-irradiated advanced cladding materials (total dose up to 70 dpa). • Complete FUTURIX-FTA baseline PIE and issue report. • Issue update to the transmutation fuels handbook. • Fabricate fuels which incorporate integral fuel cladding chemical interaction barriers. • Continue development of processing techniques for next generation cladding materials. • Continue preparations for Am-target irradiation tests in ATR in collaboration with Commissariat à l'Énergie Atomique (CEA) et aux Énergies Alternatives. • Continue preparations for China Experimental Fast Reactor irradiation of advanced cladding materials through the U.S.-China bilateral agreement. • Continue development of BISON code applications for ternary metallic fuels. • In support of ATF FeCrAl development, analyze separate effects test data for irradiation induced	• Perform cycle to cycle analysis and management of ATF concept irradiations. Capsules of potential ATF fuel concepts will be inserted and removed from the ATR as needed. • Initiate Phase 2 development and testing of high-priority ATF fuel and cladding concepts. • Continue lower-level, focused research on promising, but longer-term ATF fuel and cladding concepts. • Test in high density, high performance ceramic fuels (silicide, nitride, boride, enhanced thermal conductivity) having enhanced performance in accident conditions for LWRs and which also enable changes in cladding and core materials - R&D across multiple laboratory organizations supporting the development of innovative accident tolerant fuels. • Conduct research on the construction and deployment of a high temperature steam exposure and oxidation apparatus for severe accident simulation in a radioactive hot cell environment. • Perform Fuel fabrication to support the continued development of fabrication processes for minor actinide bearing metallic fuels. Includes fabrication of metal alloy compositions for irradiation testing, characterization, and testing. Possible support for continuous casting Cooperative Research and Development Agreement with industry. • Conduct activities on minor actinide bearing metal	• The decrease supports the transition in FY 2017 from the feasibility phase to the development and qualification phase, provided there are feasible accident tolerant fuel concepts that are identified in FY 2016. The development and qualification phase involves a scaling up of experiments, analyses, and fabrication of material for a small number of the most promising concepts that are identified in the feasibility phase.

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
creep and incorporate results to fuel performance code. • Continue development needed to demonstrate electron probe micro-analyzer capability on irradiated fuel in Irradiated Materials Characterization Laboratory. • Complete design of test train for irradiation of ATF concepts in ATR water loop 2A. Initiate fabrication of loop experiment hardware. • Complete conceptual design of TREAT water loop. Initiate acquisition of TREAT experiment support hardware.	alloy fuel composition characterization for mechanical, physical, and thermal properties. • Continue collaborations with CEA on Am-Bearing Blanket irradiation test. • Perform irradiation and PIE on advanced metallic fuel concepts. • Continue developments of modeling tool for analysis of transmutation fuels. • Research and development on advanced cladding for transmutation fuels.	

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 to provide information that can be used to objectively and transparently inform decision makers about overall research and development (R&D) directions and to integrate activities through R&D efforts on common fuel cycle goals.

The Systems Analysis and Integration subprogram also includes program assessment and coordination activities that ensure the R&D pathways being explored in the various subprograms are well integrated, executed effectively, and aligned with the overall mission of the Office of Nuclear Energy.

Activities and Explanation of Changes

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
Systems Analysis and Integration $10,500,000	**$5,000,000**	**-$5,500,000**
• 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. • 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. • Continue global impacts/benefits analyses tying nuclear energy to reducing greenhouse gas emissions. • 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. • Analyze fuel cycles using small modular reactors (Light Water Reactor, High Temperature Gas-cooled Reactor, Sodium-cooled Fast Reactor) in the transition period for fuel cycle deployment for the promising options identified by the Evaluation and Screening Study. • Working with R&D campaigns, analyze specific technology options to narrow the R&D focus. • 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.	• Coordinate with the FCR&D campaigns to develop scoping technology maturation plans for candidate technologies and assess the overall development risk. • Continue analysis of transition from the current fuel cycles to the smaller set of promising fuel cycles as identified by the Evaluation and Screening Study and analyze sets of technology specific options for the most promising fuel cycle options. • Provide analysis of system impacts of candidate Accident Tolerant Fuel concepts in the Advanced Fuels subprogram leading up to the lead test assembly demonstration. • Develop improved cost estimates with lower uncertainty for assessment of economic competitiveness of the most promising fuel cycles. • Continue to maintain the publicly-available Fuel Cycle Catalog. • Maintain the document management database for FCR&D deliverables. Maintain portals, Sharepoint, and other technology for information exchange. • Continue to provide management and administration, program controls, and program support to the FCR&D program.	• In FY 2017, Systems Analysis and Integration will limit its portfolio of analyses and evaluations of fuel cycle options to only the most critical topics that are necessary to guide R&D Campaigns in the near-term. Program assessment and coordination activities will continue to ensure FCR&D is executed effectively.

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
• Continue to provide management and administration, program controls, and program support to the FCR&D program.		

Fuel Cycle Research and Development
Materials Protection, Accounting & Control Technology

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 here in the United States.

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, which 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.

Materials Protection, Accounting & Control Technology

Activities and Explanation of Changes

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
Materials Protection, Accounting and Control Technology $8,050,000	**$7,000,000**	**-$1,050,000**
• Develop and demonstrate advanced sensors and instrumentation to fill gaps in materials protection, accounting and control technologies. • For electrochemical processing, develop and demonstrate an integrated suite of sensors and instruments (e.g., actinide sensor, level/density sensor, microfluidic sampler), and analysis and performance assessment tools (e.g., fundamental models, pattern recognition and statistical inference methods, facility performance models). • Develop and demonstrate concepts and approaches and associated technologies and analysis tools for safeguards and security of used fuel extended storage. • Evaluate additional process monitoring (voltammetry) for safeguards utilization. • Develop advanced sensors for neutron detection (e.g., solid state) applicable to both monitoring and assay applications. • Continue international engagement to help influence and support the advanced safeguards of the nuclear energy enterprise.	• Develop and demonstrate advanced sensors and instrumentation to fill gaps in materials protection, accounting and control. • Perform exploratory R&D for new sensor materials and applications. • Execute field tests of sensors and instrumentation. • Develop and demonstrate an integrated suite of sensors, instruments, and analysis and performance assessment tools for electrochemical processing. • Development and demonstrate concepts and approaches, and associated technologies and analysis tools for safeguards and security. • Optimize the safeguards and security efforts of the spent fuel storage facilities. • Initiate planning for distributed test bed lab-scale process monitoring and safeguards demonstration.	• The decrease is due to narrowing of the scope of R&D for advanced instrumentation to focus on the most promising technologies. Support to electrochemical processing and the Integrated Waste Management System continue to be priorities of this subprogram along with a small number of the most promising advanced instrumentation technologies.

Fuel Cycle Research and Development
Used Nuclear Fuel Disposition R&D

Description

This subprogram supports research and development (R&D) to identify alternatives and conduct scientific research and technology development to enable long term storage, transportation, and disposal of used nuclear fuel and wastes generated by existing nuclear fuel cycles. Activities necessary to 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 are included in the Integrated Waste Management System subprogram.

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. The activities include collaborations with international partners to leverage applicable R&D being conducted by other countries. Also, evaluations will be completed to determine the feasibility of directly disposing existing single (storage only) and dual-purpose (storage and transportation) spent-fuel canisters in a mined repository.

Deep Boreholes – Research and development of waste disposal in deep boreholes in crystalline basement rock as one alternative for disposal is a high priority for the Department, and activities and funding ($25,500,000) is maintained at a significant level in FY 2017 to continue the Deep Borehole Field Test. 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). Should this technology prove viable for small waste packages, waste canisters could 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. The Department will continue a field test that began in FY 2016.

Full-Scale Storage Cask project – Although the nuclear power industry has used dry storage for years, this storage has been for low burn-up fuel and there is less data for more contemporary high burn-up fuels. Because all fuel being removed from reactors today is high burn-up fuel, there is agreement among the Department, the Nuclear Regulatory Commission (NRC), and industry to investigate extended storage of high burn-up fuels (≥ 45 GWd/MTHM). The Department, in cooperation with NRC and industry, has begun a full-scale demonstration of storage for high burn-up fuel to support NRC storage license extensions and eventual transport of high burn-up fuel. The full-scale cask demonstration project 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. Aging effects that could be missed in short-term studies may become apparent in this long term demonstration. Post-irradiation examinations at the Department of Energy laboratories will provide the necessary data to analyze these aging effects. The full-scale demonstration will use various fuel and cladding types in use by industry.

Storage and Transportation R&D – In addition to the Full-Scale Storage Cask project, other lab testing, field studies, and modeling R&D related to the storage and transport high burn-up 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 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. Through this R&D, the Department will be able to evaluate alternative technologies that can safely and securely reduce costs associated with storage and transportation of commercial used nuclear fuel.

Adapt Idaho National Laboratory (INL) Facilities – Adapt INL facilities in order to handle and examine existing large dry storage casks that are already housed at INL. Assessments made in FY 2015 were positive regarding the feasibility of adapting INL facilities for this mission. Activities in FY 2017 continue the work begun in FY 2016.

In the FY 2017 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.

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 will address identified challenges in the subsurface through highly focused and coordinated research in Wellbore Integrity, Subsurface Stress State and Induced Seismicity, Permeability Manipulation, and New Subsurface Signals to enhance renewable energy supply, ensure material impact on climate change via CO_2 storage, and significantly mitigate environmental impacts from energy-related subsurface activities and operations.

The Office of Nuclear Energy's (NE) funding request will support the following activities relevant to subsurface engineering: continuation of a field test to support R&D on the concept of waste disposal in deep boreholes in crystalline basement rock, and research, development, and demonstration (RD&D) on characterization and performance of generic mined geologic repository media and concepts for disposal of high-level radioactive waste and used nuclear fuel.

Activities and Explanation of Changes

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
Used Nuclear Fuel Disposition R&D $62,500,000	**$74,338,000**	**+$11,838,000**
• 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. • Lead the interface with the Department 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, the Department, and industry. • 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. • 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. • Develop modeling approach and toolset for modeling of fuel and cladding in in storage and transportation environments and uncertainty quantification methodology to quantify degradation mechanisms during storage and transportation of high-burnup fuels. • 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	• Collaborate with industry in designing/fielding a dry storage cask demonstration. • Continue testing of fuel rods that were pulled from a commercial power station to establish the performance baseline of the stored used fuel. • Characterize external loadings on fuel rods during normal conditions of transport. • Continue activities on a deep borehole field test. The activities are designed to advance the science and engineering technical basis for the disposal used nuclear fuel in a deep borehole as an alternative to mined geologic repositories. • Develop an understanding of material degradation phenomena in safety components associated with long term storage and transportation systems. This work will support licensing applications for extended dry storage and subsequent retrieval and transport of high burnup used nuclear fuel. • Evaluate integration and implementation methodologies of process-level models with performance assessment tools relating to argillite disposal. Interface developed modeling tools with analysis software for uncertainty quantification and sensitivity analysis. • Continue science and engineering technical basis for the disposal of heat generating waste in salt through additional field testing. • Evaluate and develop designs specifically suitable for U.S. disposal requirements that consider not only post-closure safety but also operational safety and efficiency, economics, transportation	• The increase reflects additional funding to support activities to design and certify rail cars for use with anticipated transportation casks, for activities for testing of high burnup fuel and post-irradiation examination of spent fuel rods for the high burn-up demonstration, and for R&D on technologies that may safely and securely reduce costs associated with storage and transportation, and for R&D activities associated with exploring potential alternative disposal options for various waste and spent nuclear fuel forms.

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
borehole seals research and planning. • 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. • 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. • Perform experiments to develop the technical bases for the extended storage and transportation of used nuclear fuel, especially high-burnup fuel. • Perform analysis and experiments to evaluate fuel rod performance during truck and rail transport, collaborating with industry to ship an instrumented surrogate pressurized water reactor assembly to conduct a shaker test. • Develop a disposal system modeling and analysis capability that supports the prioritization of Disposal Research R&D and the evaluation of disposal system performance, including uncertainty, for a range of disposal options (e.g., salt, argillite, crystalline, deep borehole). • Design and research alternative safety approaches for the development of standardized transportation, aging, and disposal canisters for used nuclear fuel. • Evaluate design alternatives and conduct preliminary design activities for a used nuclear fuel transloading capability supporting research purposes for fuel currently stored at INL. • Continue activities related to acquisition of transportation rolling stock, transportation casks, and ancillary equipment, including preliminary design and acquisition of prototype rail cars for	and storage options, and U.S. geologies, inventory, and regulations. • Continue to support standardized canister work and the development of cask transloading capability of used fuel currently stored at INL. • Design, test, and fabricate prototype cask and buffer railcars, in accordance with the Association of American Railroads Standard for trains that carry high-level radioactive material. • Continue R&D activities associated with exploring potential alternative disposal options for various waste and spent nuclear fuel forms.	

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
testing. • Continue activities associated with exploring potential alternative disposal options from some DOE-managed HLW and SNF.		

Fuel Cycle Research and Development
Integrated Waste Management System

Description

This subprogram is developing and implementing the design of an integrated waste management system (IWMS). The Department began work in FY 2012 to lay the groundwork that could lead to one or more facilities for spent fuel management using a consent-based siting program and would 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)* and all of the activities in this subprogram support this *Strategy*. Full implementation of the *Strategy* requires legislation; however, in the meantime, the Department is taking action on the *Strategy* to the extent possible within existing authorities.

Starting in FY 2017, the IWMS subprogram is organized into two distinct activities:

1) Storage and Transportation – Activities include the development of generic design alternatives for interim storage as an integrated component of a waste management system and the preparation for large-scale transportation of spent nuclear fuel and high-level radioactive waste, with an initial focus on removing spent nuclear fuel from shutdown reactor sites. The subprogram will also explore options for a separate, permanent repository for defense high-level nuclear waste.

2) Consent Based Siting – Plan for and establish a credible, stable and foundational consent based siting (CBS) process for one or more facilities for spent fuel management. In December 2015, the Secretary of Energy detailed near-term steps the Department will take in the development of a CBS process, including a series of public meetings and other actions designed to solicit feedback from states, tribal and local governments, and others on the design of the process. In FY 2017, DOE will move forward with the implementation of a CBS process for both commercial and defense high-level nuclear waste.

To support the nuclear waste management program over the long term, reform of the current funding arrangement is necessary 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 2017 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 2017, the Department is requesting $76.3 million ($61.04 million from Nuclear Waste Fund; $15.26 million defense funding) for integrated waste management system subprogram activities to support preliminary generic process development and other non-R&D activities related to storage, transportation, and consent-based siting; including support for development of a separate repository for defense high-level waste. Mandatory appropriations in addition to the discretionary funding are proposed to be provided annually beginning in 2018 to fund the balance of the annual program costs for managing commercial used nuclear fuel.

Integrated Waste Management System

Activities and Explanation of Changes

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
Integrated Waste Management System $22,500,000	**$76,300,000**	**+$53,800,000**
Storage & Transportation $22,500,000 • 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. • Prepare for large-scale transportation of UNF to facilitate the acceptance of UNF at a pilot ISF within the next ten years. • 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. • 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. • Expand and maintain the Used Nuclear Fuel Storage, Transportation & Disposal Analysis Resource and Data System (UNF-ST&DARDS) database. • Initiate a Topical Safety Analysis Report (TSAR) for a generic design of a pilot interim storage facility and prepare to respond to requests for additional information from the NRC.	*Storage & Transportation $36,900,000* • Develop generic design concepts for various bare fuel storage configurations. • Complete a generic (not site-specific) pilot ISF design and associated TSAR, and submit the TSAR for NRC review. • Develop a generic design concept for a small inspection and/or remediation capability for potential deployment with the ISF. • Develop a generic design concept for a supporting laboratory that could be used to open large dry storage casks and perform examinations on the spent nuclear fuel removed from them. • Develop generic design concepts for transferring fuel assemblies from dual purpose canisters (DPC) to disposal canisters. This facility would have the capability to open all the DPCs and package the fuel into disposal containers. • Develop design concepts for transportation fleet maintenance and transportation cask maintenance facilities to support system studies necessary for make/ buy decisions. • Develop and maintain functional and operational requirements for the overall waste management system, the pilot ISF, the larger ISF, and the transportation system. • Determine and address Aging Management needs for the pilot ISF and beyond. • Review existing transportation cask CoCs to identify items for confirmation and/or resolution prior to transportation, with priority on the	*Storage & Transportation +$14,400,000* • This increase allows significant progress to be made in the development of generic design concepts for components that would support a future interim storage facility for commercial used nuclear fuel and a permanent repository for defense high-level waste. These components would include a bare fuel storage module, an inspection/remediation capability, a laboratory, a repackaging capability, and a transportation fleet/transportation cask maintenance capability. The increase in funding would also support the accelerated development of a transportation capability to move the spent fuel and high-level waste from its current storage location.

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
• Work with State Regional Groups and Tribes (SRG+T) to plan transportation activities including evaluation of approaches to implement requirements to provide funds and training to public safety officials of units of government through whose jurisdiction UNF may be transported.	systems that may be used to remove SNF from the shutdown reactor sites. • Review existing storage cask licenses to summarize their range of relevant licensing conditions and parameters. • Engage NRC staff to discuss current regulatory requirements and guidance, identify and understanding emerging regulatory issues, and improve understanding relative to regulatory interpretations and implications for interim storage and transportation licensing. • Develop and evaluate potential National Environmental Policy Act (NEPA) strategies to inform policy makers. • Prepare draft (non-site specific) scoping document for an environmental impact statement (EIS) for interim storage, identify gaps. • Procure EIS contractor and initiate preparation of EIS for Interim Storage. • Continue to work with SRG+T to develop policy on how to provide funds and training to public safety officials of units of government through whose jurisdiction UNF may be transported. • Develop and execute a Tabletop Exercise to generate lessons learned for future implementation on potential policy on how to provide funds and training to public safety officials of units of government through whose jurisdiction UNF may be transported. • Conduct detailed planning on how to provide funds and training to public safety officials of units of government through whose jurisdiction UNF may be transported utilizing the established process to begin preparations for grants. • Develop transportation routing methodology and	

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
	interface with stakeholders. Establish transportation routes to nearest Class I railroads. • Evaluate and develop plans to ship UNF from reactor sites - shutdown sites first, establish near-reactor transportation route capability for UNF transport, and establish Utility transportation route capability for UNF transport. • Conduct system analyses to evaluate an integrated approach to transportation, storage, and disposal in the waste management system with an emphasis on providing flexibility to respond to unknown situations and developments. • 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. • Expand and maintain the Used Nuclear Fuel Storage, Transportation & Disposal Analysis Resource and Data System (UNF-ST&DARDS) database.	
Consent Based Siting $0 • Limited planning activities are included in Storage & Transportation.	*Consent Based Siting $39,400,000* • Engage in Consultation & Cooperation (C&C) activities with public and stakeholders during ISF siting (hold public meetings, review/award grants, etc.). • Collect and verify needed site characterization data (to support future NEPA compliance, design, and licensing) and conduct site characterization analyses. • Conduct consent negotiations with stakeholders	*Consent Based Siting +$39,400,000* • This increase will allow for significant progress to be made in creating a dialogue with communities interested in potentially hosting a future interim storage site or repository. Activities would be focused on setting up the framework of the consent based siting process, providing grants, and engaging with interested communities to initiate a preliminary screening of candidate sites. Funding would support the hosting of several

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
	(States, Tribes, Affected Local Governments) as defined in siting process. • Draft a legally-binding agreement which would likely include terms and conditions under which the community is willing to host an interim storage facility (ISF) (i.e. consent). • Develop planning and strategy documents associated with public outreach tied to interim storage, Defense Waste disposal, and transportation of commercial used fuel and the Department of Energy wastes from current storage locations and configuration. • Conduct test/focus groups for communication products and messages. Provide education and outreach articles to public. • Continue public surveys and associated analysis of public preferences related to siting, characterization, and operation of radioactive waste management facilities for storage and disposal. • Complete and issue grants/funding to State Regional Groups, Tribes related to consent-based siting. • C&C planning and strategy development for ISF and Defense Repository. • Draft a consent-based siting process for a defense repository and ISF that takes into account lessons learned from previous siting processes of radioactive waste management facilities both domestically and abroad. Consultations with stakeholders on siting process. • Prepare for Initial Site Screening Process for Defense Waste Repository. • Conduct preliminary screening of candidate sites - Defense Waste Repository. Includes site selection	public meetings to seek feedback from interested entities on the development and implementation of the siting process.

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
	for preliminary field studies; preliminary field investigations; site work and preliminary safety assessments to support site selection.	

Fuel Cycle Research and Development
Fuel Resources

Description

The Fuel Resources subprogram seeks to identify and implement actions the Department can take to assure that economic nuclear fuel resources remain available. The program will evaluate nuclear fuel resources and develop recovery technologies to enable increased fuel resources. Priority attention in the near term will focus on developing the technology for extraction of uranium from seawater. Seawater contains more than 4 billion tons of dissolved uranium. This unconventional uranium resource, combined with a suitable extraction cost, can potentially provide a price cap and ensure centuries of uranium supply even with aggressive world-wide growth in nuclear energy applications. A key objective is to develop advanced adsorbent materials that can simultaneously enhance uranium sorption capacity, selectivity, kinetics, and materials durability to reduce the technology cost and uncertainties.

The strategy is to take advantage of recent developments in (1) high performance computing, (2) advanced characterization instruments, and (3) nanoscience and nano-manufacturing technology to enable technical breakthroughs. The technology-driven, science-based research and development 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.

In FY 2017, the subprogram will continue the efforts in innovative nano-material development, marine testing, and material durability evaluation in real seawater environments. Innovative nano-material may provide a quantum leap in uranium sorption capacity, which in turn will lead to dramatic cost reductions for seawater uranium recovery technology. Recycling of adsorbent materials for repeated uses will reduce the technology costs. It is critical to understand the durability of the material in seawater environments.

Currently, all experiments are conducted in the laboratory settings using natural seawater. The goal is to eventually evaluate the performance of newly developed adsorbent in real marine current environments. In FY 2017, the subprogram will initiate limited testing at Pacific Northwest National Laboratory's Marine Science Laboratory, building on an existing facility at Sequim Bay.

Activities and Explanation of Changes

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
Fuel Resources $5,200,000	**$5,000,000**	**-$200,000**
• 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. • Use computational modeling to identify promising ligands for increased uranium capacity and selectivity. • Utilize data from the marine testing of developed adsorbents at marine test sites to formulate engineering models of kinetic and equilibrium mechanisms. • Evaluation of desorption methods and characterize the recycling of adsorbent materials and mechanisms of degradation. • Develop adsorbent materials on high-surface area nanoporous substrates containing functional ligands for selective sorption of uranium from seawater.	• Advanced adsorbent development by irradiation-induced grafting - Prepare polymer-based adsorbents by irradiation (e-beam) induced and chemical grafting methods. • Improve uranium selectivity by studying the chemistry and mechanisms that enable the development of sites tailored for uranium retention. • Increase the reaction kinetics to reduce the time adsorbents are required to be exposed to seawater. • Continue to enhance material durability and reusability by reducing material degradation. • Marine Testing - Conduct off-shore marine testing to evaluate the performance of adsorbent materials in real seawater current conditions. • Perform advanced computer modeling for chemical speciation and ligand design to enhance uranium selectivity.	• The decrease from $5,200,000 to $5,000,000 focuses on the marine testing efforts to speed up the technology development beyond lab scale demonstration.

Fuel Cycle Research and Development
Capital Summary ($K)

	Total	Prior Years	FY 2015 Enacted	FY 2015 Current	FY 2016 Enacted	FY 2017 Request	FY 2017 vs FY 2016
Capital Operating Expenses Summary (including (Major Items of Equipment (MIE))							
Capital Equipment > $500K (including MIE)	n/a	n/a	2,300	2,300	0	0	0
Plant Projects (GPP and IGPP) (<$10M)	n/a	n/a	0	0	0	0	0
Accelerator Improvement Projects (AIP) (<$5M)	n/a	n/a	0	0	0	0	0
Total, Capital Operating Expenses	**n/a**	**n/a**	**2,300**	**2,300**	**0**	**0**	**0**
Capital Equipment > $500K (including MIE)							
Electron Probe Micro-Analyzer	4,500	n/a	1,300[1]	1,300	0	0	0
Glovebox and hoods	1,650	n/a	1,000	1,000	0	0	0
Total, Capital Equipment (including MIE)	**6,150**	**n/a**	**2,300**	**2,300**	**0**	**0**	**0**
Plant Projects (GPP and IGPP) (Total Estimated Cost (TEC) <$10M)							
Total Plant Projects (GPP/IGPP) (Total Estimated Cost (TEC) <$5M)	822	n/a	0	0	0	0	0
High Density Fuel Glovebox	822	n/a	0	0	0	0	0
Total, Plant Projects (GPP/IGPP) (Total Estimated Cost (TEC) <$10M)	**822**	**n/a**	**0**	**0**	**0**	**0**	**0**
Total, Capital Summary	**6,972**	**n/a**	**2,300**	**2,300**	**0**	**0**	**0**

[1] The FY 2015 equipment purchase is 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.

Nuclear 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 2015	FY 2016	FY 2017
Performance Goal / Measure	**Fuel Cycle R&D - Complete 90% of annual program milestones to support the long-term mission to develop options to the current commercial fuel cycle management strategy.**		
Target	90%	90%	90%
Result	94%	N/A	N/A
Endpoint Target	The R&D milestones represent progress toward several key fuel cycle outcomes: (1) Support the Administration's waste management strategy to begin operation of a pilot interim storage facility by 2021 and a larger interim storage facility by 2025, and make 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 in 2022; (3) Perform long-term R&D on advanced technologies that could lead to the next generation of sustainable fuel cycle options that have the potential to improve resource utilization and energy generation, reduce waste generation, enhance safety, and limit proliferation risk.		

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 includes a strong investment in modeling and simulation tools to bring 30 years of improved computational and material science to reactor and fuel system simulation. The results will provide advanced codes and methods to researchers, designers, and operators, helping them to better understand the behavior of nuclear energy systems in order to improve their safety, economics, and efficiency. Additionally, the program provides access to unique nuclear energy research capabilities through its Nuclear Science User Facilities (NSUF). Finally, Nuclear Energy Traineeships assesses workforce needs in critical, focused nuclear energy related fields. Collectively, NEET-sponsored activities advance the state of nuclear technology and just as importantly, support the goals, objectives and activities of the Gateway for Accelerated Innovation in Nuclear (GAIN) initiative to make these advances accessible to industry engineers and scientists in a public-private partnership so that they can best use them to assure that nuclear energy remains a competitive option for meeting our Nation's energy and environmental challenges.

These activities create the basis for improvements in safety, performance, reliability, economics, and proliferation risk reduction. They complement activities within the Reactor Concepts Research, Development and Demonstration (RD&D) and Fuel Cycle R&D programs by developing innovative solutions applicable to various 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.

Highlights of the FY 2017 Budget Request

The FY 2017 budget continues to support on-going initiatives including the third year of the final five-year term of the Nuclear Energy Innovation Hub in Modeling and Simulation (Hub) and the continuing Nuclear Energy Advanced Modeling and Simulation (NEAMS) subprograms.

FY 2017 will mark the third year in which Cybersecurity R&D has been sponsored under NEET Crosscutting Technology Development (CTD). The Internet of Things is increasingly under attack making our Nation's power generation and transmission infrastructure, including nuclear, vulnerable. FY 2017 investments will continue to be guided by the needs of industry and government to ensure safe and reliable nuclear energy.

Nuclear Energy Traineeships address priority DOE science, technology, engineering, and mathematics (STEM) nuclear energy workforce needs by focusing on advancing critical STEM disciplines and competencies to support NE mission responsibilities. In FY 2017, NE will plan and execute a formal study to evaluate the need to implement traineeships for focused topical areas to address its mission-specific and critical workforce needs.

Nuclear Energy Enabling Tehcnologies
Funding ($K)

	FY 2015 Enacted	FY 2015 Current[1]	FY 2016 Enacted	FY 2017 Request	FY 2017 vs FY 2016
Nuclear Energy Enabling Technologies					
Crosscutting Technology Development	14,000	13,605	17,000	17,185	+185
Nuclear Energy Advanced Modeling and Simulation	26,200	25,335	27,200	23,740	-3,460
Energy Innovation Hub for Modeling and Simulation	24,300	23,431	24,300	24,300	0
Nuclear Science User Facilities	36,500	35,295	41,100	23,285	-17,815
Nuclear Energy Traineeships	0	0	2,000	1,000	-1,000
Total, Nuclear Energy Enabling Technologies	**101,000**	**97,666**	**111,600**	**89,510**	**-22,090**

SBIR/STTR:

- FY 2015 Transfer: SBIR $2,929; STTR $404
- FY 2016 Projected: SBIR $3,288; STTR $493
- FY 2017 Request: SBIR $2,865; STTR $403

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

Nuclear Energy Enabling Technologies
Explanation of Major Changes ($K)

	FY 2017 vs FY 2016
Crosscutting Technology Development: The increase from $17,000,000 to $17,185,000 continues industry outreach in cybersecurity and aligns subprogram investments in applied research and development to support the capability enhancement goals, objectives and activities of the Gateway for Accelerated Innovation in Nuclear (GAIN) initiative.	**+185**
Nuclear Energy Advanced Modeling and Simulation: The decrease from $27,200,000 to $23,740,000 reflects the completion of assessment of two High Impact Problems initiated in FY 2015.	**-3,460**
Energy Innovation Hub for Modeling and Simulation: No significant changes.	**0**
Nuclear Science User Facilities: The decrease from $41,100,000 to $23,285,000 reflects the completion of $20,000,000 of activities funded by Congress above the FY 2016 request and $2,185,000 to support additional new competitive awards to facilitate access to unique nuclear energy research capabilities and also to establish and sustain a single point of easy access to the broad range of capabilities, including, people, facilities, materials and data, across the DOE complex to be made available to entities working to commercialize innovative systems and components via the GAIN initiative.	**-17,815**
Nuclear Energy Traineeships: The decrease from $2,000,000 to $1,000,000 reflects the initiation of a formal study to evaluate the need to implement traineeships for focused topical areas to address NE's mission-specific and critical workforce needs.	**-1,000**
Total, Nuclear Energy Enabling Technologies	**-22,090**

Crosscutting Technology Development

Description

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, including, as appropriate, capability enhancements that support the goals, objectives and activities of the Gateway for Accelerated Innovation in Nuclear (GAIN) initiative. 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 is coordinated with NE's other R&D programs to ensure that developed technologies and capabilities are part of an integrated investment strategy aimed at improving safety, security, reliability, and economics of operating and future nuclear power plants.

Characteristics of the 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 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
Crosscutting Technology Development		
$17,000,000	**$17,185,000**	**+$185,000**
• 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, and nuclear cybersecurity; as well as other innovative and crosscutting topics based on quality of proposed topics and identified need. • Competitively solicit and award strategic infrastructure investments at national laboratories that will not only benefit crosscutting R&D but also identified needs of NE other R&D programs. • Support finalization of the initial Hybrid Energy Systems (HES) technology development roadmap and complete go/no-go assessment on NE-Renewable Energy hybrids as a solution.	• Competitively solicit and award new multi-year R&D projects in high priority crosscutting R&D areas including, advanced sensors and instrumentation, advanced methods for manufacturing to reduce the cost of constructing light water reactors, transient testing R&D, and nuclear cybersecurity; as well as other innovative and crosscutting topics based on quality of proposed topics and identified need. • 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. • Support detailed dynamic assessment of HES cases if go/no-go assessment results in program continuation; working toward technology roadmap execution following go/no-go assessment related to component testing. • As appropriate, invest in capability enhancements that support the goals, objectives and activities of the Gateway for Accelerated Innovation in Nuclear (GAIN) initiative. • Establish a government and industry joint working group on nuclear energy cyber security.	• The increase in funding will allow for greater investment in additional technical areas of high priority crosscutting R&D areas, e.g., reducing the cost of constructing light water reactors, and the GAIN initiative.

Nuclear Energy Advanced Modeling and Simulation (NEAMS)

Description

NEAMS develops advanced modeling and simulation tools that support NE programs such as the Advanced Reactor Technologies subprogram and the Fuel Cycle R&D programs. NEAMS engages scientists and engineers in developing state-of-the-art, multi-scale models of physics and chemistry that drive advanced computational methods for simulations of nuclear energy systems. NEAMS is developing a computational ToolKit which is comprised of both reactor and fuel systems analysis capabilities. These capabilities can be coupled or run stand-alone, 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. As the NEAMS ToolKit matures, NEAMS will support the application of the ToolKit to address NE program priorities, such as the resumption of experimental activities in the Transient Reactor Test (TREAT) facility.

In FY 2017, 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.

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.

Activities and Explanation of Changes

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
Nuclear Energy Advanced Modeling and Simulation		
$27,200,000	**$23,740,000**	**-$3,460,000**
• Enhance the capabilities of the Fuels Product Line; release BISON and MARMOT updates with transient testing improvements. • Enhance the capabilities of the Reactors Product Line; release SHARP update with integration, computational efficiency, and usability updates based on early user experience; issue initial SHARP validation and assessment report. • 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. • 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. • Extend current modeling and simulation efforts for TREAT mission support to include MOOSE updates to accelerate methods for TREAT calculations, accelerated transition to full core plus experiment modeling and validation, and experiment design for future validation work.	• Continue enhancement of NEAMS Fuels Product Line capabilities; release MARMOT and BISON code updates and validation assessments. • Continue enhancement of NEAMS Reactors Product Line capabilities; release SHARP suite update with validation assessments. • Continue enhancement of NEAMS Integration Product Line capabilities; demonstrate BISON-SHARP integrated simulation. • Continue expanded validation campaign; complete assessment of first two HIPs in collaboration with DOE and industry users. • Continue TREAT mission support by applying NEAMS ToolKit to improve the operational efficiency and expand testing regimes of TREAT.	• The decrease reflects completion of assessment of two HIPs initiated in FY 2015.

Energy Innovation Hub for Modeling and Simulation

Description

The FY 2017 budget year will provide the third year of funding for the second, and final, five year phase of the Energy Innovation Hub for Modeling and Simulation (Hub). The Oak Ridge National Laboratory is leading a consortium (CASL – Consortium for Advanced Simulation of Light Water Reactors) of national laboratories, universities, and industry partners to manage Hub execution. Thus far the Hub has successfully created a virtual reactor model of an actual Westinghouse-designed, pressurized water reactor, owned and operated by the Tennessee Valley Authority-owned. The virtual reactor model is now being used to analyze and understand key challenges to the safety and economics of reactor operations. In this second five year phase, the capabilities of the Hub are being extended to support other light water reactor designs including Boiling Water Reactors and Small Modular Reactors. Similarly, the Hub membership has been expanded 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. Once installed, the tools will be used to further improve understanding of industry-defined issues that limit the energy output of their reactors.

Energy Innovation Hub for Modeling and Simulation

Activities and Explanation of Changes

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
Energy Innovation Hub for Modeling and Simulation $24,300,000	**$24,300,000**	**+$0**
• Expand Hub consortiums membership to include vendors of boiling water and small modular reactor technologies. • Expand Hub Industry Council membership to include additional electrical utility users of the virtual reactor modeling and simulation tools. • Release an updated version of the Virtual Environment for Reactor Applications (VERA) including development enhancements and capabilities. • Release a version of VERA to be used in educational settings. • Demonstrate the ability of VERA to study the impact of boron containing deposits of fuel that cause power shifts and cladding corrosion. • Establish working group to understand the requirements for maintaining the Hub developed modeling and simulation capabilities beyond the second phase.	• Release updated version of the VERA including development enhancements and capabilities. • Establish an industry-driven use of VERA in support of a Consortium for Advanced Simulation of Light Water Reactor (CASL) Test Stand deployment. • Demonstrate grid-to-rod fretting analysis methodology based on VERA capability and finalized cladding wear model. • Demonstrate Pressurized Water Reactor fuel performance modeling and simulation capabilities for loss of coolant accident conditions. • Establish the ability of VERA steady-state simulation capability to perform Boiling Water Reactor core sub-region calculation.	• Funding held at FY 2016 level provides on-going efforts to support new capabilities for phase 2 of the Hub.

Nuclear Science User Facilities

Description

The NSUF is one of a growing number of DOE user facilities in the U.S. and the nation's only designated nuclear energy user facility. As currently the only DOE user facility with partner facilities, the NSUF is the hub that connects a broad range of exceptional nuclear research capabilities, expert mentors and experimenters spanning the U.S. 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 science 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 partner user facilities. In this manner, researchers benefit from the introduction to new techniques, equipment, and personnel.

The NSUF provides no-cost access to the Idaho National Laboratory's Advanced Test Reactor (ATR), post-irradiation examination (PIE) facilities at the Materials and Fuels Complex, and high performance computing capabilities such as Falcon, complementing the existing Advanced Scientific Computing Research User Facilities. Additional NSUF capability includes PIE assets at the Center for Advanced Energy Studies; research reactors at Oak Ridge National Laboratory, Massachusetts Institute of Technology, and North Carolina State University; beam line capabilities at the Advanced Photon Source in coordination with 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, all partnered with the NSUF to bring additional user facilities to the research community. In FY 2017, the NSUF will continue the development of a virtual knowledge center, the Nuclear Energy Knowledge and Validation Center, which provides scientists across the nuclear community with the information required to assess and analyze the accuracy of advanced nuclear energy systems and associated capabilities. The NSUF also supports the continued development and publication of a nuclear infrastructure database and the development of a next-generation scientific transient testing capability as part of the Transient Reactor Test (TREAT) resumption of operations. These and other NSUF efforts are key components of the Department's GAIN initiative to make these unique nuclear energy research assets accessible to industry engineers and scientists in a public-private partnership so that they can best use them to assure that nuclear energy remains a competitive option for meeting our Nation's energy and environmental challenges. For example, the NSUF has established and will sustain a single point of easy access to the broad range of capabilities, including people, facilities, materials and data, across the DOE complex to be made available to entities working to commercialize innovative systems and components. Further, in FY 2017 the refurbishment of the limited-view TREAT hodoscope, a detection system that is essential to the transient testing mission of TREAT, will be completed. Since its designation as a user facility in 2007, the NSUF has awarded 124 experiments to 25 universities and 4 laboratories. All new awards are fully funded, eliminating mortgages and improving consistency.

Nuclear Science User Facilities

Activities and Explanation of Changes

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
Nuclear Science User Facilities		
$41,100,000	**$23,285,000**	**-$17,815,000**
• Fully fund multiple irradiation/post irradiation examination (PIE) projects. • Award, execute, and complete a minimum of 15 competitively-awarded "rapid turnaround" PIE experiments. • Lead the development, execution, and award of NE's annual infrastructure solicitation. • Continue to develop and expand content of and public access to the nuclear infrastructure database. • Provide high performance computing capabilities to users by adding new partner facilities. • Expand the NSUF capabilities and collaborations, including funding for the establishment of the Nuclear Energy Knowledge and Validation Center.	• Continue to fully fund multiple irradiation/PIE projects. • Offer high performance computing capabilities to users through the FY 2017 Consolidated Innovative Nuclear Research funding opportunity announcement. • Make the NSUF Sample Library database accessible to the research community through a web portal. • Award, execute, and complete a minimum of 15 rapid turnaround experiments. • Complete limited-view hodoscope refurbishment and initiate design and procurement of a data acquisition system that supports operation of the full-view hodoscope. • Initiate design and fabrication of other experiment-supporting equipment such as preparation benches, transport casks, and digital image capture system. • Continue development of the Nuclear Energy Knowledge and Validation Center.	• The decrease from $41,100,000 to $23,285,000 reflects the completion of $20,000,000 of activities funded by Congress above the FY 2016 request and $2,185,000 to support additional new competitive awards to facilitate access to unique nuclear energy research capabilities and also to establish and sustain a single point of easy access to the broad range of capabilities, including, people, facilities, materials and data, across the DOE complex to be made available to entities working to commercialize innovative systems and components via the GAIN initiative.

Nuclear Energy Traineeships

Description

NE has mission-specific/mission-critical workforce needs in myriad technical areas. Establishing competitively-awarded, university-led traineeships is a mechanism for providing the required focused, graduate level training to meet these highly focused needs through a tailored academic graduate program that delivers unique and innovative curriculum with rigorous thesis or dissertation research requirement aligned with the identified critical DOE mission-driven workforce need. Further, DOE laboratory partnerships would be encouraged. To inform this consideration, in FY 2017, NE will plan and execute a formal study to evaluate the need to implement traineeships for focused topical areas to address its mission-specific and critical workforce needs.

Nuclear Energy Traineeships

Activities and Explanation of Changes

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
Nuclear Energy Traineeships $2,000,000	**$1,000,000**	**-$1,000,000**
• 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 will plan and execute a formal study to evaluate the need to implement traineeships for focused topical areas to address its mission-specific and critical workforce needs.	• The decrease from $2,000,000 to $1,000,000 reflects the initiation and completion of a formal study to evaluate and confirm the need to implement traineeships for focused topical areas to address NE's mission-specific and critical workforce needs.

Nuclear Energy Enabling Technologies Capital Summary ($K)

	Total	Prior Years	FY 2015 Enacted	FY 2015 Current	FY 2016 Enacted	FY 2017 Request	FY 2017 vs FY 2016
Capital Operating Expenses Summary (including (Major Items of Equipment (MIE))							
Capital Equipment > $500K (including MIE)	n/a	n/a	18,000	18,000	0	0	-
Plant Projects (GPP and IGPP)	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	18,000	18,000	0	0	-

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 2015	FY 2016	FY 2017
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	90%	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 get more safe, clean, and reliable energy from nuclear power plants.		

Radiological Facilities Management

Overview

In FY 2017, the Department is requesting funding for the Research Reactor Infrastructure (RRI) subprogram. RRI supports the continued operation of U.S. university research reactors by providing university research reactor fuel services, as well as maintenance of, and safety upgrades to, fuel fabrication equipment and facilities.

Highlights of the FY 2017 Budget Request

In FY 2017, 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 research reactors located at 24 U.S. universities. Major program deliverables will be to procure new plate fuel elements and ship them to supported universities and also ship used plate and TRIGA reactor fuel elements from supported universities to DOE used fuel receipt facilities. Initiated by the National Nuclear Security Administration (NNSA) in FY 2014 and assumed by the Office of Nuclear Energy (NE) in FY 2015, RRI will continue to fund required safety upgrades to allow resumption of university research reactor fuel fabrication operations at TRIGA International in Romans, France. In addition, work will continue on reuse of lightly irradiated TRIGA fuel in DOE inventory and other initiatives that evaluate alternatives to the current TRIGA reactor fuel sole-source supply issue. Continued delays and uncertainties associated with the schedule for resumption of production at the TRIGA International fuel fabrication facility has the potential to disrupt the continued operability of a subset of the 12 TRIGA university research reactors serviced by the RRI subprogram. Evaluation of alternatives commenced in 2015 and will continue through 2017.

Radiological Facilities Management
Funding ($K)

	FY 2015 Enacted	FY 2015 Current	FY 2016 Enacted	FY 2017 Request	FY 2017 vs FY 2016
Radiological Facilities Management					
Space and Defense Infrastructure	20,000	20,000	18,000	0	-18,000
Research Reactor Infrastructure	5,000	5,000	6,800	7,000	+200
Total, Radiological Facilities Management	**25,000**	**25,000**	**24,800**	**7,000**	**-17,800**

Radiological Facilities Management
Explanation of Major Changes ($K)

	FY 2017 vs FY 2016
Space and Defense Infrastructure: The decrease from $18,000,000 to $0 represents no funding requested in FY 2017 for Oak Ridge Infrastructure. Infrastructure used for Office of Nuclear Energy research and development is fully funded through associated program budgets.	**-18,000**
Research Reactor Infrastructure: No significant change. The increase from $6,800,000 to $7,000,000 mitigates annual increases to fresh fuel prices imposed by vendors.	**+200**
Total, Radiological Facilities Management	**-17,800**

Radiological Facilities Management
Space and Defense Infrastructure

Description

Consistent with Congressional direction, this category provided funds in FY 2016 to support Oak Ridge National Laboratory (ORNL) hot cells. Office of Nuclear Energy facility use is fully funded through associated program budgets.

Space and Defense Infrastructure

Activities and Explanation of Changes

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
Space and Defense Infrastructure $18,000,000	**$0**	**-$18,000,000**
• Complete procurement and installation of HEPA filters for the main hot cell and glovebox exhaust system in the Radiochemical Engineering Development Center. • Procure exhaust fans and dampers for ventilation system upgrades at the Irradiated Fuels Examination Facility. • Procure the lab area HEPA housing to replace the aging HEPA housing that is a Safety Class component. • Complete electrical upgrades for the Motor Control Center at the Radiochemical Engineering Development Center. • Replace pump motors, valves, and other components on the Radiochemical Engineering Development Center Cooling Tower.	• No funding is requested.	• Decrease represents FY 2017 request levels.

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 research reactors to support their continued operation. 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.

Activities and Explanation of Changes

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
Research Reactor Infrastructure $6,800,000	**$7,000,000**	**+$200,000**
• Procure 40 and deliver between 33 and 36 plate fuel elements required annually by University of Missouri (MURR) and Massachusetts Institute of Technology (MIT) as determined by need and fuel availability. • Complete up to 5 used fuel shipments to SRS and the Idaho National Laboratory (INL), pending resolution of moratorium on such shipments to INL. • Continue RRI project management, quality assurance, nuclear material accountability, and transportation cask maintenance. • Continue TRIGA fuel alternatives analysis and implementation activities as warranted by the FY 2014 analysis results and status of TRIGA International outage. • Complete activities needed for Nuclear Regulatory Commission (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. • Ship up to one cask load of lightly irradiated 8.5 wt% standard TRIGA fuel elements from the Irradiated Fuel Storage Facility at INL to selected U.S. university research reactor facilities. • Continue funding of safety upgrades to allow resumption of university research reactor fuel fabrication operations at TRIGA International in Romans, France. Funding of this project was initiated by NNSA in 2014 and assumed by NE in FY 2015.	• Continue funding safety upgrades to allow resumption of fuel fabrication operations at TRIGA International in Romans, France upon completion of the upgrade project. • Procure 40 and deliver between 33 and 36 plate fuel elements required annually by MURR and MIT as determined by need and fuel availability. • Ship up to two cask loads of lightly irradiated 8.5 wt% standard TRIGA fuel elements from the Irradiated Fuel Storage Facility at INL to selected U.S. university research reactor facilities. • Complete up to 5 used fuel shipments to SRS and the INL, pending resolution of moratorium on such shipments to the INL. • Continue RRI project management, quality assurance, nuclear material accountability, and transportation cask maintenance.	• No significant change. The increase mitigates annual increases to fresh fuel prices imposed by vendors.

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, 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 2017 Budget Request

In FY 2017, 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 2017, these activities include:

- Continuing investments at the ATR and Advanced Test Reactor Critical Facility (ATRC) to improve reliability and availability of the ATR in order to meet research customer demands. This plan, jointly developed with Naval Reactors (NR), will increase efficiency and irradiation days by prioritizing the plant, equipment, and experimental loop investments necessary to assure ATR operational viability beyond 2050.
- Continuing preliminary design activities and performance baseline development activities for the Sample Preparation Laboratory (SPL) Project at the INL to satisfy near-term advanced Post-Irradiation Examination (PIE) capabilities needed to improve understanding of nuclear fuels and material performance.
- Completing the remaining refurbishments of major Transient Reactor Test Facility (TREAT) systems and preparations for final readiness review activities. Operations at TREAT are scheduled to resume by FY 2018.
- Initiating the resurfacing, reconstruction, and sealing of major primary roads at INL as part of a Departmental effort through the National Laboratory Operations Board (LOB) to focus critical funds on revitalizing general purpose infrastructure at DOE national laboratories and plants. This activity will improve the safety for all vehicle traffic on primary two-lane, multi-direction roadways and prevents continued degradation and failure of primary roads surfaces and roadbeds.
- Initiating the disposition of Nuclear Energy owned excess contaminated facilities at INL identified through Departmental efforts associated with the Excess Contaminated Facilities Working Group established by the Secretary in January 2015. This focus on excess facilities is an outgrowth of DOE's broader efforts, led by the LOB, to assess legacy infrastructure on an enterprise-wide prioritized basis and develop a plan for the future.

Idaho Facilities Management
Funding ($K)

	FY 2015 Enacted	FY 2015 Current	FY 2016 Enacted	FY 2017 Request	FY 2017 vs FY 2016
Idaho Facilities Management					
INL Nuclear Research Reactor Operations and Maintenance	99,264	99,111	100,244	101,616	+1,372
INL Non-Reactor Nuclear Research Facility Operations and Maintenance	76,207	75,090	75,340	75,379	+39
INL Engineering and Support Facility Operations and Maintenance	11,356	11,627	32,459	29,284	-3,175
INL Regulatory Compliance	13,804	14,803	12,539	14,306	+1,767
Construction	5,369	5,369	2,000	6,000	+4,000
Total, Idaho Facilities Management	**206,000**	**206,000**	**222,582**	**226,585**	**+4,003**

Idaho Facilities Management
Explanation of Major Changes ($K)

	FY 2017 vs FY 2016 Request
INL Nuclear Research Reactor Operations and Maintenance: The increase from $100,244,000 to $101,616,000 reflects funding for investments in Advanced Test Reactor (ATR) and Advanced Test Reactor Critical Facility (ATRC) to improve reliability and availability, funding for the resumption of transient testing at Transient Reactor Test Facility (TREAT) including preparations for operations in FY 2018, cost of ATR fuel, and staff required to maintain and operate ATR consistent with Departmental programmatic and safety requirements.	**+1,372**
INL Non-Reactor Nuclear Research Facility Operations and Maintenance: The increase from $75,340,000 to $75,379,000 reflects funding for other project costs to develop performance baseline documentation for the Sample Preparation Laboratory Project.	**+39**
INL Engineering and Support Facility Operations and Maintenance: The decrease from $32,459,000 to $29,284,000 reflects full funding in FY 2016 for the refurbishment and replacement of the Idaho National Laboratory (INL) site-wide power distribution infrastructure and funding in FY 2017 for the resurfacing, reconstruction, and sealing of major primary roads at INL and the disposition of Nuclear Energy owned excess contaminated facilities at INL identified through Departmental efforts. Remaining funds reflect steady state support for effective management of the buildings, structures, and systems that support the non-nuclear facilities at INL, Federally-funded program activities, and community regulatory support activities.	**-3,175**
INL Regulatory Compliance: The increase from $12,539,000 to $14,306,000 reflects funding necessary for other project costs for the Remote-Handled Low-Level Waste (RHLLW) Disposal Facility Project consistent with the project schedule.	**+1,767**
Construction: The increase from $2,000,000 to $6,000,000 reflects Pre-CD-2 design funding for the Sample Preparation Laboratory (SPL) Project.	**+4,000**
Total, Idaho Facilities Management	**+4,003**

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 Facility (TREAT), 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 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 the primary scientific capability of the Nuclear Science User Facilities. 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 Reactor. Activities associated with the resumption of operations at 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.

To satisfy the irradiation needs of ATR users, significant efforts will continue in FY 2017 to refurbish and replace major ATR components and systems in order to improve the availability and reliability of ATR. This plan, jointly developed with NR, will address a significant portion of the Top 100 Plant Heath Committee items and eliminate the majority of ATR deferred maintenance items by the completion of the next Core Internals Change-out. The goal of this multi-year effort is to achieve 90% operating predictability and at least 210 irradiation days per year by FY 2021.

INL Nuclear Research Reactor Operations and Maintenance

Activities and Explanation of Changes

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
INL Nuclear Research Reactor Operations and Maintenance $100,244,000	**$101,616,000**	**+$1,372,000**
• Maintain and operate the Idaho National Laboratory (INL) reactors and supporting infrastructure while accommodating business model impacts. • Maintain a two year minimum Advanced Test Reactor (ATR) fuel inventory and sufficient ATR critical spares. • Continue preparatory activities for the ATR Core Internals Change-out (CIC), currently planned for 2020. • Conduct at least 60 irradiation campaigns as scheduled while maintaining an operating efficiency greater than 80%. • Continue replacement of electrical equipment at ATR that is past the end of useful life. • Complete replacement of the ATR Evaporation Pond Liner. • Initiate investments to improve ATR and ATR Critical Facility (ATRC) availability and reliability including ATRC Control Console replacement. • Complete Transient Reactor Test Facility (TREAT) fuel inspections and fire protection upgrades. • Initiate mock operations at TREAT to support training and prepare for reactor operations. • Complete integrated function testing of TREAT reactor plant systems.	• Continue investments to improve ATR and ATRC availability and reliability such as refurbishments and replacements of reactor equipment and acquisition of critical spares. • Maintain and operate the INL reactors and supporting infrastructure while accommodating business model impacts. • Maintain a two year minimum ATR fuel inventory and sufficient ATR critical spares. • Continue preparatory activities for the ATR CIC, currently planned for 2020. • Conduct at least 60 irradiation campaigns as scheduled while maintaining an operating efficiency greater than 80%. • Continue replacement of electrical equipment at ATR that is past the end of useful life. • Continue mock operation at TREAT to support training and prepare for reactor operations. • Complete the remaining refurbishments of major TREAT equipment such as the fuel handling cask. • Complete preparations for final readiness activities to resume operations at TREAT.	• The increase reflects funding for investments in ATR and ATRC to improve availability and reliability, funding for the resumption of transient testing at TREAT including preparing for operations in FY 2018, 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 subprogram 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 NE's 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.

Funding supports 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.

INL Non-Reactor Nuclear Research Facility Operations and Maintenance

Activities and Explanation of Changes

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
INL Non-Reactor Nuclear Research Facility Operations and Maintenance $75,340,000	**$75,379,000**	**+39,000**
• Operate and maintain the Materials and Fuels Complex (MFC) infrastructure and facilities to support facility operations and programmatic work activities. • Perform maintenance within the MFC nuclear facilities and infrastructure, consistent with the approved safety bases. Initiate maintenance activities associated with hot cell windows and manipulators. • Continue off-site disposition of surplus NE-owned special nuclear material consistent with programmatic needs and approved nuclear material allotment forecasts. • Continue the MFC upgraded documented safety analysis implementation for Hot the Fuels Examination Facility (HFEF) and the Zero Power Physics Reactor (ZPPR). • Complete all preparatory activities for operation of the HFEF and Fuel Conditioning Facility Overpack. • Initiate shipments of spent fuel treatment products from the Transient Reactor Test Facility (TREAT) warehouse to the Material Security and Consolidation Facility. • Complete Critical Decision (CD)-1, Approve Alternative Selection and Cost Range documentation and initiate development of CD-2 documentation, including environmental and the performance baseline, for the Sample Preparation Laboratory (SPL) Project.	• Operate and maintain MFC infrastructure and facilities to support facility operations and programmatic work activities. • Perform maintenance within the MFC nuclear facilities and infrastructure consistent with the approved safety bases. Continue maintenance activities associated with hot cell windows and manipulators. • Continue off-site disposition of surplus NE-owned special nuclear material consistent with programmatic needs and approved nuclear material allotment forecasts. • Continue the MFC upgraded documented safety analysis implementation for ZPPR. • Complete the MFC upgraded documented safety analysis implementation for HFEF and activity closeout. • Continue development of documentation to support the performance baseline for the Sample Preparation Laboratory (SPL) Project.	• The increase reflects funding for other project costs to develop performance baseline documentation for the Sample Preparation Laboratory Project.

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. This subcategory includes 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. This includes one-time funding to disposition NE owned excess contaminated facilities at INL identified through Departmental efforts associated with the Excess Contaminated Facilities Working Group established by the Secretary in January 2015.

Additionally, as part of a Departmental effort through the National Laboratory Operations Board, one-time funding is being focused on revitalizing general purpose infrastructure at DOE national laboratories and plants. For NE, this funding is being provided to support resurfacing, reconstruction, and sealing of major primary roads at INL to improve the safety for all vehicle traffic on primary two-lane, multi-direction roadways, reduces vehicle maintenance costs and prevents continued degradation and failure of primary roads surfaces and roadbeds.

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.

INL Engineering and Support Facility Operations and Maintenance

Activities and Explanation of Changes

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
INL Engineering and Support Facility Operations and Maintenance $32,459,000	**$29,284,000**	**-$3,175,000**
• Initiate the refurbishment and replacement of Idaho National Laboratory (INL) power distribution infrastructure including the Supervisory Control and Data Acquisition (SCADA) system and site substation replacements. • Conduct planned disposition work for non-nuclear excess buildings. • Conduct planned roof repair and replacement activities utilizing cool roof technology. • Procure replacement emergency services vehicles and associated equipment such as firefighting apparatus.	• Initiate the resurfacing, reconstruction, and sealing of major sections of INL's major primary roads that are in poor condition, including East Portland Avenue and Lincoln Boulevard. • Conduct planned disposition work for non-nuclear excess buildings. • Initiate the disposition of the Radiological Environmental Laboratory (CF-690) and Scoville Ordnance Offices (CF-633). • Conduct planned roof repair and replacement activities utilizing cool roof technology. • Procure replacement emergency services vehicles and associated equipment such as firefighting apparatus.	• The decrease reflects one-time funding received in FY 2016 for the refurbishment and replacement of the INL site-wide power distribution infrastructure and one-time funding provided in FY 2017 for the resurfacing, reconstruction, and sealing of major primary roads at INL and the disposition of NE owned excess contaminated facilities at INL.

Idaho Facilities Management
INL Regulatory Compliance

Description

This subcategory supports activities for continued compliance with State and Federal environmental laws and other regulations that are under the purview of the 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 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 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
INL Regulatory Compliance $12,539,000	**$14,306,000**	**+$1,767,000**
• Continue regulatory compliance program management. • Meet Idaho National Laboratory (INL) Site Treatment Plan milestones for treatment of two cubic meters of mixed low level waste (MLLW). • Complete 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 EBR-II used nuclear fuel. • Support Remote-Handled Low-Level Waste (RHLLW) Disposal Facility Project operational activities, including initiation of infiltration testing and analysis to demonstrate facility performance consistent with the performance assessment developed in accordance with Departmental requirements and commence documentation development to support facility operations.	• Continue regulatory compliance program management. • Meet INL Site Treatment Plan milestones for treatment of two cubic meters of MLLW. • Complete 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 EBR-II used nuclear fuel. • Support RHLLW Disposal Facility Project operational activities, including completion of facility performance monitoring, commence update of facility performance assessment and composite analysis developed in accordance with Departmental requirements, and begin preparation for nuclear facility operational readiness.	• The increase reflects the funding necessary for other project costs for the RHLLW Disposal Facility Project consistent with the project schedule.

Idaho Facilities Management
Construction

Description

Line-item capital projects are sometimes required at the Idaho National Laboratory (INL) to maintain its ability to support mission goals. These projects help achieve the Department's and the NE's 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.

Construction

Activities and Explanation of Changes

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
Construction $2,000,000	**$6,000,000**	**+$4,000,000**
Sample Preparation Laboratory (16-E-200) ($2,000,000) • Complete conceptual design (CD) activities in support of CD-1, "Approve Alternative Selection and Cost Range". • Complete conceptual design activities for the preferred alternative.	*Sample Preparation Laboratory (16-E-200) ($6,000,000)* • Continue preliminary design and performance baseline development activities in support of CD-2, "Approve Performance Baseline".	*Sample Preparation Laboratory (16-E-200) ($+4,000,000)* • The increase in funding is to support pre-CD-2 design and analysis activities for the Sample Preparation Laboratory (SPL) Project.

Idaho Facilities Management
Capital Summary ($K)

	Total	Prior Years	FY 2015 Enacted	FY 2015 Current	FY 2016 Enacted	FY 2017 Request	FY 2017 vs FY 2016
Capital Operating Expenses Summary (including (Major Items of Equipment (MIE))							
Plant Projects (GPP) (<$10M)	n/a	0	0	0	0	0	0
Total, Capital Operating Expenses	**n/a**	**0**	**0**	**0**	**0**	**0**	**+0**
Plant Projects (GPP) (Total Estimated Cost (TEC) <$10M)							
Total Plant Projects (GPP) (Total Estimated Cost (TEC) <$5M)	n/a	1,080	394	394	2,393	0	-2,393
Total, Plant Projects (GPP) (Total Estimated Cost (TEC) <$10M)	**n/a**	**1,080**	**394**	**394**	**2,393**	**0**	**-2,393**
Total, Capital Summary	**n/a**	**1,080**	**394**	**394**	**2,393**	**0**	**-2,393**

Idaho Facilities Management
Construction Projects Summary ($K)

	Total	Prior Years	FY 2015 Enacted	FY 2015 Current	FY 2016 Enacted	FY 2017 Request	FY 2017 vs FY 2016
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	16,398	5,369	5,369	0	0	0
Other Project Costs (OPC)*	18,996	11,999	2,553	2,553	1,504	2,940	+1,436
Total Project Cost (TPC) Project Number 13-D-905	**40,763**	**28,397**	**7,922**	**7,922**	**1,504**	**2,940**	**+1,436**
16-E-200, Sample Preparation Laboratory, INL							
Total Estimated Cost (TEC)	83,000	0	0	0	2,000	6,000	+4,000
Other Project Costs (OPC)*	12,000	6,431	0	0	1,500	2,800	+1,300
Total Project Cost (TPC) Project Number 16-E-200	**95,000**	**6,431**	**0**	**0**	**3,500**	**8,800**	**+5,300**
Total All Construction Projects							
Total Total Estimated Cost (TEC)	104,767	16,398	5,369	5,369	2,000	6,000	+4,000
Total Other Project Costs (OPC)	30,996	18,430	2,553	2,553	3,004	5,740	+2,736
Total Project Cost (TPC) All Construction Projects	**135,763**	**34,828**	**7,922**	**7,922**	**5,004**	**11,740**	**+6,736**

*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 2015	FY 2016	FY 2017
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	76.7%	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 general plant and construction projects within approved cost profiles and schedules, as measured by the total percentages of projects with cost performance indexes and schedule performance indexes between 0.9 and 1.15 (using earned value measurement systems for GPPs and other program defined maintenance and upgrade projects). This measures effectiveness of project management at Idaho facilities.**		
Target	80%	90%	90%
Result	100%	N/A	N/A
Endpoint Target	Maintain the total percentage of projects with good cost and schedule indexes at 90% or better.		

16-E-200, Sample Preparation Laboratory
Idaho National Laboratory
Project is for Design and Construction

1. Significant Changes and Summary

Significant Changes
This Construction Project Data Sheet (CPDS) is an update of the FY 2016 CPDS and does not include a new start for the budget year.

Summary
The most recent DOE O 413.3B approved Critical Decision (CD) is for CD-0, which was approved on January 31, 2011. The Mission Need Statement (MNS) was updated on June 18, 2015 to re-align the project with the FY 2016 budget request and Office of Nuclear Energy Research and Development strategy. The 2015 MNS update supports an approach that satisfies the near-term needs for an advanced post-irradiation examination (PIE) capability, which is a smaller capability gap than envisioned in 2011. The re-alignment of Mission Need resulted in a reduction of the high end of the estimated Total Project Cost (TPC) Range from $395M to $95M.

Due to the smaller footprint of the new Laboratory, siting location has changed precluding the need to demolish an existing structure.

This project data sheet supports continuation of preliminary design and other related activities initiated in FY 2016 necessary to support approval of CD-2, Approve Performance Baseline. The SPL will provide sample preparation for micro-/nano-scale structural, chemical, mechanical, and thermal properties analyses. This capability will augment non-destructive examination, elemental analysis, and radiological capabilities already present or being developed at INL. The SPL will, when coupled with existing facilities and recapitalization efforts, fulfill near-term capabilities necessary for conducting the advanced post-irradiation examination needed to improve understanding of nuclear fuels and material performance at the micro-, nano-, and atomic scales. In accordance with the National Environmental Policy Act (NEPA) (42 USC§ 4321 et seq.), a thorough analysis of the environmental consequences of a range of reasonable alternatives will be performed prior to selecting an action.

The proposed laboratory will require equipment that will allow high hazard materials to be routinely prepared and tested in a safe, secure, and environmentally-controlled environment. In addition, this laboratory will contribute to the suite of capabilities fulfilling near-term advanced post-irradiation examination needs that will serve as a center for advanced fuels and materials characterization, as well as development of new processes, tools, and instruments to further research.

The Sample Preparation Laboratory Project is now anticipated to be a non-major acquisition project with a preliminary rough order of magnitude TPC range between $0 and $95M. The project is currently completing conceptual design activities necessary to support finalization of the cost range and to support approval of CD-1, Approve Alternative Selection and Cost Range. The FY 2017 Total Estimated Cost (TEC) funding will be used to support development of facility design and associated documentation necessary for approval of CD-2.

A Federal Project Director has not been assigned to this project.

2. Critical Milestone History

(fiscal quarter or date)

	CD-0	Conceptual Design Complete	CD-1	CD-2	Final Design Complete	CD-3	D&D Complete	CD-4
FY2016	1/31/2011	4QFY 2014	3QFY 2015	TBD	TBD	TBD	TBD	TBD
FY2017	6/18/2015	3QFY 2016	3QFY 2016	TBD	TBD	TBD	N/A	TBD

CD-0 – Approve Mission Need for a construction project with a conceptual scope and cost range [Note: Original Mission Need Statement was approved 1/31/2011; an updated Mission Need Statement was approved 6/18/15]
Conceptual Design Complete – Actual date the conceptual design was completed (if applicable)
CD-1 – Approve Design Scope and Project Cost and Schedule Ranges
CD-2 – Approve Project Performance Baseline
Final Design Complete – Estimated/Actual date the project design will be/was complete(d)
CD-3 – Approve Start of Construction
D&D Complete –Completion of D&D work (see Section 9)
CD-4 – Approve Start of Operations or Project Closeout
PB – Indicates the Performance Baseline

	Performance Baseline Validation	CD-3A
FY 2016	TBD	TBD
FY 2017	TBD	TBD

CD-3A – Long Lead for equipment.

3. Project Cost History

	TEC, Design	TEC, Construction	TEC, Total	OPC Except D&D	OPC, D&D	OPC, Total	TPC
FY 2016	10,000	68,000	78,000	17,000	0	17,000	95,000
FY 2017[a,b]	10,000	73,000	83,000	12,000	0	12,000	95,000

a. Project costs revised based on preliminary scoping of project based on updated Mission Need Statement approved 3QFY 2015.
b. Project costs are preliminary pending CD-2 approval and represent the high end of the cost range.

No construction, excluding approved long lead procurement, will be performed until the project performance baseline has been validated and CD-3 has been approved.

4. Project Scope and Justification

Scope
The Sample Preparation Laboratory (SPL) will be designed and constructed to receive irradiated materials and to prepare samples for micro-/nano-scale structural, chemical, mechanical, and thermal properties analyses. These capabilities will enhance non-destructive examination, elemental analysis, and radiological capabilities already present at the Materials and Fuels Complex (MFC). The SPL may also be designed to provide source material and sample storage capability. The laboratory will provide the necessary shielding, equipment, and containment for the source material receiving; sample preparation; and the handling, storage, and packaging of irradiated nuclear fuel samples and activated materials.

This laboratory, in conjunction with other facilities and capabilities at the MFC, will support testing of the full range of irradiated materials for DOE and related nuclear programs, with a quick turnaround of results. The SPL may accommodate large samples to eliminate the need to send samples through the Hot Fuel Examination Facility (HFEF) at the MFC. Inter-facility transport capability, with remote loading/unloading at terminal locations and/or in-cell storage, may be included to lower radiation dose to workers and support as low as reasonably achievable (ALARA) goals.

Key scope elements of the project include:

- Design and construction of a sample preparation capability for irradiated nuclear materials;
- Design and construction of a cask receiving/shipping capability that can accommodate casks used for transport of irradiated nuclear materials;

- Design and construction of no more than two mechanical properties testing cells;
- Design and construction of a laboratory building (15,000 - 30,000 square feet) sized to accommodate the above identified capabilities, including supporting systems (e.g., ventilation systems, utilities) and office space;
- Facility commissioning and startup.

The proposed facility will be a non-reactor nuclear facility that will incorporate requirements to achieve the goals stated in Executive Order 13423 "*Strengthening Federal Environmental, Energy, and Transportation Management*."

Funds appropriated under this data sheet may be used to provide independent assessments related to project planning and execution.

Justification

The behavior of fuels and materials in a nuclear reactor irradiation environment is the limiting factor in nuclear plant safety, longevity, efficiency, and economics. During the last 15 years, nano-scale (10^{-9} meter) characterization of nonnuclear materials has become routine, with capabilities for sub-angstrom (10^{-10}meter) investigation becoming increasingly available to researchers in other fields. An understanding of nuclear fuel and material performance in the nuclear reactor internal environment at this scale is critical to the development of the innovative fuels and materials required for tomorrow's nuclear energy systems.

Existing post-irradiation examination and thermal and mechanical property testing capabilities at U.S. Department of Energy (DOE) laboratories, universities, and in the private sector are widely dispersed. Current post-irradiation examination capabilities serve basic needs for fuel examination, material handling, and waste disposal, but are limited in their ability to function on the micro-, nano-, and atomic scale. Advanced characterization of radioactive samples at nano-scale to micro-scale length resolutions will support the development of modern computer codes that could enable order of magnitude improvements in the time and cost of developing new fuels.

The SPL will support a variety of programs and users by receiving irradiated nuclear materials and by preparing samples for micro-/nano-scale structural, chemical, mechanical, and thermal properties analyses. This improved sample preparation capability will enhance non-destructive examination, elemental, and radiological capabilities already present at the Materials and Fuels Complex (MFC). The new SPL may also provide source material and sample storage capability. The laboratory will, when coupled with existing facilities and recapitalization efforts, fulfill near-term advanced post-irradiation capabilities necessary for conducting the advanced post-irradiation examination needed to improve understanding of nuclear fuels and materials performance at the micro-, nano-, and atomic scales. This new understanding will allow for the development of innovative fuels and materials that can be used by the nuclear energy community. Irradiation-driven phenomena can only be understood through conducting a scientific program that includes experimental irradiation testing and post-irradiation examination, materials characterization, and testing coupled with modeling and simulation.

The project is being conducted in accordance with the project management requirements in DOE O 413.3B, Program and Project Management for the Acquisition of Capital Assets.

5. Financial Schedule

(dollars in thousands)

	Appropriations	Obligations	Costs
Total Estimated Cost (TEC)			
Design			
FY 2016	2,000	2,000	2,000
FY 2017	6,000	6,000	6,000
Outyears	N/A	N/A	TBD
Total, Design	N/A	N/A	10,000
Construction			
FY 2017	0	0	0
Outyears	N/A	N/A	TBD
Total, Construction	N/A	N/A	73,000
TEC			
FY 2016	2,000	2,000	2,000
FY 2017	6,000	6,000	6,000
Outyears	TBD	TBD	TBD
Total, TEC	83,000	83,000	83,000
Other Project Cost (OPC)			
OPC			
FY 2012	3,931	3,931	1,677
FY 2013	500	500	2,643
FY 2014	2,000	2,000	754
FY 2015	0	0	555
FY 2016	1,500	1,500	1,960
FY 2017	2,800	2,800	842
Outyears	TBD	TBD	TBD
Total, OPC	12,000	12,000	12,000
Total Project Cost (TPC)			
FY 2012	3,931	3,931	1,677
FY 2013	500	500	2,643
FY 2014	2,000	2,000	754
FY 2015	0	0	555
FY 2016	3,500	3,500	3,960
FY 2017	8,800	8,800	6,842
Outyears	TBD	TBD	TBD
Total, TPC	95,000	95,000	95,000

6. Details of Project Cost Estimate

(dollars in thousands)

	Current Total Estimate	Previous Total Estimate	Original Validated Baseline
Total Estimated Cost (TEC)			
Design			
Design	8,500	8,500	N/A
Contingency	1,500	1,500	N/A
Total, Design	10,000	10,000	N/A
Construction			
Site Work	6,000	6,000	N/A
Equipment	15,000	15,000	N/A
Construction	40,500	35,500	N/A
Contingency	11,500	11,500	N/A
Total, Construction	73,000	68,000	N/A
Total, TEC	83,000	78,000	N/A
Contingency, TEC	13,000	13,000	N/A
Other Project Cost (OPC)			
OPC except D&D			
Conceptual Planning	1,930	1,930	N/A
Conceptual Design	4,500	4,500	N/A
Hot startup	2,000	3,430	N/A
Other OPC Costs	2,370	5,940	N/A
Contingency	1,200	1,200	N/A
Total, OPC	12,000	17,000	N/A
Contingency, OPC	1,200	1,200	N/A
Total, TPC	95,000	95,000	N/A
Total, Contingency	14,200	14,200	N/A

7. Schedule of Appropriation Requests

($K)

Request		Prior Years	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	Outyears	Total
FY 2016	TEC	0	2,000	TBD	TBD	TBD	TBD	0	0	78,000
	OPC	6,431	1,500	TBD	TBD	TBD	TBD	0	0	17,000
	TPC	6,431	3,500	TBD	TBD	TBD	TBD	0	0	95,000
FY 2017	TEC	0	2,000	6,000	TBD	TBD	TBD	TBD	TBD	83,000
	OPC	6,431	1,500	2,800	TBD	TBD	TBD	TBD	TBD	12,000
	TPC	6,431	3,500	8,800	TBD	TBD	TBD	TBD	TBD	95,000

8. Related Operations and Maintenance Funding Requirements

Start of Operation or Beneficial Occupancy (fiscal quarter or date)	TBD
Expected Useful Life (number of years)	40

Expected Future Start of D&D of this capital asset (fiscal quarter) TBD

(Related Funding requirements)

(dollars in thousands)

	Annual Costs		Life Cycle Costs	
	Current Total Estimate	Previous Total Estimate	Current Total Estimate	Previous Total Estimate
Operations	N/A	N/A	N/A	N/A
Utilities				
Maintenance & Repair	N/A	N/A	N/A	N/A
Total	N/A	N/A	N/A	N/A

Expected operations and maintenance costs will be established at CD-1.

9. D&D Information

The new area being constructed in this project is not replacing existing facilities.

	Square Feet
New area being constructed by this project at INL……..	20,000 – 40,000
Area of D&D in this project at INL……..	0
Area at INL to be transferred, sold, and/or D&D outside the project including area previously "banked" ……..	0
Area of D&D in this project at other sites ……	0
Area at other sites to be transferred, sold, and/or D&D outside the project including area previously "banked" ……	0
Total area eliminated ……..	0

Site location, building name or numbers, and square footages of existing facilities to be replaced: N/A

As a new Laboratory facility, the proposed SPL is not subject to Freeze the Footprint (>50% lab space).

10. Acquisition Approach

An acquisition approach will be completed and approved as part of CD-1, Approve Alternative Selection and Cost Range. A standard design-bid-build project delivery method is envisioned to be utilized for the design and construction of the SPL. A fixed price construction contract is anticipated for construction of the Sample Preparation Laboratory.

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. The S&S program 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 2017 Budget Request

The FY 2017 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 2017, 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 2017 request will focus on implementing infrastructure investments, capital improvements, emerging technology investments, and enhanced cyber security program capabilities to adequately secure site assets; including:

- Completing critical physical security infrastructure investments required to maintain an S&S program consistent with Departmental requirements such as refurbishing the protective force live-fire shoot house training facility and initiating designs, related analyses, and modifications to support a multi-year effort to enhance physical security infrastructure across several INL complexes.
- Physical security systems life-cycle replacement of vehicle explosive detection technology and implementation of a rapid deployment security system for incident response.
- Replacement of Engagement Simulation System (ESS) equipment and ammunition utilized in performance testing.
- Implementing enhanced network forensics capabilities for increased intrusion detection and response.

Idaho Sitewide Safeguards and Security
Funding ($K)

	FY 2015 Enacted	FY 2015 Current	FY 2016 Enacted	FY 2017 Request	FY 2017 vs FY 2016
Idaho Sitewide Safeguards and Security					
Protective Forces	57,547	60,661	65,611	65,738	+127
Security Systems	14,718	11,309	11,632	12,690	+1,058
Security Infrastructure	0	0	11,681	10,478	-1,203
Information Security	3,451	3,632	3,721	3,985	+264
Personnel Security	7,050	6,153	6,749	6,549	-200
Material Control & Accountability	4,340	4,440	4,456	4,354	-102
Program Management	5,626	6,386	7,845	9,251	+1,406
Cyber Security	11,268	11,419	14,466	16,258	+1,792
Total, Idaho Sitewide Safeguards and Security	**104,000**	**104,000**	**126,161**	**129,303**	**+3,142**

Idaho Sitewide Safeguards and Security
Explanation of Major Changes ($K)

	FY 2017 vs FY 2016
Protective Forces: The increase from $65,611,000 to $65,738,000 reflects costs to maintain FY 2016 staffing levels consistent with Departmental protection requirements, the site labor wage agreement and cost model. Funding also supports protective force equipment, training, facilities, and management.	**+127**
Security Systems: The increase from $11,632,000 to $12,690,000 provides funds to implement rapid deployment intrusion detection capabilities, complete preventative/corrective maintenance, and scheduled lifecycle replacements of physical security systems.	**+1,058**
Security Infrastructure: The decrease from $11,681,000 to $10,478,000 reflects completion of FY 2016 critical infrastructure investments and provides funds for the highest priority critical infrastructure investments in FY 2017 to refurbish the Live-Fire Shoot House training facility to improve safety and perform designs, related analyses, and modifications to support a multi-year effort to enhance physical security infrastructure across several INL complexes.	**-1,203**
Information Security: The increase from $3,721,000 to $3,985,000 provides funds to maintain information security services for key Idaho National Laboratory (INL) facilities consistent with the site operational needs.	**+264**
Personnel Security: The decrease from $6,749,000 to $6,549,000 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.	**-200**
Material Control & Accountability: The decrease from $4,456,000 to $4,354,000 provides funds to maintain accounting and control of special nuclear material (SNM) at key INL facilities consistent with the site operational needs.	**-102**
Program Management: The increase from $7,845,000 to $9,251,000 supports life-cycle replacement of Engaged Simulation System (ESS) equipment and ammunition as well as planned performance assurance activities.	**+1,406**
Cyber Security: The increase from $14,466,000 to $16,258,000 supports the addition of essential cyber security specialists, lifecycle hardware/software upgrades and replacements for classified and unclassified systems, and enhanced network forensics capabilities for increased intrusion detection and response.	**+1,792**
Total, Idaho Sitewide Safeguards and Security	**+3,142**

Idaho Sitewide Safeguards and Security

Description

The S&S program funds Office of Nuclear Energy (NE) base physical and cyber security activities for the Idaho National Laboratory (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.

Protective Forces

Protective Forces 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 site assets consistent with site security plans. Protective force personnel are deployed 24 hours a day, 7 days a week, across the 890 square miles to deter, detect, delay, and respond to adversarial threats.

Security Systems

Physical Security Systems provides preventative and corrective maintenance and performance testing of intrusion detection and assessment systems, entry and search control equipment, barriers, secure storage, lighting, sensors, entry/access control devices, locks, explosives detection, and tamper-safe monitoring. Ensures 24 hour a day, 7 days a week operation of approximately 4,600 security alarms and 6,100 security locks at multiple security areas.

Security Infrastructure

Security Infrastructure provides critical security infrastructure investments and protection enhancements necessary to ensure adequate protection of assets consistent with Departmental requirements. These include, but are not limited to: upgrades, refurbishments or replacement of protective force training and muster facilities; physical security systems or equipment required by Departmental Orders, such as perimeter intrusion detection and assessment systems, closed-circuit televisions, central and/or secondary alarm stations; and other similar activities.

Information Security

Information Security provides for the protection and control of classified and sensitive matter that is generated, received, transmitted, used, stored, reproduced, and/or destroyed. 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.

Personnel Security

Personnel Security provides 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 includes both contractor and federally funded activities.

Materials Control and Accountability

Material Control & Accountability (MC&A) provides the personnel, equipment, and services required to account for and control special nuclear materials (SNM) from diversion. MC&A is accomplished through the administration of a robust formal inventory process that allows security personnel to locate and track specific quantities of SNM in real time, state of the art measurement equipment, non-destructive analysis, and a robust tamper indicating device program.

Program Management

Program Management includes policy oversight, development, and update of site security plans; vulnerability assessments and performance testing to ensure adequate protection of SNM; 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 protection methodology/posture.

Cyber Security

Cyber Security maintains the staffing, computing infrastructure, and network security configuration necessary to support classified and unclassified information and electronic operations. 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.

Activities and Explanation of Changes

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
Protective Forces $65,611,000	**$65,738,000**	**+$127,000**
• Provides funds to maintain a Protective Force consistent with the Site Security Plan, approved site labor wage agreement, and Idaho National Laboratory (INL) cost model changes, including associated training activities and facilities required to maintain protective force qualifications. • Provides funding to purchase Protective Force equipment such as ammunition, weapons, protective gear and vehicles.	• 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. • Provides funding to purchase Protective Force equipment such as ammunition, weapons, protective gear and vehicles.	• Reflects funds necessary to maintain FY 2016 staffing levels, protective force equipment, training, facilities, and management.
Security Systems $11,632,000	**$12,690,000**	**+$1,058,000**
• Provides funds for staff and equipment to plan and conduct preventative and corrective maintenance on physical security systems at multiple security areas. • Supports the operation of INL central alarm stations, development and modification of security alarm systems and life cycle replacement of systems.	• Provides funds for staff and equipment to plan and conduct preventative and corrective maintenance on physical security systems at multiple security areas. • Supports the operation of INL central alarm stations, development and modification of security alarm systems and life cycle replacement of systems.	• Reflects projected physical security systems life cycle replacement needs and implementation of rapid deployment intrusion detection capabilities.
Security Infrastructure $11,681,000	**$10,478,000**	**-$1,203,000**
• Upgrade Perimeter Intrusion Detection and Assessment System (PIDAS) at the Materials and Fuels Complex (MFC). • Upgrade Central Alarm System (CAS) at MFC.	• Refurbish the Live-Fire Shoot House Refurbishment to provide critical life-safety upgrades (enhanced wall height, and steel backing) necessary to allow long-term use of the facility. • Perform designs, related analyses, and modifications to support a multi-year effort to enhance physical security infrastructure across several INL complexes.	• Reflects funds necessary to implement highest priority critical infrastructure investments and to initiate physical security enhancement activities.
Information Security $3,721,000	**$3,985,000**	**+$264,000**
• Provides funds to implement information security activities to protect classified and sensitive unclassified matter including Classified Matter Protection and Control, Technical Surveillance	• Provides funds to implement information security activities to protect classified and sensitive unclassified matter including Classified Matter Protection and Control, Technical Surveillance	• Reflects funds necessary to maintain information security services consistent with site operational demands.

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
Countermeasures, Classification/ Declassification, and Operations Security programs.	Countermeasures, Classification/ Declassification, and Operations Security programs.	
Personnel Security $6,749,000	**$6,549,000**	**-$200,000**
• Provides funds for federal and contractor personnel security programs including processing, tracking and adjudication of security investigations, Homeland Security Presidential Directive-12 (HSPD-12) badging and smart card administration, foreign visits and assignments, and management of the human reliability program including medical examinations.	• Provides funds for federal and contractor personnel security programs including processing, tracking and adjudication of security investigations, HSPD-12 badging and smart card administration, foreign visits and assignments, and management of the human reliability program including medical examinations.	• Reflects funds necessary to maintain personnel security services consistent with the site operational demands.
Material Control & Accountability $4,456,000	**$4,354,000**	**-$102,000**
• Provides funds to maintain the site's special nuclear material (SNM) database and tracking systems, coordinate on-and off-site material movements, and to conduct SNM inventories.	• Provides funds to maintain the site's SNM database and tracking systems, coordinate on- and off-site material movements, and to conduct SNM inventories.	• Reflects funds necessary to maintain Material Control & Accountability (MC&A) services consistent with the site operational demands.
Program Management $7,845,000	**$9,251,000**	**+$1,406,000**
• Provides funds to maintain and develop, update, and maintain security program documentation, vulnerability/risk assessments and to conduct performance testing to assure program effectiveness.	• Provides funds to maintain and develop, update, and maintain security program documentation, vulnerability/risk assessments and to conduct performance testing to assure program effectiveness.	• Reflects increased performance assurance activities and life-cycle replacement of Engaged Simulation System (ESS) equipment and ammunition.
Cyber Security $14,466,000	**$16,258,000**	**+$1,792,000**
• Maintains an effective cyber security program consistent with the Department's measured risk management and vulnerability and incident management strategies including staffing, training, tools, hardware/software lifecycle replacement, and certification and accreditation for classified and unclassified systems. • Establishes Idaho National Laboratory (INL) Industrial Control Systems cyber security program.	• Maintains an effective cyber security program consistent with the Department's measured risk management and vulnerability and incident management strategies including staffing, training, tools, hardware/software lifecycle replacement, and certification and accreditation for classified and unclassified systems. • Maintains and continues development of INL Industrial Control Systems cyber security program. • Implements enhanced network forensics capabilities for increased intrusion detection and response.	• Reflects funds necessary to maintain cyber security services consistent with the site operational demands and provides for increased intrusion detection and response capabilities to mitigate dynamic cyber security threats.

Idaho Sitewide Safeguards and Security
Capital Summary ($K)

	Total	Prior Years	FY 2015 Enacted	FY 2015 Current	FY 2016 Enacted	FY 2017 Request	FY 2017 vs FY 2016
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	0
Plant Projects (GPP)	n/a	0	0	0	11,681	3,875	-7,806
Total, Capital Operating Expenses	**n/a**	**0**	**1,500**	**1,500**	**13,181**	**5,375**	**-7,806**
Capital Equipment > $500K (including MIE)							
Total Non-MIE Capital Equipment (>$500K)	n/a	0	1,500	1,500	1,500	1,500	0
Total, Capital Equipment (including MIE)	**n/a**	**0**	**1,500**	**1,500**	**1,500**	**1,500**	**0**
Plant Projects (GPP)							
Materials and Fuels Complex (MFC) Perimeter Intrusion Detection and Assessment System (PIDAS) Upgrade					8,281	0	-8,281
MFC Central Alarm System (CAS) Upgrade					3,400	0	-3,400
Live Fire Shoot House Refurbishment	n/a	0	0	0	0	3,875	+3,875
Total, Plant Projects (GPP)	**n/a**	**0**	**0**	**0**	**11,681**	**3,875**	**-7,806**
Total, Capital Summary	**n/a**	**0**	**1,500**	**1,500**	**13,181**	**5,375**	**-7,806**

International Nuclear Energy Cooperation

Overview

International Nuclear Energy Cooperation's (INEC) mission is to act as the Department's overall lead for all international activities related to civil nuclear energy, including analysis, development, coordination and implementation of international civil nuclear energy policy and integration of the Office of Nuclear Energy's (NE) international nuclear technical activities. These activities contribute to international bilateral and multilateral engagement and civil nuclear energy research and development (R&D) activities with countries with an established, or who are considering development of, a civilian nuclear power sector. INEC also utilizes workshops and expert-based exchange fora to engage industry, stakeholders and foreign governments on international civil nuclear issues such as training, financing, safety and options for multinational cooperation on used nuclear fuel disposal.

INEC provides the Department the ability to meet growing demands for engagement with international partners on civil nuclear policy, research, development, and demonstration (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 2017 Budget Request

In FY 2017, INEC will continue to support existing international engagement with advanced and developing nuclear energy countries in coordination with the Department of State and other agencies. INEC will also continue to advance multilateral collaboration with the International Atomic Energy Agency (IAEA), the Organisation for Economic Co-operation and Development/Nuclear Energy Agency (OECD/NEA), the International Framework for Nuclear Energy Cooperation (IFNEC), and other fora focusing on concepts such as multinational cooperation on used fuel disposal and the collaborative studies to advance these concepts. In FY 2017, INEC will initiate efforts to develop a program for international nuclear energy education outreach, modeled after the Department of State's International Military Education and Training program. The goal of the new program is to support diplomatic, nonproliferation, climate, and international economic objectives for the safe and secure use of peaceful uses of nuclear technology in emerging countries developing nuclear energy programs.

International Nuclear Energy Cooperation
Funding ($K)

	FY 2015 Enacted	FY 2015 Current	FY 2016 Enacted	FY 2017 Request	FY 2017 vs FY 2016
International Nuclear Energy Cooperation					
International Nuclear Energy Cooperation	3,000	3,000	3,000	4,500	**+1,500**
Total, International Nuclear Energy Cooperation	**3,000**	**3,000**	**3,000**	**4,500**	**+1,500**

International Nuclear Energy Cooperation
Explanation of Major Changes ($K)

	FY 2017 vs FY 2016
International Nuclear Energy Cooperation: The increase from $3,000,000 to $4,500,000 reflects $1,000,000 to support development of a program for international nuclear energy education outreach. This new function will be modeled after the Department of State's International Military Education and Training program. The goal of the new program is to support diplomatic, nonproliferation, climate, and international economic objectives for the safe and secure use of peaceful uses of nuclear technology in emerging countries developing nuclear energy programs. This increase will accommodate $500,000 in additional multilateral and bilateral international activities.	**+1,500**
Total, International Nuclear Energy Cooperation	**+1,500**

Activities and Explanation of Changes

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
International Nuclear Energy Cooperation		
$3,000,000	**$4,500,000**	**+$1,500,000**
• 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. • Support the transition of the International Framework for Nuclear Energy Cooperation (IFNEC) Secretariat to Organisation for Economic Co-operation and Development/Nuclear Energy Agency (OECD/NEA). • Provide expertise and technical assistance to the Department of Commerce in its efforts to support U.S. civil nuclear exports. • Advance multilateral collaboration on multinational cooperation on used nuclear fuel disposal and continue analytical studies supporting this engagement. • Develop new collaboration opportunities with the United Kingdom, France, India, and Japan in light of R&D Agreements, implementing arrangements and Action Plan updates completed in 2014 and 2015. • Implement a Commercial Engagement Strategy.	• Continue to 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. • Provide additional support for bilateral engagement, including workshops, laboratory visits, and trips that NE supports for nuclear newcomer countries. • Continue to provide expertise and technical assistance to the Department of Commerce in its efforts to support U.S. civil nuclear exports. • Continue to support the transition of the IFNEC Secretariat to OECD/NEA. • Continue to advance multilateral collaboration with the International Atomic Energy Agency (IAEA) and OECD/NEA on key issues such as multinational cooperation on used nuclear fuel disposal and continue analytical studies supporting this engagement. • Support IFNEC Reliable Nuclear Fuel Services Working Group efforts in developing multinational approaches in used nuclear fuel disposal. • Continue to support NE's participation in multilateral fora such as the IAEA and OECD/NEA. • Organize and participate in a Joint Convention Topical Meeting to consider safety and responsibility challenges involved in developing a multinational repository. • Support to INPRO ROADMAPS and KIND.	• Funds requested to establish a new program on international nuclear energy education outreach to support diplomatic, nonproliferation, climate, and international economic objectives for the safe and secure use of peaceful uses of nuclear technology in emerging countries developing nuclear energy programs ($1,000,000). • Support bilateral engagement, including workshops, lab visits, and trips that NE supports for nuclear newcomer countries as well as additional workshops and training with Ukraine, such as curricula development for new nuclear training institute and additional safety related work to ensure the reactors are able to safely manage instability in the grid due to the conflict ($500,000).

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
• International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO) study on transfer of responsibility. • Support to INPRO Roadmaps for a Transition to Globally Sustainable Nuclear Energy Systems (ROADMAPS) and Key Indicators for Innovative Nuclear Energy Systems (KIND).	• Support for bilateral engagement, including workshops, lab visits, and trips that NE supports for nuclear newcomer countries. • Workshops and training with Ukraine, such as curricula development for new nuclear training institute and additional safety related work to ensure the reactors are able to safely manage instability in the grid due to the conflict. • Develop new international nuclear energy education outreach program.	

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 provider 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, select federal staff and support for the Office of Technology Transition, and the Office of Human Capital Service Center. NE Program Direction also supports the Office of the General Counsel and Energy Information Administration staff 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 2017.

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 2017 Budget Request

The Nuclear Energy Program Direction request reflects an increase of $8.7 million from the FY 2016 Enacted Budget. This increase is necessary to support on-going funding requirements of NE’s current staffing levels. NE’s reduced budget requests in FY 2015 and FY 2016, in conjunction with a congressionally directed rescission of prior year appropriations, allowed NE to reduce its end of year balances in this account by over 50%. Also included within this request, and consistent with DOE guidance, is an increase to support NE’s Working Capital Fund (WCF) requirements, with the exception of the Cyber One and Financial Statement Audits business lines which will continue to be funded within the NE program elements.

During FY 2016 and FY 2017, NE will be realigning available resources to support increased federal emphasis on implementing the Administration’s Strategy for the disposition of commercial and defense high level waste and spent nuclear fuel. This includes increased support for developing a consent based siting (CBS) process for nuclear waste management and disposal facilities. CBS requires a significant commitment of human capital to assure consistency with federal policies and strategies in the planning, engagement, responsiveness, and the adaptation of plans that address changing and dynamic conditions. Because this program is expected to grow with this increased federal emphasis, the staffing of the program office will need to grow in order to provide appropriate guidance and oversight.

Program Direction
Funding ($K)

	FY 2015 Enacted	FY 2015 Current	FY 2016 Enacted	FY 2017 Request	FY 2017 vs FY 2016
Program Direction Summary					
Washington Headquarters					
Salaries and Benefits	30,426	30,426	31,096	32,946	+1,850
Travel	1,250	1,250	1,250	1,250	0
Support Services	2,200	2,200	2,260	2,900	+640
Other Related Expenses	6,300	6,300	6,572	10,666	+4,094
Total, Washington Headquarters	**40,176**	**40,176**	**41,178**	**47,762**	**+6,584**
Oak Ridge Operations Office					
Salaries and Benefits	1,111	1,111	551	552	+1
Travel	25	25	25	15	-10
Support Services	300	300	240	240	0
Other Related Expenses	1,650	1,650	1,140	1,140	0
Total, Oak Ridge Operations Office	**3,086**	**3,086**	**1,956**	**1,947**	**-9**
Idaho Operations Office					
Salaries and Benefits	26,250	26,250	26,891	28,416	+1,525
Travel	575	575	575	675	+100
Support Services	2,493	2,493	2,200	2,490	+290
Other Related Expenses	7,420	7,420	7,200	7,410	+210
Total, Idaho Operations Office	**36,738**	**36,738**	**36,866**	**38,991**	**+2,125**
Total Program Direction					
Salaries and Benefits	57,787	57,787	58,538	61,914	+3,376
Travel	1,850	1,850	1,850	1,940	+90
Support Services	4,993	4,993	4,700	5,630	+930
Other Related Expenses	15,370	15,370	14,912	19,216	+4,304
Total, Program Direction	**80,000**	**80,000**	**80,000**	**88,700**	**+8,700**
Federal FTEs	**394**	**375**	**372**	**380**	**8**

	FY 2015 Enacted	FY 2015 Current	FY 2016 Enacted	FY 2017 Request	FY 2017 vs FY 2016
Support Services					
Technical Support					
Mission Related	2,000	2,000	2,000	2,200	+200
Advisory and Assistance	185	185	180	260	+80
Total, Technical Support	2,185	2,185	2,180	2,460	+280
Management Support					
Administrative	1,000	1,000	1,000	1,170	+170
IT	1,808	1,808	1,520	2,000	+480
Total Management Support	2,808	2,808	2,520	3,170	+650
Total, Support Services	**4,993**	**4,993**	**4,700**	**5,630**	**+930**
Other Related Expenses					
Working Capital Fund	6,980	6,980	6,895	9,256	+2,361
Training	500	500	500	640	+140
Miscellaneous	6,390	6,390	6,017	7,320	+1,303
Rents and Utilities	1,500	1,500	1,500	2,000	+500
Total, Other Related Expenses	**15,370**	**15,370**	**14,912**	**19,216**	**+4,304**

Program Direction

Activities and Explanation of Changes

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
Program Direction $80,000,000	**$88,700,000**	**+$8,700,000**
Salaries and Benefits $58,538,000	**$61,914,000**	**+$3,376,000**
Provides salaries and benefits for 372 federal staff.	Provides salaries and benefits for 380 federal staff.	Increase provides for a net increase of 1.6% in federal salary costs for step increases and federal pay scale increases. This increase also funds anticipated retirements and new hires for FY 2017.
Travel $1,850,000	**$1,940,000**	**+$90,000**
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 $4,700,000	**$5,630,000**	**+$930,000**
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.	Increase of $280,000, for technical support services reflects the need for additional funding as a result of full utilization of prior year balances. Increase of $650,000, in management support services reflects the need for additional funding as a result of full utilization of prior year balances and on-going service costs.
Other Related Expenses $14,912,000	**$19,216,000**	**+$4,304,000**
Provides for NE's share of goods and services procured through the Department's Working Capital Fund (WCF); 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 $10,000 for official reception and representation 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. Consistent with DOE guidance all NE WCF requirements are requested within Program Direction starting in FY 2017.	Increase of $2,361,000, reflects the full burden of Working Capital Fund provided through Program Direction activities (with the exception of the Cyber One and Financial Statement Audits business lines), additional iManage requirements, and NE's allocated share of charges to upgrade Office of Personnel Management computer systems. Increase of $1,943,000 reflects additional new appropriations necessary to maintain existing federal support activities. Prior to FY 2015 NE had generated unused carryover balances in excess of Department guidance and NE initiated an effort to reduce these

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
		balances by offsetting the requirement for new appropriations. These actions, in conjunction with the Congressionally directed rescission of balances in FY 2015, have completed the multi-year effort to reduce NE balances to appropriate levels. With the elimination of the excess balances full funding to maintain current support activities is required in FY 2017.

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 and reduce deferred maintenance at INL.

Costs for Direct-Funded Maintenance and Repair (including Deferred Maintenance Reduction) ($K)

	FY 2015 Actual Cost	FY 2015 Planned Cost	FY 2016 Planned Cost	FY 2017 Planned Cost
Idaho National Laboratory	20,443	14,765	33,295	29,209
Total, Direct-Funded Maintenance and Repair	20,443	14,765	33,295	29,209

Costs for Indirect-Funded Maintenance and Repair (including Deferred Maintenance Reduction) ($K)

	FY 2015 Actual Cost	FY 2015 Planned Cost	FY 2016 Planned Cost	FY 2017 Planned Cost
Idaho National Laboratory	14,578	15,327	21,181	21,156
Total, Indirect-Funded Maintenance and Repair	14,578	15,327	21,181	21,156

Report on FY 2015 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 2015 to the amount planned for FY 2015, including Congressionally directed changes.

Nuclear Energy
Total Costs for Maintenance and Repair ($K)

	FY 2015 Actual Cost	FY 2015 Planned Cost
Idaho National Laboratory	35,021	30,092
Total, Maintenance and Repair	**35,021**	**30,092**

Each year, the "Planned Cost" for maintenance and repair is a minimum target amount. The Nuclear Energy program met its planned minimum target in FY 2015.

Nuclear Energy
Research and Development ($K)

	FY 2015 Enacted	FY 2015 Current[1]	FY 2016 Enacted	FY 2017 Request	FY 2017 vs FY 2016
Basic	35,447	35,439	29,570	8,426	-21,144
Applied	679,095	667,296	725,811	692,352	-33,459
Development	111,952	110,007	122,057	101,629	-20,428
Subtotal, R&D	**826,494**	**812,742**	**877,438**	**802,407**	**-75,031**
Equipment	0	0	0	0	-
Construction	0	0	0	0	-
Total, R&D	**826,494**	**812,742**	**877,438**	**802,407**	**-75,031**

[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 2015 Transferred	FY 2016 Projected Transfer	FY 2017 Request Projected Transfer	FY 2017 vs FY 2016
STEP R&D				
SBIR	145	150	0	-150
STTR	20	23	0	-23
Reactor Concepts RD&D				
SBIR	3,857	4,252	3,480	-772
STTR	532	637	490	-147
Fuel Cycle R&D				
SBIR	5,061	5,439	5,556	+117
STTR	698	816	781	-35
Nuclear Energy Enabling Technologies				
SBIR	2,929	3,288	2,865	-423
STTR	404	493	403	-90
Total, SBIR	**11,992**	**13,129**	**11,901**	**-1,228**
Total, STTR	**1,654**	**1,969**	**1,674**	**-295**

Department Of Energy

FY 2017 Congressional Budget

Funding By Appropriation By Site

($K)

Nuclear Energy	FY 2015 Current	FY 2016 Enacted	FY 2017 Request
Argonne National Laboratory			
Fuel Cycle R & D			
Fuel Cycle R & D	12,500	10,100	12,600
Nuclear Energy Enabling Technologies			
Nuclear Energy Enabling Technologies	5,243	5,525	4,760
Reactors Concepts RD&D			
Reactors Concepts RD&D	14,684	17,560	13,760
International Nuclear Energy Cooperation			
International Nuclear Energy Cooperation	918	725	990
Total, Argonne National Laboratory	**33,345**	**33,910**	**32,110**
Brookhaven National Laboratory			
Fuel Cycle R & D			
Fuel Cycle R & D	2,500	1,700	1,100
Reactors Concepts RD&D			
Reactors Concepts RD&D	105	85	85
International Nuclear Energy Cooperation			
International Nuclear Energy Cooperation	25	0	10
Total, Brookhaven National Laboratory	**2,630**	**1,785**	**1,195**
Idaho National Laboratory			
Fuel Cycle R & D			
Fuel Cycle R & D	47,400	39,500	36,300
Radiological Facilities Management			
Radiological Facilities Management	4,882	6,500	6,700
Idaho Facilities Management			
Idaho Facilities Management	199,467	215,443	219,316
Idaho Sitewide Safeguards and Security			
Idaho Sitewide Safeguards and Security	100,981	123,019	126,203
Nuclear Energy Enabling Technologies			
Nuclear Energy Enabling Technologies	44,546	49,939	29,562
Reactors Concepts RD&D			
Reactors Concepts RD&D	52,807	51,598	45,260
International Nuclear Energy Cooperation			
International Nuclear Energy Cooperation	870	1,155	1,030
SMR Licensing Technical Support			
SMR Licensing Technical Support	0	1,000	500
Total, Idaho National Laboratory	**450,953**	**488,154**	**464,871**

Department Of Energy

FY 2017 Congressional Budget

Funding By Appropriation By Site

($K)

Nuclear Energy	FY 2015 Current	FY 2016 Enacted	FY 2017 Request
Idaho Operations Office			
University Research Program			
University Research	4,980	4,980	0
Fuel Cycle R & D			
Fuel Cycle R & D	54,900	62,100	90,600
Radiological Facilities Management			
Radiological Facilities Management	98	300	300
Idaho Facilities Management			
Idaho Facilities Management	5,242	5,550	6,569
Idaho Sitewide Safeguards and Security			
Idaho Sitewide Safeguards and Security	2,600	2,700	3,100
Program Direction-NE			
Program Direction-NE	8,700	8,700	10,575
Nuclear Energy Enabling Technologies			
Nuclear Energy Enabling Technologies	16,489	7,021	4,750
Reactors Concepts RD&D			
Reactors Concepts RD&D	38,654	38,212	21,980
International Nuclear Energy Cooperation			
International Nuclear Energy Cooperation	505	35	492
SMR Licensing Technical Support			
SMR Licensing Technical Support	54,500	60,600	88,600
Supercritical Transformational Electric Power Generation			
Supercritical Transformational Electric Power Generation	4,815	0	0
Total, Idaho Operations Office	**191,483**	**190,198**	**226,966**
Kansas City Site Office			
Idaho Facilities Management			
Idaho Facilities Management	200	200	200
Total, Kansas City Site Office	**200**	**200**	**200**
Lawrence Berkeley National Laboratory			
Fuel Cycle R & D			
Fuel Cycle R & D	2,300	3,100	3,800
Nuclear Energy Enabling Technologies			
Nuclear Energy Enabling Technologies	100	200	90
Reactors Concepts RD&D			
Reactors Concepts RD&D	30	0	0
Total, Lawrence Berkeley National Laboratory	**2,430**	**3,300**	**3,890**

Department Of Energy

FY 2017 Congressional Budget

Funding By Appropriation By Site

($K)

Nuclear Energy	FY 2015 Current	FY 2016 Enacted	FY 2017 Request
Lawrence Livermore National Laboratory			
Fuel Cycle R & D			
Fuel Cycle R & D	1,000	1,100	1,200
Nuclear Energy Enabling Technologies			
Nuclear Energy Enabling Technologies	1,000	1,000	900
Reactors Concepts RD&D			
Reactors Concepts RD&D	50	50	50
Total, Lawrence Livermore National Laboratory	**2,050**	**2,150**	**2,150**
Los Alamos National Laboratory			
Fuel Cycle R & D			
Fuel Cycle R & D	12,600	12,600	12,800
Nuclear Energy Enabling Technologies			
Nuclear Energy Enabling Technologies	1,940	2,095	1,840
Reactors Concepts RD&D			
Reactors Concepts RD&D	0	200	0
International Nuclear Energy Cooperation			
International Nuclear Energy Cooperation	0	50	0
Total, Los Alamos National Laboratory	**14,540**	**14,945**	**14,640**
Nevada Field Office			
Program Direction-NE			
Program Direction-NE	139	161	161
Total, Nevada Field Office	**139**	**161**	**161**
Oak Ridge Institute for Science & Education			
Program Direction-NE			
Program Direction-NE	104	104	104
Nuclear Energy Enabling Technologies			
Nuclear Energy Enabling Technologies	20	0	0
Total, Oak Ridge Institute for Science & Education	**124**	**104**	**104**
Oak Ridge National Laboratory			
Fuel Cycle R & D			
Fuel Cycle R & D	24,900	22,000	30,300
Radiological Facilities Management			
Radiological Facilities Management	19,898	17,930	0
Nuclear Energy Enabling Technologies			
Nuclear Energy Enabling Technologies	26,510	26,239	26,011
Reactors Concepts RD&D			
Reactors Concepts RD&D	17,099	18,395	15,880
International Nuclear Energy Cooperation			
International Nuclear Energy Cooperation	305	410	550
Total, Oak Ridge National Laboratory	**88,712**	**84,974**	**72,741**

Department Of Energy

FY 2017 Congressional Budget

Funding By Appropriation By Site

($K)

Nuclear Energy	FY 2015 Current	FY 2016 Enacted	FY 2017 Request
Oak Ridge Office			
Fuel Cycle R & D			
Fuel Cycle R & D	500	500	500
Program Direction-NE			
Program Direction-NE	526	526	1,291
SMR Licensing Technical Support			
SMR Licensing Technical Support	0	200	0
Total, Oak Ridge Office	**1,026**	**1,226**	**1,791**
Pacific Northwest National Laboratory			
Fuel Cycle R & D			
Fuel Cycle R & D	10,500	10,900	12,000
Nuclear Energy Enabling Technologies			
Nuclear Energy Enabling Technologies	0	0	20
Reactors Concepts RD&D			
Reactors Concepts RD&D	1,425	1,775	900
International Nuclear Energy Cooperation			
International Nuclear Energy Cooperation	262	100	50
Total, Pacific Northwest National Laboratory	**12,187**	**12,775**	**12,970**
Sandia National Laboratories			
Fuel Cycle R & D			
Fuel Cycle R & D	12,700	16,800	22,400
Nuclear Energy Enabling Technologies			
Nuclear Energy Enabling Technologies	475	440	270
Reactors Concepts RD&D			
Reactors Concepts RD&D	2,810	3,870	2,900
International Nuclear Energy Cooperation			
International Nuclear Energy Cooperation	0	190	0
SMR Licensing Technical Support			
SMR Licensing Technical Support	0	200	0
Supercritical Transformational Electric Power Generation			
Supercritical Transformational Electric Power Generation	0	4,760	0
Total, Sandia National Laboratories	**15,985**	**26,260**	**25,570**
Savannah River Operations Office			
Fuel Cycle R & D			
Fuel Cycle R & D	4,500	4,400	7,500
Total, Savannah River Operations Office	**4,500**	**4,400**	**7,500**
SLAC National Accelerator Laboratory			
Fuel Cycle R & D			
Fuel Cycle R & D	300	0	0
Total, SLAC National Accelerator Laboratory	**300**	**0**	**0**

Department Of Energy

FY 2017 Congressional Budget

Funding By Appropriation By Site

($K)

Nuclear Energy	FY 2015 Current	FY 2016 Enacted	FY 2017 Request
Washington Headquarters			
University Research Program			
University Research	20	20	0
Fuel Cycle R & D			
Fuel Cycle R & D	4,642	19,000	18,838
Radiological Facilities Management			
Radiological Facilities Management	122	70	0
Idaho Facilities Management			
Idaho Facilities Management	1,091	1,389	500
Idaho Sitewide Safeguards and Security			
Idaho Sitewide Safeguards and Security	419	442	0
Transfer from State Department			
Transfer from State Department	2,150	0	0
Program Direction-NE			
Program Direction-NE	70,531	70,509	76,569
Nuclear Energy Enabling Technologies			
Nuclear Energy Enabling Technologies	1,343	19,141	21,307
Reactors Concepts RD&D			
Reactors Concepts RD&D	947	9,973	7,945
International Nuclear Energy Cooperation			
International Nuclear Energy Cooperation	115	335	1,378
SMR Licensing Technical Support			
SMR Licensing Technical Support	0	500	500
Supercritical Transformational Electric Power Generation			
Supercritical Transformational Electric Power Generation	20	240	0
Total, Washington Headquarters	**81,400**	**121,619**	**127,037**
Total, Nuclear Energy	**902,004**	**986,161**	**993,896**

Fossil Energy Research and Development

Fossil Energy Research and Development

Fossil Energy Research and Development

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Fossil Energy Research and Development
Proposed Appropriation Language

(INCLUDING USE OF PRIOR YEAR BALANCES)

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 (42 U.S.C. 7101 et seq.), 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), **[**$632,000,000**]** *$600,000,000*, to remain available until expended*, of which $240,000,000 shall be from prior year unobligated balances previously appropriated*: *Provided*, That of **[**such amount $114,202,000**]** *the amount made available under this heading in this Act, $60,998,000* shall be available until September 30, **[**2017**]** *2018*, for program direction*: Provided further, That of the $600,000,000 provided under this heading, $360,000,000 is appropriated from the general fund and $240,000,000 is derived from funds appropriated in prior Acts under the headings ''Fossil Energy Research and Development'' and ''Clean Coal Technology'' for prior solicitations under the Clean Coal Power Initiative from projects selected under such solicitations that have not reached financial close prior to the date of enactment of this Act: Provided further, That such funds appropriated in prior Acts shall be deobligated, if necessary, and shall be made available for activities under this heading without regard to the provisions in the Act in which the funds were originally appropriated: Provided further, That no amounts may be repurposed pursuant to this paragraph 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. (Energy and Water Development and Related Agencies Appropriations Act, 2016.)*

Explanation of Changes

The FY 2017 Budget Request proposes to use $240,000,000 of prior year balances from Clean Coal Power Initiative projects that have not reached financial close.

Public Law Authorizations

CCS and Advanced Power Systems (formerly CCS and Power Systems):
- Public Law 95-91.

Fuel Supply Impact Mitigation (formerly 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".

NETL Infrastructure/Laboratory Facilities (formerly Plant and Capital Equipment)
NETL Infrastructure/Site-wide Facilities (formerly Plant 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"

NETL Infrastructure/Environmental Restoration (formerly 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"

Crosscutting Research and Analysis/Education and Outreach/Special Recruitment Programs (formerly 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 2015 Enacted	FY 2015 Current	FY 2016 Enacted	FY 2017 Request
$560,587	$548,885	$632,000	$600,000[1]

Overview

The Fossil Energy Research and Development (FER&D) program advances technologies related to the reliable, efficient, affordable, and environmentally sound use of fossil fuels that are important to our Nation's security and economic prosperity. FER&D leads Federal research, development, and demonstration efforts on advanced Carbon Capture and Storage (CCS) technologies to facilitate achievement of the President's climate goals. FER&D also conducts research related to the prudent and sustainable development of domestic unconventional oil and gas resources. These FER&D programs create public benefits by 1) performing and managing research that addresses externalities related to the environmentally sound use of fossil fuels, 2) partnering with industry and others to advance environmentally prudent 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 2017 Budget Request

In FY 2017, FER&D will continue to focus on CCS and activities that increase the efficiency and availability of advanced power systems integrated with CCS.

It is important to demonstrate that electric generation technology with CCS can be deployed at commercial scale while maintaining reliable, predictable and safe operations. Therefore, the FER&D portfolio includes several major integrated CCS demonstration projects encompassing different technological approaches and applications of CCS. A number of those projects have not yet reached financial close. DOE intends to deobligate $240 million from CCPI projects that have not yet reached financial close and repurpose these funds to support the FY 2017 R&D portfolio.

The FY 2017 Budget Request takes a significant first step toward fulfilling the U.S. pledge to seek to double federal clean energy research and development investments government-wide over the next 5 years as part of Mission Innovation, an initiative launched by the U.S. and 19 other countries to accelerate widespread clean energy technology innovation and cost reduction. The Fossil Energy R&D FY 2017 Budget Request of $600 million includes $564 million for the support of Mission Innovation, an increase of $31 million from the Enacted FY 2016 of $533 million. These investments will drive innovation essential for economic growth, provide clean, affordable and reliable energy, and advance energy security.

In FY 2017 FER&D proposes a restructuring of the account to support clarity in the Budget Request, improve execution, and eliminate the categorization by fuel type that is no longer appropriate for this R&D portfolio. Changes include:

- The Coal/CCS and Power Systems budget line will be renamed CCS and Advanced Power Systems to reflect that the research and development performed under this program is focused on developing CCS technologies, best practices for carbon storage, and innovative power systems that reduce the costs of CCS. The technologies developed under the program support both coal and natural gas power generation.
- The STEP program will become an activity under the Advanced Energy Systems subprogram. It will support development of a more efficient power cycle facilitating lower cost CCS. Furthermore the more advanced direct fired configuration provides additional benefits as the CO_2 can be captured at the storage pressure avoiding CO_2 separation and compression penalties.
- Changes at the subprogram and activity levels within CCS and Advanced Power Systems are also proposed to streamline the budget structure and better align related activities under the same subprograms. These changes are described in the relevant sections of the Budget Request.
- The Natural Gas Technologies program will be renamed Fuel Supply Impact Mitigation to clarify that the focus is on continued implementation of priority research and development to ensure that fossil fuel development and delivery to power systems is conducted in a manner that is environmentally sound and protective of human health and safety. Changes at the subprogram level within Fuel Supply Impact Mitigation are also proposed and are described in that section of the Budget Request.

[1] Includes $240 million in use of prior year balances.

- The National Energy Technology Laboratory Coal Research and Development program and the Program Direction line will be restructured through the proposed National Energy Technology Laboratory (NETL) reorganization to better describe NETL's funding requirements, increase consistency with other national laboratories, and increase transparency in how funds are utilized, promoting enhanced visibility into cost drivers and more efficient resource allocation decisions. NETL Research & Operations and NETL Infrastructure will become new budget lines.
- The Plant and Capital Equipment and Supercomputer programs and the vast majority of the Fossil Energy Environmental Restoration program will become part of the new NETL Infrastructure program. The remainder of the Fossil Energy Environmental Restoration program will fund policy and oversight efforts in Program Direction at headquarters.

CCS and Advanced Power Systems (formerly Coal/CCS and Power Systems)

Descriptions of major funding and programmatic changes and highlights within the CCS and Advanced Power Systems program for FY 2017 are as follows:

Carbon Capture

In FY 2017 Carbon Capture maintains priority on post-combustion and pre-combustion capture for fossil fuel-fired power plants. The subprogram supports a new emphasis on reducing the costs and technical challenges of natural gas carbon capture. Advanced Combustion Systems focuses on the development of technologies such as pressurized oxy-combustion and chemical looping processes that facilitate carbon capture. For this reason, it is moved under the Carbon Capture subprogram as part of the proposed restructuring.

The Post-Combustion Capture activity will provide initial funding in FY 2017 for one additional (three total) post-combustion large pilot projects (10+ MWe) aimed at reducing costs and validating performance and operation for fossil fuel-fired power plants. The new Natural Gas Carbon Capture activity will support the front end engineering and design (FEED) study for and initial construction costs of one large pilot specifically designed to capture CO_2 from a natural gas power plant. The Advanced Combustion Systems activity will fully fund two additional (four total) FEED studies - 1 chemical looping (2 total) and 1 oxy-combustion (2 total). The program will also accelerate the discovery of transformational carbon capture technologies for both pre- and post-combustion capture systems for both coal and natural gas. FY 2017 funding also supports the field testing of carbon capture systems at the National Carbon Capture Center.

Carbon Storage

In FY 2017 the Carbon Storage subprogram portfolio priorities are rebalanced, moving from the large-scale injection operations of the Regional Carbon Sequestration Partnership (RCSP) projects to support for an on- and off-shore site characterization and technology validation efforts; commercial-scale site characterization and Brine Extraction Storage Tests (BEST) field activities; and lower-cost post injection monitoring technologies at RCSP field sites. The FY 2017 Budget Request supports new and existing Carbon Storage subprogram projects and the Department's cross-functional Subsurface Science, Technology and Engineering RD&D (Subsurface) crosscut in developing laboratory-and bench-scale technologies for carbon storage and monitoring. The Budget Request will support Energy Data Exchange (EDX) expansion and development of National Risk Assessment Partnership (NRAP) simulation toolsets.

Advanced Energy Systems (AES)

In FY 2017 funding enables the subprogram to develop a new generation of fossil-fueled energy conversion systems integrated with CCS that may be capable of producing competitively priced electric power. The Supercritical Transformational Electric Power (STEP) initiative, which is proposed as an activity under AES as part of the FY 2017 restructuring, supports the Department's Supercritical CO_2 (sCO_2) crosscut, which is focused on technology development for supercritical carbon dioxide-based power conversion cycles. In coordination with the sCO_2 crosscut team, the STEP activity within AES will continue the design and construction of the STEP facility.

Crosscutting Research and Analysis (formerly Crosscutting Research)

Funding for computational modeling in FY 2017 will support computer-aided design tools for the Advanced Energy Systems subprogram so that novel concepts can be explored and analysis can be conducted on pre-commercial systems. This modeling supports first principle and physics based modeling of phenomenon for complex energy conversion and carbon capture processes tools and techniques. Funding for University Coal Research and the Historically Black Colleges and Universities (HBCUs) and Other Minority Institutions (formerly called HBCUs

Education and Training) subactivities will support grants to educate and support minority institutions. In FY 2017, the increase in funding for the new Extreme Environment Materials activity, which combines the former Crosscutting Materials R&D and Advanced Ultrasupercritical Materials R&D efforts, will support Code Certification of High Temperature Materials, digital data management, informatics, reliability and access, and R&D focused on technology development of advanced materials and component testing of high temperature materials for directly-heated sCO_2. Increased support for atom to metals and born certified materials efforts will support the development of tools to enable the design of new materials capable of operation in harsh high temperature environments. The increase in funding for Water Management R&D supports field testing of advanced desalination technology using effluents from the BEST field project site (funded separately through the Carbon Storage subprogram). The activity continues to support improved water efficiency at power plants focusing on treatment and use of non-traditional water.

Fuel Supply Impact Mitigation (formerly Natural Gas Technologies)

The Fuel Supply Impact Mitigation program will focus on continued implementation of priority collaborative research and development to ensure that unconventional oil and gas development is conducted in a manner that is environmentally sound and protective of human health and safety. The program will focus on technologies to reduce surface and subsurface footprint, emissions, and water use in order to enable safe and responsible development of unconventional domestic oil and natural gas resources in coordination with the Department of the Interior and the Environmental Protection Agency. The program will continue midstream natural gas infrastructure efforts focused on advanced cost-effective technologies to detect and mitigate methane emissions from natural gas transmission, distribution, and storage facilities and to communicate results on methane emissions mitigation to stakeholders. In addition, the program will continue efforts in methane quantification focused on validation of emission data from the natural gas infrastructure. The Gas Hydrates subprogram, through public sector-led efforts, will continue to evaluate the occurrence, nature, and behavior of naturally occurring gas hydrates and the resulting resource, hazard, and environmental implications.

NETL Research and Operations

The new NETL Research and Operations program supports NETL research activities. The program is comprised of the following subprograms: (1) Research and Development (2) Site Operations (3) Program Oversight and (4) Feasibility of Recovering Rare Earth Elements. The Research and Development funding supports salaries/benefits and travel for NETL staff directly associated with conducting both intramural and extramural research activities for FER&D programs. The R&D activities are performed by a staff of scientists, engineers, and technical project managers. The Site Operations subprogram includes funding for Federal employees and contractors who perform site operations at the laboratories. The Program Oversight subprogram includes funding for Federal employees and contractors performing research-enabling functions such as legal, finance, procurement, information technology, and human resources that are necessary for the performance of NETL activities. In order to increase consistency with the manner in which other national laboratories are funded, the conduct of laboratory management, communications, procurement, and certain IT activities is included in the Program Direction budget line. The Feasibility of Recovering Rare Earth Elements (REE) subprogram was established to perform an assessment and analysis of the feasibility of economically recovering rare earth elements from coal and coal byproduct streams. No funding is requested for REE activities in FY 2017.

NETL Infrastructure

The new NETL Infrastructure program supports the upkeep of a lab footprint valued at $600 million in three geographic locations -- Morgantown, WV; Pittsburgh, PA; and Albany, OR. These sites include 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. The funding will provide infrastructure repairs and improvements for both laboratory/research facilities and site-wide/general purpose facilities. This budget line also includes fixed occupancy costs for operating and maintaining research facilities and other site-wide facilities, such as support services and other related costs for building maintenance and information technology infrastructure. The program is comprised of the following subprograms: (1) Laboratory Facilities, which includes the NETL High-Performance Computer-Joule; (2) Site-wide Facilities; (3) Safeguards and Security; and (4) Environmental Restoration.

Program Direction

This program provides the funding for all headquarters personnel and operational expenses for FER&D. In addition, it provides support for day-to-day field office functions and operational expenses for NETL. Also included is the Import/Export Authorization program, which will continue regulatory reviews and oversight of the transmission of

natural gas across the U.S. borders. As part of the proposed FER&D budget restructuring, Program Direction funding no longer includes support for Federal employees performing research-enabling functions. These activities are funded in the NETL Research & Operations line. Operational costs such as grounds maintenance and utilities are also included in the new NETL Research and Operations line. Fixed occupancy funding, such as building and laboratory repairs and information technology infrastructure, have moved to the new NETL Infrastructure budget line.

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 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. Fossil Energy R&D contains the following crosscuts:

Advanced Materials (Adv Mat): Affordable, reliable, and high-performance materials are critical for clean energy applications and for global manufacturing competitiveness in the 21st century. The new Advanced Materials crosscut, identified as a priority in both the 2015 Quadrennial Technology Review and Quadrennial Energy Review, will employ advanced synthesis, modeling, and characterization to accelerate and reduce the cost of materials qualification in a wide variety of clean energy applications, from discovery through deployment. While materials RD&D underpins much of DOE's historic and current portfolio across both basic science and applied offices, this newly formed crosscut focuses on a subset of materials R&D that will involve close coordination among the participating offices in forming a cohesive network with the following capabilities: (1) materials design and synthesis, (2) functional (applied) design, (3) process scale-up, (4) qualification, and (5) digital data and informatics.

Supercritical CO_2 (sCO_2): The supercritical carbon dioxide (sCO_2) based power generation initiative is a technology-focused crosscut that will facilitate industry's transition to realize power cycles based on sCO_2 as the working fluid. 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 FY 2017 Request builds on industry outreach and focused R&D efforts in FY 2015, and the development of more detailed conceptual plans, technical approach, and cost and schedule estimates relevant to a 10 MWe pilot test facility in FY 2016. These inputs will inform the development of the Supercritical Transformational Electric Power Generation (STEP) solicitation, to be issued and awarded in FY 2016, for the design, construction and operation of a 10 MWe pilot test facility. Initiation of design and construction of the STEP facility would begin in early FY 2017. Recognizing that the near-term deployment and potential market applications for commercial sCO2 power cycles are primarily in the fossil energy area, the STEP pilot project is being managed by the Office of Fossil Energy.

Subsurface Science, Technology and Engineering RD&D (Subsurface): 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 will address identified challenges in the subsurface through highly focused and coordinated research in Wellbore Integrity, Subsurface Stress State and Induced Seismicity, Permeability Manipulation, and New Subsurface Signals to enhance renewable energy supply, ensure material impact on climate change via CO2 storage, and significantly mitigate environmental impacts from energy-related subsurface activities and operations.

Energy-Water Nexus (EWN): There is increasing urgency to address the energy-water nexus in an integrated way due to changing precipitation and temperature patterns, accelerated drawdown of critical water supplies, population growth and regional migration trends, and the introduction of new technologies that could shift water and energy demands. 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 two categories of cyber-related activities: protecting the DOE enterprise from a range of cyber threats that can adversely impact mission capabilities 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, Credentials, and Access Management (ICAM).

FY 2017 Crosscuts ($K)

	sCO_2	Subsurface	EWN	Adv Mat	Cyber-security	Total
CCS and Advanced Power Systems	30,300	90,875	15,800	23,150	0	**160,125**
Fuel Supply Impact Mitigation	0	7,000	0	0	0	**7,000**
NETL Infrastructure	0	0	0	0	4,872	**4,872**
Total, Crosscuts	**30,300**	**97,875**	**15,800**	**23,150**	**4,872**	**171,997**

Fossil Energy Research and Development
Funding by Congressional Control
($K) (Non-Comparable)

	FY 2015 Enacted	FY 2015 Current[2]	FY 2016 Enacted	FY 2017 Request	FY 2017 vs FY 2016
Coal					
CCS and Power Systems					
Carbon Capture	88,000	85,269	101,000	0	-101,.000
Carbon Storage	100,000	96,896	106,000	0	-106,000
Advanced Energy Systems	103,000	99,803	105,000	0	-105,000
Crosscutting Research	49,000	47,560	50,000	0	-50,000
Supercritical Carbon Dioxide Technology	10,000	9,690	15,000	0	-15,000
NETL Coal Research and Development	50,000	50,000	53,000	0	-53,000
Total, CCS and Power Systems	**400,000**	**389,218**	**430,000**	**0**	**-430,000**
Total, Coal	**400,000**	**389,218**	**430,000**	**0**	**-430,000**
Natural Gas Technologies	**25,121**	**24,341**	**43,000**	**0**	**-43,000**
Unconventional Fossil Energy Technologies from Petroleum – Oil Technologies	**4,500**	**4,360**	**20,321**	**0**	**-20,321**
Program Direction	**119,000**	**119,000**	**114,202**	**0**	**-114,202**
Plant & Capital Equipment	**15,782**	**15,782**	**15,782**	**0**	**-15,782**
FE Environmental Restoration	**5,897**	**5,897**	**7,995**	**0**	**-7,995**
Supercomputer	**0**	**0**	**0**	**0**	**0**
Special Recruitment Programs	**700**	**700**	**700**	**0**	**-700**

[2] Funding reflects FY 2015 SBIR/STTR funds which were transferred from FER&D to Science.

	FY 2015 Enacted	FY 2015 Current[2]	FY 2016 Enacted	FY 2017 Request	FY 2017 vs FY 2016
CCS and Advanced Power Systems					
Carbon Capture	0	0	0	170,352	+170,352
Carbon Storage	0	0	0	90,875	+90,875
Advanced Energy Systems	0	0	0	47,800	+47,800
Crosscutting Research and Analysis	0	0	0	59,350	+59,350
Total, CCS and Advanced Power Systems	**0**	**0**	**0**	**368,377**	**+368,377**
Fuel Supply Impact Mitigation	**0**	**0**	**0**	**26,500**	**+26,500**
Program Direction	**0**	**0**	**0**	**60,998**	**+60,998**
NETL Research and Operations	**0**	**0**	**0**	**76,070**	**+76,070**
NETL Infrastructure	**0**	**0**	**0**	**68,055**	**+68,055**
Subtotal, Fossil Energy Research & Development	**0**	**0**	**0**	**600,000**	**+600,000**
Use of Prior Year Balances	0	0	0	-240,000	-240,000
Rescission of Prior Year Balances	0	0	0	0	0
Total, Fossil Energy Research & Development	**0**	**0**	**0**	**360,000**	**+360,000**
Federal FTEs[3]	**651**	**651**	**649**	**658**	**+9**

SBIR/STTR:

- FY 2015 Transferred: SBIR $10,284; STTR: $1,418
- FY 2016 Projected: SBIR $12,268; STTR: $1,839
- FY 2017 Request: SBIR $11,373; STTR: $1,599

[3] Includes Federal FTEs in the following Programs: NETL Coal R&D, NETL Research and Operations, and Program Direction.

Fossil Energy Research and Development
Funding by Congressional Control ($K) (Comparable)[4]

	FY 2015 Enacted	FY 2015 Current[5]	FY 2016 Enacted	FY 2017 Request	FY 2017 vs FY 2016
CCS and Advanced Power Systems					
Carbon Capture	116,000	112,400	131,000	170,352	+39,352
Carbon Storage	100,000	96,896	106,000	90,875	-15,125
Advanced Energy Systems	85,000	82,362	90,000	47,800	-42,200
Crosscutting Research and Analysis	49,700	48,260	50,700	59,350	+8,650
Total, CCS and Advanced Power Systems	**350,700**	**339,918**	**377,700**	**368,377**	**-9,323**
Fuel Supply Impact Mitigation	**25,121**	**24,341**	**43,000**	**26,500**	**-16,500**
Unconventional Fossil Energy Technologies	**4,500**	**4,360**	**20,321**	**0**	**-20,321**
NETL Research and Operations	**88,029**	**88,029**	**91,984**	**76,070**	**-15,914**
NETL Infrastructure	**39,545**	**39,545**	**38,950**	**68,055**	**+29,105**
Program Direction	**63,105**	**63,105**	**60,045**	**60,998**	**+953**
Subtotal, Fossil Energy Research & Development	**571,000**	**559,298**	**632,000**	**600,000**	**-32,000**
Use of Prior Year Balances	0	0	0	-240,000	-240,000
Rescission of Prior Year Balances	-10,413	-10,413	0	0	0
Total, Fossil Energy Research & Development	**560,587**	**548,885**	**632,000**	**360,000**	**-272,000**
Federal FTEs[6]	**651**	**651**	**649**	**658**	**+9**

SBIR/STTR:
- FY 2015 Transferred: SBIR $10,284; STTR: $1,418
- FY 2016 Projected: SBIR $12,268; STTR: $1,839
- FY 2017 Request: SBIR $11,373; STTR: $1,599

[4] In the comparable table, FY 2015 and FY 2016 funding is shown in the FY 2017 structure.

[5] Funding reflects FY 2015 SBIR/STTR funds which were transferred from FER&D to Science.

[6] Includes Federal FTEs in the following Programs: NETL Research and Operations and Program Direction.

Proposed Budget Structure Changes

FER&D is proposing to restructure its budget to streamline the structure, align subprograms that support related efforts under the same program, provide a more comprehensive view of the costs associated with NETL, and eliminate categorization of activities by fuel type.

This section of the budget narrative provides a series of crosswalks from the current budget structure to the proposed structure. Three series of crosswalks are provided. The first provides information on the restructuring of the programs that were previously within the CCS and Power Systems budget lines, with the exception of NETL Coal R&D which is addressed in the set of crosswalks that address the new NETL budget lines. The second series of crosswalks addresses the reorganization of the Plant and Capital Equipment, Program Direction, Fossil Energy Environmental Restoration, NETL Coal R&D and Supercomputer budget lines. The third series of crosswalks addresses changes to what was the Natural Gas Technologies program and is now proposed to be called the Fuel Supply Impact Mitigation program.

Restructuring of Coal/CCS and Power Systems

1. The Coal/CCS and Power Systems budget line will be renamed CCS and Advanced Power Systems to reflect that the research and development performed under this program is focused on developing CCS technologies and innovative power systems that reduce the costs of CCS for both coal and natural gas power generation.
2. Within *CCS and Advanced Power Systems*, *Advanced Combustion Systems* will move from *Advanced Energy Systems* to *Carbon Capture* because development of technologies such as pressurized oxy-combustion and chemical looping processes facilitate carbon capture.
3. A new *Natural Gas Carbon Capture* activity will be created under *Carbon Capture.* This activity will be focused on R&D towards 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 using what has been determined to be the best available carbon capture technology available for demonstration at the time.
4. The *Storage Infrastructure* activity within *Carbon Storage* will be renamed *Storage Field Management* to clarify that this activity is focused on demonstrating safe and permanent geologic storage of CO_2 and providing best practices for doing so.
5. The *Sub-Disciplinary Storage R&D* activity will be renamed *Risk and Integration Tools* to reflect that this activity centers on risk assessment and system model integration and validation.
6. *The Supercritical Transformational Electric Power (STEP)* activity will be moved under *Advanced Energy Systems* (AES) appearing as *STEP (Supercritical CO_2)*. This previously was a separate program but is being moved under AES as it is part of this broader portfolio of new fossil-fuel energy conversion systems integrated with CCS that may be capable of producing competitively priced electricity.
7. *The Cross-Cutting Research activity* will be renamed *Crosscutting Research and Analysis (CRA)*. Proposed changes will streamline the budget structure and align activities that support related efforts under the same subprogram.
    a. There are 6 subprograms proposed under CRA[1] – *Computational Sciences, Education and Outreach*, *Energy Evaluation and Analysis, Extreme Environment Materials, Sensors and Controls,* and *Water Management R&D*.
        i. *Computational Sciences* combines the former *Computational System Dynamics* and *Focus Area for Computational Energy Science.*
        ii. *Education and Outreach* is comprised of the *University Coal Research, Historically Black Colleges and Universities (HBCUs) and Other Minority Institutions, Special Recruitment Programs*, and *International Activities* subactivities. *Special Recruitment Programs* was previously not part of the *CCS and Power Systems* budget. All university educational initiatives are now consolidated under *Education and Outreach*.
            1. The former *HBCUs Education and Training* area is renamed *HBCUs and Other Minority Institutions* to better reflect the breadth of institutions supported.

[1]The *Plant Optimization Technologies* line is eliminated. However, all the activities under it remain. This will streamline the budget structure, eliminating lines that are not Congressional Controls without decreasing transparency.

2. *International Activities* combines the former *Coal Technology Export* and *International Program Support areas.*

iii. *Energy Evaluation and Analysis* combines the former *Environmental Activities* and *Technical and Economic Analysis* lines.

iv. *Extreme Environment Materials* combines the former *Crosscutting Materials R&D* and *Advanced Ultrasupercritical R&D* lines.

v. *Sensors and Controls,* which was formerly *Sensors, Controls and Other Novel Concepts, remains under Crosscutting Research and Analysis.* The shortening of the name does not reflect a change in programmatic content.

vi. *Water Management R&D remains under Crosscutting Research and Analysis.*

Budget Structure Crosswalk
FY 2015 Enacted ($K)

Proposed FY 2017 Budget Structure

FY 2016 Budget Structure	CCS and Advanced Power Systems				
	Carbon Capture				
	Post-Combustion Capture Systems	Pre-Combustion Capture Systems	Natural Gas Carbon Capture	Advanced Combustion Systems	Total, Carbon Capture
Coal/CCS and Power Systems					
Carbon Capture					
Post-Combustion Capture Systems	76,000	—	—	—	76,000
Pre-Combustion Capture Systems	—	12,000	—	—	12,000
Advanced Energy Systems					
Advanced Combustion Systems	—	—	—	28,000	28,000
	—	—	—	—	—
	76,000	**12,000**	**—**	**28,000**	**116,000**

Budget Structure Crosswalk
FY 2015 Enacted ($K)

Proposed FY 2017 Budget Structure

FY 2016 Budget Structure	CCS and Advanced Power Systems				
	Carbon Storage				
	Storage Field Management	Advanced Storage R&D	Carbon Use and Reuse	Risk and Integration Tools	Total, Carbon Storage
Coal/CCS and Power Systems					
Carbon Storage					
Storage Infrastructure	66,000	—	—	—	66,000
Advanced Storage R&D	—	23,500	—	—	23,500
Carbon Use and Reuse	—	—	2,000	—	2,000
Sub-disciplinary Storage R&D	—	—	—	8,500	8,500
	66,000	**23,500**	**2,000**	**8,500**	**100,000**

Budget Structure Crosswalk

FY 2015 Enacted ($K)

	Proposed FY 2017 Budget Structure					
	CCS and Advanced Power Systems					
	Advanced Energy Systems (AES)					
FY 2016 Budget Structure	**Gasification Systems**	**Advanced Turbines**	**STEP (Supercritical CO_2)**	**Solid Oxide Fuel Cells**	**Coal and Coal Biomass to Liquids**	**Total, AES**
Coal/CCS and Power Systems						
Advanced Energy Systems						
Gasification Systems	25,000	—	—	—	—	25,000
Advanced Turbines	—	15,000	—	—	—	15,000
Coal and Coal Biomass to Liquids	—	—	—	—	5,000	5,000
Solid Oxide Fuel Cells	—	—	—	30,000	—	30,000
Supercritical Transformational Electric Power (STEP)	—	—	10,000	—	—	10,000
	25,000	**15,000**	**10,000**	**30,000**	**5,000**	**85,000**

Budget Structure Crosswalk

FY 2015 Enacted ($K)

FY 2016 Budget Structure	Proposed FY 2017 Budget Structure									
	CCS and Advanced Power Systems									
	Crosscutting Research and Analysis (CRA)									
	Compu-tational Sciences	Education and Outreach				Sensors and Controls	Energy Evaluation and Analysis	Extreme Environ-ment Materials	Water Manage-ment R&D	Total, CRA
		University Coal Research	HBCUs and Other Minority Institutions	Special Recruit-ment Programs	Inter-national Activities					
Coal/CCS and Power Systems										
Crosscutting Research										
Coal Utilization Science										
Computational System Dynamics	12,000	—	—	—	—	—	—	—	—	12,000
Focus Area for Computational Energy Science	12,000	—	—	—	—	—	—	—	—	12,000
University Training and Research										
University Coal Research	—	3,000	—	—	—	—	—	—	—	3,000
HBCU's, Education and Training	—	—	900	—	—	—	—	—	—	900
International Activities								—	—	
Coal Technology Export	—	—	—	—	500	—	—	—	—	500
Int"l. Program Support	—	—	—	—	600	—	—	—	—	600
Energy Analysis								—	—	
Environmental Activities	—	—	—	—	—	—	750	—	—	750
Technical and Economic Analysis	—	—	—	—	—	—	750	—	—	750
Plant Optimization Technologies										
Sensors, Controls and Other Novel Concepts	—	—	—	—	—	4,500	—	—	—	4,500
Crosscutting Materials R&D	—	—	—	—	—	—	—	2,000	—	2,000
Advanced Ultrasupercritical	—	—	—	—	—	—	—	5,000	—	5,000
Water Management R&D	—	—	—	—	—	—	—	—	7,000	7,000
Special Recruitment Programs	—	—	—	700	—	—	—	—	—	700
	24,000	**3,000**	**900**	**700**	**1,100**	**4,500**	**1,500**	**7,000**	**7,000**	**49,700**

Budget Structure Crosswalk
FY 2015 Current ($K)

Proposed FY 2017 Budget Structure

FY 2016 Budget Structure	CCS and Advanced Power Systems – Carbon Capture: Post-Combustion Capture Systems	Pre-Combustion Capture Systems	Natural Gas Carbon Capture	Advanced Combustion Systems	Total, Carbon Capture
Coal/CCS and Power Systems					
Carbon Capture					
Post-Combustion Capture Systems	73,641	—	—	—	73,641
Pre-Combustion Capture Systems	—	11,628	—	—	11,628
Advanced Energy Systems					
Advanced Combustion Systems	—	—	—	27,131	27,131
	—	—	—	—	—
	73,641	**11,628**	—	**27,131**	**112,400**

Budget Structure Crosswalk
FY 2015 Current ($K)

Proposed FY 2017 Budget Structure

FY 2016 Budget Structure	CCS and Advanced Power Systems – Carbon Storage: Storage Field Management	Advanced Storage R&D	Carbon Use and Reuse	Risk and Integration Tools	Total, Carbon Storage
Coal/CCS and Power Systems					
Carbon Storage					
Storage Infrastructure	63,953	—	—	—	63,953
Advanced Storage	—	22,770	—	—	22,770
Carbon Use and Reuse	—	—	1,937	—	1,937
Sub-disciplinary Storage R&D	—	—	—	8,236	8,236
	63,953	**22,770**	**1,937**	**8,236**	**96,896**

Budget Structure Crosswalk

FY 2015 Current ($K)

Proposed FY 2017 Budget Structure

	CCS and Advanced Power Systems					
	Advanced Energy Systems (AES)					
FY 2016 Budget Structure	**Gasification Systems**	**Advanced Turbines**	**STEP (Supercritical CO_2)**	**Solid Oxide Fuel Cells**	**Coal and Coal Biomass to Liquids**	**Total, AES**
Coal/CCS and Power Systems						
Advanced Energy Systems						
Gasification Systems	24,224	—	—	—	—	24,224
Advanced Turbines	—	14,534	—	—	—	14,534
Coal and Coal Biomass to Liquids	—	—	—	—	4,845	4,845
Solid Oxide Fuel Cells	—	—	—	29,069	—	29,069
Supercritical Transformational Electric Power (STEP)	—	—	9,690	—	—	9,690
	24,224	**14,534**	**9,690**	**29,069**	**4,845**	**82,362**

Budget Structure Crosswalk

FY 2015 Current ($K)

Proposed FY 2017 Budget Structure

FY 2016 Budget Structure	CCS and Advanced Power Systems									
	Crosscutting Research and Analysis (CRA)									
	Computational Sciences	Education and Outreach				Sensors and Controls	Energy Evaluation and Analysis	Extreme Environment Materials	Water Management R&D	Total, CRA
		University Coal Research	HBCUs and Other Minority Institutions	Special Recruitment Programs	International Activities					
Coal/CCS and Power Systems										
Crosscutting Research										
Coal Utilization Science										
Computational System Dynamics	11,628	—	—	—	—	—	—	—	—	11,628
Focus Area for Computational Energy Science	11,628	—	—	—	—	—	—	—	—	11,628
University Training and Research										
University Coal Research	—	2,907	—	—	—	—	—	—	—	2,907
HBCU's, Education and Training	—	—	872	—	—	—	—	—	—	872
International Activities								—	—	
Coal Technology Export	—	—	—	—	500	—	—	—	—	500
Int"l. Program Support	—	—	—	—	600	—	—	—	—	600
Energy Analysis								—	—	
Environmental Activities	—	—	—	—	—	—	750	—	—	750
Technical and Economic Analysis	—	—	—	—	—	—	750	—	—	750
Plant Optimization Technologies										
Sensors, Controls and Other Novel Concepts	—	—	—	—	—	4,360	—	—	—	4,360
Crosscutting Materials R&D	—	—	—	—	—	—	—	1,937	—	1,937
Advanced Ultrasupercritical	—	—	—	—	—	—	—	4,845	—	4,845
Water Management R&D	—	—	—	—	—	—	—	—	6,783	6,783
Special Recruitment Programs	—	—	—	700	—	—	—	—	—	700
	23,256	**2,907**	**872**	**700**	**1,100**	**4,360**	**1,500**	**6,782**	**6,783**	**48,260**

Budget Structure Crosswalk

FY 2016 Enacted ($K)

Proposed FY 2017 Budget Structure

FY 2016 Budget Structure	CCS and Advanced Power Systems – Carbon Capture				
	Post-Combustion Capture Systems	Pre-Combustion Capture Systems	Natural Gas Carbon Capture	Advanced Combustion Systems	Total, Carbon Capture
Coal/CCS and Power Systems					
Carbon Capture					
Post-Combustion Capture Systems	89,000	—	—	—	89,000
Pre-Combustion Capture Systems	—	12,000	—	—	12,000
Advanced Energy Systems					
Advanced Combustion Systems	—	—	—	30,000	30,000
	—	—	—	—	—
	89,000	**12,000**	**—**	**30,000**	**131,000**

FY 2016 Budget Structure	CCS and Advanced Power Systems – Carbon Storage				
	Storage Field Management	Advanced Storage R&D	Carbon Use and Reuse	Risk and Integration Tools	Total, Carbon Storage
Coal/CCS and Power Systems					
Carbon Storage					
Storage Infrastructure	66,000	—	—	—	66,000
Advanced Storage R&D	—	21,500	—	—	21,500
Carbon Use and Reuse	—	—	10,000	—	10,000
Sub-disciplinary Storage R&D	—	—	—	8,500	8,500
	66,000	**21,500**	**10,000**	**8,500**	**106,000**

Budget Structure Crosswalk

FY 2016 Enacted ($K)

Proposed FY 2017 Budget Structure

	CCS and Advanced Power Systems					
	Advanced Energy Systems (AES)					
FY 2016 Budget Structure	**Gasification Systems**	**Advanced Turbines**	**STEP (Supercritical CO_2)**	**Solid Oxide Fuel Cells**	**Coal and Coal Biomass to Liquids**	**Total, AES**
Coal/CCS and Power Systems						
Advanced Energy Systems						
Gasification Systems	25,000	—	—	—	—	25,000
Advanced Turbines	—	15,000	—	—	—	15,000
Coal and Coal Biomass to Liquids	—	—	—	—	5,000	5,000
Solid Oxide Fuel Cells	—	—	—	30,000	—	30,000
Supercritical Transformational Electric Power (STEP)	—	—	15,000	—	—	15,000
	25,000	**15,000**	**15,000**	**30,000**	**5,000**	**90,000**

Budget Structure Crosswalk

FY 2016 Enacted ($K)

Proposed FY 2017 Budget Structure

FY 2016 Budget Structure	CCS and Advanced Power Systems – Crosscutting Research and Analysis (CRA)									
		Education and Outreach								
	Compu-tational Sciences	University Coal Research	HBCUs and Other Minority Institutions	Special Recruit-ment Programs	Inter-national Activities	Sensors and Controls	Energy Evaluation and Analysis	Extreme Environ-ment Materials	Water Manage-ment R&D	Total, CRA
Coal/CCS and Power Systems										
Crosscutting Research										
Coal Utilization Science										
Computational System Dynamics	12,000	—	—	—	—	—	—	—	—	12,000
Focus Area for Computational Energy Science	12,000	—	—	—	—	—	—	—	—	12,000
University Training and Research										
University Coal Research	—	2,000	—	—	—	—	—	—	—	2,000
HBCU's, Education and Training	—	—	1,000	—	—	—	—	—	—	1,000
International Activities								—	—	
Coal Technology Export	—	—	—	—	500	—	—	—	—	500
Int"l. Program Support	—	—	—	—	600	—	—	—	—	600
Energy Analysis								—	—	
Environmental Activities	—	—	—	—	—	—	700	—	—	700
Technical and Economic Analysis	—	—	—	—	—	—	700	—	—	700
Plant Optimization Technologies										
Sensors, Controls and Other Novel Concepts	—	—	—	—	—	4,500	—	—	—	4,500
Crosscutting Materials R&D	—	—	—	—	—	—	—	1,000	—	1,000
Advanced Ultrasupercritical	—	—	—	—	—	—	—	9,000	—	9,000
Water Management R&D	—	—	—	—	—	—	—	—	6,000	6,000
Special Recruitment Programs	—	—	—	700	—	—	—	—	—	700
	24,000	**2,000**	**1,000**	**700**	**1,100**	**4,500**	**1,400**	**10,000**	**6,000**	**50,700**

Budget Structure Crosswalk

FY 2017 Request ($K)

Proposed FY 2017 Budget Structure

FY 2016 Budget Structure	CCS and Advanced Power Systems – Carbon Capture: Post-Combustion Capture Systems	Pre-Combustion Capture Systems	Natural Gas Carbon Capture	Advanced Combustion Systems	Total, Carbon Capture
Coal/CCS and Power Systems					
Carbon Capture					
Post-Combustion Capture Systems	97,200	—	—	—	97,200
Pre-Combustion Capture Systems	—	12,000	—	—	12,000
Advanced Energy Systems					
Advanced Combustion Systems	—	—	—	30,152	30,152
	—	—	31,000	—	31,000
	97,200	**12,000**	**31,000**	**30,152**	**170,352**

FY 2016 Budget Structure	CCS and Advanced Power Systems – Carbon Storage: Storage Field Management	Advanced Storage R&D	Carbon Use and Reuse	Risk and Integration Tools	Total, Carbon Storage
Coal/CCS and Power Systems					
Carbon Storage					
Storage Infrastructure	44,875	—	—	—	44,875
Advanced Storage R&D	—	28,000	—	—	28,000
Carbon Use and Reuse	—	—	0	—	0
Sub-disciplinary Storage R&D	—	—	—	18,000	18,000
	44,875	**28,000**	**0**	**18,000**	**90,875**

Budget Structure Crosswalk

FY 2017 Request ($K)

Proposed FY 2017 Budget Structure

FY 2016 Budget Structure	CCS and Advanced Power Systems					Total
	Advanced Energy Systems (AES)					
	Gasification Systems	Advanced Turbines	STEP (Supercritical CO_2)	Solid Oxide Fuel Cells	Coal and Coal Biomass to Liquids	Total, AES
Coal/CCS and Power Systems						
Advanced Energy Systems						
Gasification Systems	5,500	—	—	—	—	5,500
Advanced Turbines	—	10,000	—	—	—	10,000
Coal and Coal Biomass to Liquids	—	—	—	—	0	0
Solid Oxide Fuel Cells	—	—	—	8,000	—	8,000
Supercritical Transformational Electric Power (STEP)	—	—	24,300	—	—	24,300
	5,500	**10,000**	**24,300**	**8,000**	**0**	**47,800**

Budget Structure Crosswalk

FY 2017 Request ($K)

Proposed FY 2017 Budget Structure

	CCS and Advanced Power Systems									
	Crosscutting Research and Analysis (CRA)									
		Education and Outreach								
FY 2016 Budget Structure	**Compu-tational Sciences**	**University Coal Research**	**HBCUs and Other Minority Institutions**	**Special Recruit-ment Programs**	**Inter-national Activities**	**Sensors and Controls**	**Energy Evaluation and Analysis**	**Extreme Environ-ment Materials**	**Water Manage-ment R&D**	**Total, CRA**
Coal/CCS and Power Systems										
Crosscutting Research										
Coal Utilization Science										
Computational System Dynamics	7,000	—	—	—	—	—	—	—	—	7,000
Focus Area for Computational Energy Science	3,000	—	—	—	—	—	—	—	—	3,000
University Training and Research								—	—	
University Coal Research	—	2,000	—	—	—	—	—	—	—	2,000
HBCU's, Education and Training	—	—	1,000	—	—	—	—	—	—	1,000
International Activities								—	—	
Coal Technology Export	—	—	—	—	500	—	—	—	—	500
Int"l. Program Support	—	—	—	—	600	—	—	—	—	600
Energy Analysis								—	—	
Environmental Activities	—	—	—	—	—	—	450	—	—	450
Technical and Economic Analysis	—	—	—	—	—	—	400	—	—	400
	—	—	—	—	—	—	0	—	—	0
Plant Optimization Technologies										
Sensors, Controls and Other Novel Concepts	—	—	—	—	—	4,750	—	—	—	4,750
Crosscutting Materials R&D	—	—	—	—	—	—	—	15,150	—	15,150
Advanced Ultrasupercritical	—	—	—	—	—	—	—	8,000	—	8,000
Water Management R&D	—	—	—	—	—	—	—	—	15,800	15,800
Special Recruitment Programs	—	—	—	700	—	—	—	—	—	700
	10,000	**2,000**	**1,000**	**700**	**1,100**	**4,750**	**850**	**23,150**	**15,800**	**59,350**

Restructuring of NETL Coal R&D, Plant and Capital Equipment, Program Direction, Fossil Energy Environmental Restoration and Supercomputer

This restructuring of NETL operational lines is proposed to better describe NETL's funding requirements, increase consistency with other national laboratories, and increase transparency in how funds are utilized, promoting enhanced visibility into cost drivers and more efficient resource allocation decisions.

The new NETL Infrastructure program includes the former Supercomputer and Plant and Capital Equipment programs as well as a portion of each of the NETL Coal Research and Development, Fossil Energy Environmental Restoration, and Program Direction budget lines. The portion of funding that moved from NETL Coal Research and Development and Program Direction was associated with contractor site support activity and materials associated with maintenance and infrastructure needs. The portion of funding that moved from Fossil Energy Environmental Restoration was associated with CERCLA and RCRA remedial actions and safeguards and securities activities.

The new NETL Research and Operations program includes certain funds that were part of the former NETL Coal Research and Development program as well as certain funds that were formerly in the NETL portion of Program Direction. The Research and Development funding supports salaries/benefits and travel for NETL staff directly associated with conducting both intramural and extramural research activities, funding for Federal employees and contractors who perform site operations at the laboratories, and for Federal employees and contractors performing research-enabling functions such as legal, finance, procurement, information technology, and human resources that are necessary for the performance of NETL activities.

Program Direction funding no longer includes support for Federal employees performing research enabling functions. Program Direction at NETL continues to include funding for the conduct of activities performed by field offices (for example management of the lab, communications, procurement, and certain IT activities). Fixed occupancy funding, such as building and laboratory repairs and information technology infrastructure, have moved to the new NETL Infrastructure budget line. Operational costs such as grounds maintenance and utilities are included in the new NETL Research and Operations budget line. The portion of funding that moved from Fossil Energy Environmental Restoration to Washington HQ Program Direction was associated with HQ oversight of all Fossil Energy Environmental, Security, Safety & Health activities.

Budget Structure Crosswalk FY2015 Enacted and Current ($k)
Proposed 2017 Budget Structure

	NETL Infrastructure				Program Direction			NETL Research and Operations				
FY 2016 Budget Structure	Laboratory Facilities	Sitewide Facilities	Safeguards & Security	Environmental Restoration	Washington HQ	NETL	Import / Export	Research and Development	Site Operations	Program Oversight	Feasibility of Recovering Rare Earth Elements	Total Budget Authority
Program Direction												
Salaries and Benefits	-	-	-	-	16,371	15,551	1,437	15,621	6,478	7,600	-	63,058
Travel	-	-	-	-	900	475	22	933	56	136	-	2,522
Support Services	1,960	2,780	3,684	-	85	10,460	-	1,062	1,933	-	-	21,964
Other Related Expenses	3,117	3,308	-	-	12,057	3,944	624	1,217	5,829	1,360	-	31,456
Total, Program Direction	5,077	6,088	3,684	-	29,413	30,430	2,083	18,833	14,296	9,096	-	119,000
NETL Coal Research & Development												
Salaries and Benefits	-	-	-	-	-	-	-	26,880	-	-	-	26,880
Travel	-	-	-	-	-	-	-	1,000	-	-	-	1,000
Other Services	1,601	-	2,595	-	-	-	-	1,114	1,810	-	-	7,120
Recovery of Rare Earth Elements	-	-	-	-	-	-	-	-	-	-	15,000	15,000
Total, NETL Coal Research & Development	1,601	-	2,595	-	-	-	-	28,994	1,810	-	15,000	50,000
Plant & Capital Equipment												
General Plant Projects	9,469	6,313	-	-	-	-	-	-	-	-	-	15,782
Total, Plant & Capital Equipment	9,469	6,313	-	-	-	-	-	-	-	-	-	15,782
Fossil Energy Environmental Restoration												
CERCLA Remedial Actions	-	-	-	200	-	-	-	-	-	-	-	200
RCRA Remedial Actions	-	-	-	1,697	-	-	-	-	-	-	-	1,697
Other ESS&H Actions	-	-	2,821	-	1,179	-	-	-	-	-	-	4,000
Total, Fossil Energy Environmental Restoration	-	-	2,821	1,897	1,179	-	-	-	-	-	-	5,897
												-
Super Computer												
SuperComputer	-	-	-	-	-	-	-	-	-	-	-	-
Total, Super Computer	-	-	-	-	-	-	-	-	-	-	-	-
Total	**16,147**	**12,401**	**9,100**	**1,897**	**30,592**	**30,430**	**2,083**	**47,827**	**16,106**	**9,096**	**15,000**	**190,679**

Budget Structure Crosswalk FY2015 Enacted and Current ($k)
Proposed 2017 Budget Structure
Program Direction

FY 2016 Budget Structure	NETL Infrastructure				Program Direction			NETL Research and Operations				Total Budget Authority
	Laboratory Facilities	Sitewide Facilities	Safeguards & Security	Environmental Restoration	Washington HQ	NETL	Import / Export	Research and Development	Site Operations	Program Oversight	Feasibility of Recovering Rare Earth Elements	
Program Direction												
Washington Headquarters												
Salaries and Benefits	-	-	-	-	16,371	-	-	-	-	-	-	16,371
Travel	-	-	-	-	900	-	-	-	-	-	-	900
Support Services	-	-	-	-	85	-	-	-	-	-	-	85
Other Related Expenses	-	-	-	-	12,057	-	-	-	-	-	-	12,057
Total, Washington Headquarters	-	-	-	-	29,413	-	-	-	-	-	-	29,413
National Energy Technology Laboratory												
Salaries and Benefits	-	-	-	-	-	15,551	-	15,621	6,478	7,600	-	45,250
Travel	-	-	-	-	-	475	-	933	56	136	-	1,600
Support Services	1,960	2,780	3,684	-	-	10,460	-	1,062	1,933	-	-	21,879
Other Related Expenses	3,117	3,308	-	-	-	3,944	-	1,217	5,829	1,360	-	18,775
Total, National Energy Technology Laboratory	5,077	6,088	3,684	-	-	30,430	-	18,833	14,296	9,096	-	87,504
Import/Export Authorization												
Salaries and Benefits	-	-	-	-	-	-	1,437	-	-	-	-	1,437
Travel	-	-	-	-	-	-	22	-	-	-	-	22
Support Services	-	-	-	-	-	-	-	-	-	-	-	-
Other Related Expenses	-	-	-	-	-	-	624	-	-	-	-	624
Total, Import/Export Authorization	-	-	-	-	-	-	2,083	-	-	-	-	2,083
Total Program Direction												
Salaries and Benefits	-	-	-	-	16,371	15,551	1,437	15,621	6,478	7,600	-	63,058
Travel	-	-	-	-	900	475	22	933	56	136	-	2,522
Support Services	1,960	2,780	3,684	-	85	10,460	-	1,062	1,933	-	-	21,964
Other Related Expenses	3,117	3,308	-	-	12,057	3,944	624	1,217	5,829	1,360	-	31,456
Total, Program Direction	5,077	6,088	3,684	-	29,413	30,430	2,083	18,833	14,296	9,096	-	119,000

Budget Structure Crosswalk FY2016 Enacted ($k)
Proposed 2017 Budget Structure

	NETL Infrastructure				Program Direction			NETL Research and Operations				
FY 2016 Budget Structure	Laboratory Facilities	Sitewide Facilities	Safeguards & Security	Environmental Restoration	Washington HQ	NETL	Import / Export	Research and Development	Site Operations	Program Oversight	Feasibility of Recovering Rare Earth Elements	Total Budget Authority
Program Direction												
Salaries and Benefits	-	-	-	-	16,259	15,551	1,367	15,621	6,478	7,600	-	62,876
Travel	-	-	-	-	900	475	20	783	56	136	-	2,370
Support Services	4,479	3,190	1,717	-	66	9,030	-	883	726	-	-	20,091
Other Related Expenses	1,565	1,308	-	-	11,071	3,680	626	3,425	5,829	1,361	-	28,865
Total, Program Direction	6,044	4,498	1,717	-	28,296	28,736	2,013	20,712	13,089	9,097	-	114,202
NETL Coal Research & Development												
Salaries and Benefits	-	-	-	-	-	-	-	28,880	-	-	-	28,880
Travel	-	-	-	-	-	-	-	1,000	-	-	-	1,000
Other Services	1,683	-	2,231	-	-	-	-	2,096	2,110	-	-	8,120
Recovery of Rare Earth Elements	-	-	-	-	-	-	-	-	-	-	15,000	15,000
Total, NETL Coal Research & Development	1,683	-	2,231	-	-	-	-	31,976	2,110	-	15,000	53,000
Plant & Capital Equipment												
General Plant Projects	9,469	6,313	-	-	-	-	-	-	-	-	-	15,782
Total, Plant & Capital Equipment	9,469	6,313	-	-	-	-	-	-	-	-	-	15,782
FE Environmental Restoration												
CERCLA Remedial Actions	-	-	-	600	-	-	-	-	-	-	-	600
RCRA Remedial Actions	-	-	-	1,695	-	-	-	-	-	-	-	1,695
Other ESS&H Actions	-	-	4,700	-	1,000	-	-	-	-	-	-	5,700
Total, FE Environmental Restoration	-	-	4,700	2,295	1,000	-	-	-	-	-	-	7,995
Super Computer												
SuperComputer	-	-	-	-	-	-	-	-	-	-	-	-
Total, Super Computer	-	-	-	-	-	-	-	-	-	-	-	-
Total	**17,196**	**10,811**	**8,648**	**2,295**	**29,296**	**28,736**	**2,013**	**52,688**	**15,199**	**9,097**	**15,000**	**190,979**

Budget Structure Crosswalk FY2016 Enacted ($k)
Proposed 2017 Budget Structure

Program Direction

FY 2016 Budget Structure	NETL Infrastructure				Program Direction			NETL Research and Operations				Total Budget Authority
	Laboratory Facilities	Sitewide Facilities	Safeguards & Security	Environmental Restoration	Washington HQ	NETL	Import / Export	Research and Development	Site Operations	Program Oversight	Feasibility of Recovering Rare Earth Elements	
Program Direction												
Washington Headquarters												
Salaries and Benefits	-	-	-	-	16,259	-	-	-	-	-	-	16,259
Travel	-	-	-	-	900	-	-	-	-	-	-	900
Support Services	-	-	-	-	66	-	-	-	-	-	-	66
Other Related Expenses	-	-	-	-	11,071	-	-	-	-	-	-	11,071
Total, Washington Headquarters	-	-	-	-	28,296	-	-	-	-	-	-	28,296
National Energy Technology Laboratory												
Salaries and Benefits	-	-	-	-	-	15,551	-	15,621	6,478	7,600	-	45,250
Travel	-	-	-	-	-	475	-	783	56	136	-	1,450
Support Services	4,479	3,190	1,717	-	-	9,030	-	883	726	-	-	20,025
Other Related Expenses	1,565	1,308	-	-	-	3,680	-	3,425	5,829	1,361	-	17,168
Total, National Energy Technology Laboratory	6,044	4,498	1,717	-	-	28,736	-	20,712	13,089	9,097	-	83,893
Import/Export Authorization												
Salaries and Benefits	-	-	-	-	-	-	1,367	-	-	-	-	1,367
Travel	-	-	-	-	-	-	20	-	-	-	-	20
Support Services	-	-	-	-	-	-	-	-	-	-	-	-
Other Related Expenses	-	-	-	-	-	-	626	-	-	-	-	626
Total, Import/Export Authorization	-	-	-	-	-	-	2,013	-	-	-	-	2,013
Total Program Direction												
Salaries and Benefits	-	-	-	-	16,259	15,551	1,367	15,621	6,478	7,600	-	62,876
Travel	-	-	-	-	900	475	20	783	56	136	-	2,370
Support Services	4,479	3,190	1,717	-	66	9,030	-	883	726	-	-	20,091
Other Related Expenses	1,565	1,308	-	-	11,071	3,680	626	3,425	5,829	1,361	-	28,865
Total, Program Direction	6,044	4,498	1,717	-	28,296	28,736	2,013	20,712	13,089	9,097	-	114,202

Budget Structure Crosswalk FY2017 Request ($k)
Proposed 2017 Budget Structure

FY 2016 Budget Structure	NETL Infrastructure				Program Direction			NETL Research and Operations				Total Budget Authority
	Laboratory Facilities	Sitewide Facilities	Safeguards & Security	Environmental Restoration	Washington HQ	NETL	Import / Export	Research and Development	Site Operations	Program Oversight	Feasibility of Recovering Rare Earth Elements	
Program Direction												
Salaries and Benefits	-	-	-	-	16,259	15,551	1,367	16,707	6,478	7,600	-	63,962
Travel	-	-	-	-	900	475	20	783	56	136	-	2,370
Support Services	4,479	3,190	1,717	-	66	9,030	-	1,883	726	-	-	21,091
Other Related Expenses	1,565	1,308	-	-	12,024	3,680	626	3,425	5,829	1,361	-	29,818
Total, Program Direction	6,044	4,498	1,717	-	29,249	28,736	2,013	22,798	13,089	9,097	-	117,241
NETL Coal Research & Development												
Salaries and Benefits	-	-	-	-	-	-	-	27,134	-	-	-	27,134
Travel	-	-	-	-	-	-	-	880	-	-	-	880
Other Services	1,683	-	2,231	-	-	-	-	1,856	1,216	-	-	6,986
Recovery of Rare Earth Elements	-	-	-	-	-	-	-	-	-	-	-	-
Total, NETL Coal Research & Development	1,683	-	2,231	-	-	-	-	29,870	1,216	-	-	35,000
Plant & Capital Equipment												
General Plant Projects	10,662	13,520	-	-	-	-	-	-	-	-	-	24,182
Total, Plant & Capital Equipment	10,662	13,520	-	-	-	-	-	-	-	-	-	24,182
Fossil Energy Environmental Restoration												
CERCLA Remedial Actions	-	-	-	525	-	-	-	-	-	-	-	525
RCRA Remedial Actions	-	-	-	1,697	-	-	-	-	-	-	-	1,697
Other ESS&H Actions	-	-	8,978	-	1,000	-	-	-	-	-	-	9,978
Total, Fossil Energy Environmental Restoration	-	-	8,978	2,222	1,000	-	-	-	-	-	-	12,200
Super Computer												
SuperComputer	16,500	-	-	-	-	-	-	-	-	-	-	16,500
Total, Super Computer	16,500	-	-	-	-	-	-	-	-	-	-	16,500
Total	**34,889**	**18,018**	**12,926**	**2,222**	**30,249**	**28,736**	**2,013**	**52,668**	**14,305**	**9,097**	**-**	**205,123**

Budget Structure Crosswalk FY2017 Request ($k)
Proposed 2017 Budget Structure
Program Direction

FY 2016 Budget Structure	NETL Infrastructure				Program Direction			NETL Research and Operations				Total Budget Authority
	Laboratory Facilities	Sitewide Facilities	Safeguards & Security	Environmental Restoration	Washington HQ	NETL	Import / Export	Research and Development	Site Operations	Program Oversight	Feasibility of Recovering Rare Earth Elements	
Program Direction												
Washington Headquarters												
Salaries and Benefits	-	-	-	-	16,259	-	-	-	-	-	-	16,259
Travel	-	-	-	-	900	-	-	-	-	-	-	900
Support Services	-	-	-	-	66	-	-	-	-	-	-	66
Other Related Expenses	-	-	-	-	12,024	-	-	-	-	-	-	12,024
Total, Washington Headquarters	-	-	-	-	29,249	-	-	-	-	-	-	29,249
National Energy Technology Laboratory												
Salaries and Benefits	-	-	-	-	-	15,551	-	16,707	6,478	7,600	-	46,336
Travel	-	-	-	-	-	475	-	783	56	136	-	1,450
Support Services	4,479	3,190	1,717	-	-	9,030	-	1,883	726	-	-	21,025
Other Related Expenses	1,565	1,308	-	-	-	3,680	-	3,425	5,829	1,361	-	17,168
Total, National Energy Technology Laboratory	6,044	4,498	1,717	-	-	28,736	-	22,798	13,089	9,097	-	85,979
Import/Export Authorization												
Salaries and Benefits	-	-	-	-	-	-	1,367	-	-	-	-	1,367
Travel	-	-	-	-	-	-	20	-	-	-	-	20
Support Services	-	-	-	-	-	-	-	-	-	-	-	-
Other Related Expenses	-	-	-	-	-	-	626	-	-	-	-	626
Total, Import/Export Authorizatio	-	-	-	-	-	-	2,013	-	-	-	-	2,013
Total Program Direction												
Salaries and Benefits	-	-	-	-	16,259	15,551	1,367	16,707	6,478	7,600	-	63,962
Travel	-	-	-	-	900	475	20	783	56	136	-	2,370
Support Services	4,479	3,190	1,717	-	66	9,030	-	1,883	726	-	-	21,091
Other Related Expenses	1,565	1,308	-	-	12,024	3,680	626	3,425	5,829	1,361	-	29,818
Total, Program Direction	6,044	4,498	1,717	-	29,249	28,736	2,013	22,798	13,089	9,097	-	117,241

Restructuring of Natural Gas Technologies

The Natural Gas Technologies program is renamed Fuel Supply Impact Mitigation to reflect the fact that this program is focused on addressing certain environmental impacts of fossil fuel supply and delivery. Natural gas technologies related to the operation of natural gas power plants are included in the new CCS and Advanced Power Systems program.

The former Emissions Mitigation from Midstream Infrastructure and the Emissions Quantification from Natural Gas Infrastructure subprograms are combined into a single Emissions Mitigation and Quantification subprogram to enable more effective program management and execution.

Budget Structure Crosswalk (FY 2015 Enacted $K)
Proposed FY 2017 Budget Structure

FY 2016 Budget Structure	Fuel Supply Impact Mitigation			Total
	Environmentally Prudent Development	Emissions Mitigation and Quantification	Gas Hydrates	
Natural Gas Technologies				
Environmentally Prudent Development	10,121	—	—	10,121
Emissions Mitigation from Midstream Infrastructure	—	—	—	—
Emissions Quantification from Natural Gas Infrastructure	—	—	—	—
Gas Hydrates	—	—	15,000	15,000
	10,121	**—**	**15,000**	**25,121**

Budget Structure Crosswalk (FY 2015 Current $K)
Proposed FY 2017 Budget Structure

FY 2016 Budget Structure	Fuel Supply Impact Mitigation			Total
	Environmentally Prudent Development	Emissions Mitigation and Quantification	Gas Hydrates	
Natural Gas Technologies				
Environmentally Prudent Development	9,807	—	—	9,807
Emissions Mitigation from Midstream Infrastructure	—	—	—	—
Emissions Quantification from Natural Gas Infrastructure	—	—	—	—
Gas Hydrates	—	—	14,534	14,534
	9,807	**—**	**14,534**	**24,341**

Budget Structure Crosswalk (FY 2016 Enacted $K)
Proposed FY 2017 Budget Structure

FY 2016 Budget Structure	Fuel Supply Impact Mitigation			Total
	Environmentally Prudent Development	Emissions Mitigation and Quantification	Gas Hydrates	
Natural Gas Technologies				
Environmentally Prudent Development	11,200	—	—	11,200
Emissions Mitigation from Midstream Infrastructure	—	7,000	—	7,000
Emissions Quantification from Natural Gas Infrastructure	—	5,000	—	5,000
Gas Hydrates	—	—	19,800	19,800
	11,200	**12,000**	**19,800**	**43,000**

Budget Structure Crosswalk (FY 2017 Request $K)
Proposed FY 2017 Budget Structure

FY 2016 Budget Structure	Fuel Supply Impact Mitigation			Total
	Environmentally Prudent Development	Emissions Mitigation and Quantification	Gas Hydrates	
Natural Gas Technologies				
Environmentally Prudent Development	13,000	—	—	13,000
Emissions Mitigation from Midstream Infrastructure	—	8,000	—	8,000
Emissions Quantification from Natural Gas Infrastructure	—	3,000	—	3,000
Gas Hydrates	—	—	2,500	2,500
	13,000	**11,000**	**2,500**	**26,500**

CCS and Advanced Power Systems

Overview

CCS and Advanced Power Systems supports secure, affordable, and environmentally acceptable near-zero emission fossil energy through research, development, and demonstration (RD&D) to improve the performance of advanced Carbon Capture and Storage (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.

The budget restructuring proposal proposes to rename the Coal/CCS and Power Systems program to CCS and Advanced Power Systems. This change reflects the Department's focus on developing advanced power generation integrated with carbon capture and storage technologies for coal and natural gas plants. The goal is to reduce both the energy required by and the capital costs of CO_2 capture and storage from new and existing fossil fuel-power plants. 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 CCS and Advanced Power Systems 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, 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 developing technologies that capture 90% of the CO_2 from fossil fuel power systems at less than $40/tonne and that are available for demonstration by 2020. The Carbon Storage subprogram leads the world in validating the safe and permanent injection of CO_2 in deep geologic reservoirs through DOE's network of seven Regional Carbon Sequestration Partnerships (RCSPs). Projects under the RCSPs have completed injection of or continue to inject and monitor CO_2 at six (with a final goal of eight) storage sites across North America. The CCS and Advanced Power Systems program is also pursuing the development of advanced power generation systems such as the supercritical CO_2 (sCO_2) power cycle and solid oxide fuel cells that can further reduce the costs of CCS by facilitating more efficient capture of a pure stream of CO_2. Ongoing advancements in sensors, turbine components, and extreme environment materials will further bolster cost reduction for advanced power systems integrated with CCS.

It is important to demonstrate that electric generation technology with CCS can be deployed at commercial scale while maintaining reliable, predictable and safe operations. Therefore, the FER&D portfolio includes several major integrated CCS demonstration projects encompassing different technological approaches and applications of CCS. A number of those projects have not yet reached financial close. DOE intends to deobligate $240 million from CCPI projects that have not yet reached financial close and repurpose these funds to support the FY 2017 R&D portfolio.

Highlights of the FY 2017 Budget Request

In FY 2017, the Coal budget line item will be renamed CCS and Advanced Power Systems. This change reflects that programmatic categorization by fossil fuel type has become an inadequate representation of the areas of expertise that have been built within the Office of Fossil Energy's RD&D portfolio. In general, coal and natural gas power plants have more in common regarding environmental controls of air emission than with issues related to natural gas and coal resource production. The CCS and Advanced Power Systems program will continue to leverage the existing knowledge and RD&D portfolio associated with power generation systems and capture technologies needed to implement advanced technologies and processes to capture carbon dioxide (CO_2) from new and existing fossil fuel power plants. A summary of additional changes follows:

1. Within *CCS and Advanced Power Systems*, *Advanced Combustion Systems* will move from *Advanced Energy Systems* to *Carbon Capture* because development of technologies such as pressurized oxy-combustion and chemical looping processes facilitate carbon capture.
2. A new *Natural Gas Carbon Capture* activity will be created under *Carbon Capture.* This activity will be focused on R&D towards 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 using what has been determined to be the best available carbon capture technology available for demonstration at the time.

3. The *Storage Infrastructure* activity within *Carbon Storage* will be renamed *Storage Field Management* to clarify that this activity is focused on demonstrating safe and permanent geologic storage of CO_2 and providing best practices for doing so.
4. The *Sub-Disciplinary Storage R&D* activity will be renamed *Risk and Integration Tools* to reflect that this activity centers on risk assessment and system model integration and validation.
5. *The Supercritical Transformational Electric Power (STEP)* activity will be moved under *Advanced Energy Systems* (AES) appearing as *STEP (Supercritical CO_2)*. This previously was a separate program but is being moved under AES as it is part of this broader portfolio of new fossil-fuel energy conversion systems integrated with CCS that may be capable of producing competitively priced electricity.
6. *The Cross-Cutting Research activity* will be renamed *Crosscutting Research and Analysis (CRA)*. Proposed changes will streamline the budget structure and align activities that support related efforts under the same subprogram.
    a. There are 6 subprograms proposed under CRA[1] – *Computational Sciences, Education and Outreach*, *Energy Evaluation and Analysis, Extreme Environment Materials, Sensors and Controls,* and *Water Management R&D*.
        i. *Computational Sciences* combines the former *Computational System Dynamics* and *Focus Area for Computational Energy Science.*
        ii. *Education and Outreach* is comprised of the *University Coal Research, Historically Black Colleges and Universities (HBCUs) and Other Minority Institutions, Special Recruitment Programs*, and *International Activities* subactivities. *Special Recruitment Programs* was previously not part of the *CCS and Power Systems* budget. All university educational initiatives are now consolidated under *Education and Outreach*.
            1. The former *HBCUs Education and Training* area is renamed *HBCUs and Other Minority Institutions* to better reflect the breadth of institutions supported.
            2. *International Activities* combines the former *Coal Technology Export* and *International Program Support areas.*
        iii. *Energy Evaluation and Analysis* combines the former *Environmental Activities* and *Technical and Economic Analysis* lines.
        iv. *Extreme Environment Materials* combines the former *Crosscutting Materials R&D* and *Advanced Ultrasupercritical R&D* lines.
        v. *Sensors and Controls,* which was formerly *Sensors, Controls and Other Novel Concepts,* remains under *Crosscutting Research and Analysis.* The shortening of the name does not reflect a change in programmatic content.
        vi. *Water Management R&D* remains under *Crosscutting Research and Analysis.*

For comparability, all discussions of funding changes that follow assume the FY 2017 proposed budget structure. Funding crosswalks in the Budget Structure Crosswalks chapter of this narrative provide details of the proposed changes.

Carbon Capture

Funding for the Post-Combustion Capture Systems activity provides for continued scale-up of second generation technologies by supporting three large-scale pilot tests (10 MWe+) and a focus on transformational technology development that will address the key issues of lowering the capital cost of carbon capture systems and reducing the energy penalty. Pre-combustion Capture Systems funding will support field projects and research and development on 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). Natural Gas Carbon Capture funding will support a Front End Engineering and Design (FEED) study and initial construction of one large-scale pilot facility to test advanced post-combustion capture CO_2 technology or an advanced combustion system that enables CO_2 capture on a natural gas power system. Advanced Combustion Systems funding supports two additional FEED studies for large-scale pilots: a second chemical looping pilot and a second pressurized oxy-combustion pilot. These second projects avoid a single point failure for each technology and will allow for more industrial partnership opportunities.

[1]The *Plant Optimization Technologies* line is eliminated. However, all the activities under it remain. This will streamline the budget structure, eliminating lines that are not Congressional Controls without decreasing transparency.

Carbon Storage

Storage Field Management includes funding for the RCSPs, for commercial-scale characterization and small-scale field projects, and for fit-for-purpose field testing, including the Brine Extraction Storage Test (BEST). Funding for Storage Field Management is decreasing largely because most of the RCSPs are transitioning to lower cost post-injection monitoring. In FY 2017, Advanced Storage Research and Development includes support for new and existing projects and, as part of the Department's Subsurface Science, Technology and Engineering RD&D (Subsurface) crosscut, development of laboratory-and bench-scale technologies, and monitoring, verification, accounting, and assessment (MVAA) tool development. Risk and Integration Tools funding will be used for the Energy Data Exchange (EDX) and the National Risk Assessment Partnership (NRAP), both of which continue to improve data infrastructure and management and expand technical risk assessment and quantification methodologies in support of Carbon Storage subprogram goals. Funding for the Carbon Storage subprogram is a crucial part of the Subsurface crosscut, which will address identified challenges in the subsurface across DOE research and development programs through highly focused and coordinated research in wellbore integrity, stress state and induced seismicity, permeability manipulation, new subsurface signals to enhance renewable energy supply, ensure material impact on climate change via CO_2 storage, and significantly mitigate environmental impacts from energy-related subsurface activities and operations. No funding is requested for Carbon Use and Reuse in FY 2017.

Advanced Energy Systems (AES)

In FY 2017, the subprogram will develop a new generation of clean fossil-fuel energy conversion systems integrated with CCS that are capable of producing competitively priced electric power with reduced CO_2 emissions. Many of these technologies require new approaches to electricity generation, and simultaneously achieve higher efficiencies while capturing CO_2 as part of the conversion process. Much of this research is targeted at improving overall system efficiency, reducing capital and operating costs, and enabling affordable carbon capture. The AES program includes research and development on gasification systems, advanced turbines, and solid oxide fuel cells. AES funding enables FER&D, in coordination with DOE's Supercritical Carbon Dioxide (sCO_2) crosscut, to support initiation of design and construction of the STEP pilot facility in 2017, the solicitation for which will be issued and awarded in FY 2016. FY 2017 funding will enable FER&D to order long lead time components for the 10 MWe STEP pilot facility. This reduces risk of schedule slip due to late delivery of critical components such as heaters and turbines.

Crosscutting Research and Analysis (CRA)

The funding for computational modeling builds computer-aided design tools for the AES activity so that novel concepts can be explored and analysis can be conducted on pre-commercial systems. The modeling supports first principle and physics-based modeling of phenomenon for complex energy conversion and carbon capture processes tools and techniques. These tools will be used to optimize data handling and exploit information technology in the design of advanced energy systems with carbon capture. Funding for the University Coal Research and HBCUs and Other Minority Institutions activities will support grants to educate minority students and support minority institutions. Energy Evaluation and Analysis will carry out analyses of potential environmental impacts of fossil fuel use and large-scale deployment of different generations of CCS. In FY 2017, the increase in funding for Extreme Environment Materials will support code certification of high temperature materials, digital data management, informatics, reliability and access, and research and development focused on technology development of advanced materials and component testing of high temperature materials for directly-fired sCO_2. The increase in funding for Extreme Environment Materials also supports the development of tools to enable the design of new materials capable of operation in harsh high temperature environments. Sensors and Controls is focused on obtaining data in harsh environments and the transient control of transformational advanced energy systems. Funding for Water Management R&D supports R&D efforts to minimize freshwater use in thermoelectric cooling. This includes FER&D's annual share of the U.S.-China Clean Energy Research Center (CERC) Energy-Water track and field testing of advanced desalination technology using effluents from the BEST field project site (which is funded through the Carbon Storage subprogram).

FY 2017 Crosscuts ($K)

	Subsurface	sCO_2	EWN	Adv Mat	Total
Carbon Storage	90,875	0	0	0	90,875
Crosscutting Research and Analysis	0	0	15,800	23,150	38,950
Advanced Energy Systems	0	30,300	0	0	30,300
Total, CCS and Advanced Power Systems	**90,875**	**30,300**	**15,800**	**23,150**	**160,125**

Within the FY 2017 Budget Request, the CCS and Advanced Power Systems program supports four Departmental Crosscuts: Subsurface Science, Technology and Engineering RD&D (Subsurface), Supercritical CO_2 (sCO_2), Energy-Water Nexus (EWN), and Advanced Materials (Adv Mat).

Subsurface 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 enhance renewable energy supply, ensure material impact on climate change via CO_2 sequestration, and significantly mitigate environmental impacts from energy-related subsurface activities and operations. The CCS and Advanced Power Systems program will contribute to the Subsurface crosscut through the Carbon Storage subprogram's efforts to develop and validate technologies for the safe and permanent geologic storage of captured CO_2.

The supercritical carbon dioxide (sCO_2) based power generation effort is a technology-focused crosscutting initiative that will facilitate industry's transition to realize power cycles based on sCO_2 as the working fluid. Recognizing that the near-term deployment and potential market applications for commercial sCO2 power cycles are primarily in the fossil energy area, the 10 MW Supercritical Transformational Electric Power Generation (STEP) pilot is being managed by the Office of Fossil Energy. Initiation of design and construction of the STEP pilot test facility would begin in early FY 2017 through funding requested in the STEP activity under Advanced Energy Systems (AES). AES also contributes to the Supercritical CO_2 crosscut through funding requested in the Advanced Turbines activity to develop turbines for the directly-fired sCO2 power cycle.

The CCS and Advanced Power Systems program will contribute to the Energy-Water Nexus (EWN) crosscut through funding within the Water Management R&D program. It will support FER&D's efforts to reduce freshwater consumption in power plants and develop lower cost desalinization technologies for treating water produced through CCS. In collaboration with EPSA and several other offices, a U.S. domestic cross-cutting R&D investment is maintained as part of the U.S. China Clean Energy Research Center's (CERC) track on energy and water. FE topics covered by the CERC investment include: 1) water use reduction at thermoelectric plants; and 2) treatment and management of nontraditional waters.

In 2017, the CCS and Advanced Power Systems program will contribute to the Advanced Materials crosscut through the Extreme Environment Materials activity which encompasses the spectrum of fundamental materials design for advanced ultra-supercritical and sCO2 environments through qualification of functional materials that support the next generation of advanced power generation. In FY 2017 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. This area will conduct research and development focused on technology development of advanced materials and component testing of high temperature materials for directly-fired sCO_2. This work is being coordinated with other offices through the Advanced Materials crosscut to maximize the value of this research across DOE programs.

Fossil Energy Research and Development
Funding by Congressional Control ($K)
(Non-Comparable)

	FY 2015 Enacted	FY 2015 Current[2]	FY 2016 Enacted	FY 2017 Request	FY 2017 vs FY 2016
Coal					
CCS and Power Systems					
Carbon Capture					
Post-Combustion Capture Systems	76,000	73,641	89,000	0	-89,000
Pre-Combustion Capture Systems	12,000	11,628	12,000	0	-12,000
Total Carbon Capture	**88,000**	**85,269**	**101,000**	**0**	**-101,000**
Carbon Storage					
Storage Infrastructure	66,000	63,953	66,000	0	-66,000
Advanced Storage R&D	13,500	13,081	21,500[3]	0	-21,500
Monitoring, Verification, Accounting, and Assessment	10,000	9,689	0	0	0
Carbon Use and Reuse	2,000	1,937	10,000	0	-10,000
Sub-disciplinary Storage R&D	8,500	8,236	8,500	0	-8,500
Total Carbon Storage	**100,000**	**96,896**	**106,000**	**0**	**-106,000**
Advanced Energy Systems					
Advanced Combustion Systems	28,000	27,131	30,000	0	-30,000
Gasification Systems	25,000	24,224	25,000	0	-25,000
Advanced Turbines	15,000	14,534	15,000	0	-15,000
Coal and Coal Biomass to Liquids	5,000	4,845	5,000	0	-5,000
Solid Oxide Fuel Cells	30,000	29,069	30,000	0	-30,000
Total Advanced Energy Systems	**103,000**	**99,803**	**105,000**	**0**	**-105,000**
Cross-cutting Research					
Plant Optimization Technologies					
Sensors, Controls and Other Novel Concepts	4,500	4,360	4,500	0	-4,500
Cross-cutting Materials R&D	2,000	1,937	1,000	0	-1,000

[2] Funding reflects FY 2015 SBIR/STTR funds which were transferred from FER&D to Science.

[3] In FY 2016, Monitoring, Verification, Accounting, and Assessment was moved into Advanced Storage R&D to better improve the integration between the technologies developed in these two budget lines.

	FY 2015 Enacted	FY 2015 Current[2]	FY 2016 Enacted	FY 2017 Request	FY 2017 vs FY 2016
Advanced Ultrasupercritical Materials R&D	5,000	4,845	9,000	0	-9,000
Water Management R&D	7,000	6,783	6,000	0	-6,000
Subtotal Plant Optimization Technologies	**18,500**	**17,925**	**20,500**	**0**	**-20,500**
Coal Utilization Science					
Computational System Dynamics	12,000	11,628	12,000	0	-12,000
Focus Area for Computational Energy Science	12,000	11,628	12,000	0	-12,000
Subtotal Coal Utilization Science	**24,000**	**23,256**	**24,000**	**0**	**-24,000**
Energy Analyses					
Environmental Activities	750	750	700	0	-700
Technical and Economic Analysis	750	750	700	0	-700
Subtotal Energy Analyses	**1,500**	**1,500**	**1,400**	**0**	**-1,400**
University Training and Research					
University Coal Research	3,000	2,907	2,000	0	-2,000
HBCU's, Education, and Training	900	872	1,000	0	-1,000
Subtotal University Training and Research	**3,900**	**3,779**	**3,000**	**0**	**-3,000**
International Activities					
Coal Technology Export	500	500	500	0	-500
International Program Support	600	600	600	0	-600
Subtotal International Activities	**1,100**	**1,100**	**1,100**	**0**	**-1,100**
Total Cross-cutting Research	**49,000**	**47,560**	**50,000**	**0**	**-50,000**
NETL Coal Research and Development					
Feasibility of Recovering Rare Earth Elements	15,000	15,000	15,000	0	-15,000
NETL Coal R&D (Other)	35,000	35,000	38,000	0	-38,000
Total NETL Coal Research and Development	**50,000**	**50,000**	**53,000**	**0**	**-53,000**
Supercritical Transformational Electric Power	**10,000**	**9,690**	**15,000**	**0**	**-15,000**
TOTAL CCS AND POWER SYSTEMS	**400,000**	**389,218**	**430,000**	**0**	**-430,000**
CCS and Advanced Power Systems					
Carbon Capture					
Post-Combustion Capture Systems	0	0	0	97,200	+97,200
Pre-Combustion Capture Systems	0	0	0	12,000	+12,000
Natural Gas Carbon Capture	0	0	0	31,000	+31,000
Advanced Combustion Systems	0	0	0	30,152	+30,152
Total Carbon Capture	**0**	**0**	**0**	**170,352**	**+170,352**

	FY 2015 Enacted	FY 2015 Current[2]	FY 2016 Enacted	FY 2017 Request	FY 2017 vs FY 2016
Carbon Storage					
Storage Field Management	0	0	0	44,875	+44,875
Advanced Storage R&D	0	0	0	28,000	+28,000
Carbon Use and Reuse	0	0	0	0	0
Risk and Integration Tools	0	0	0	18,000	+18,000
Total Carbon Storage	**0**	**0**	**0**	**90,875**	**+90,875**
Advanced Energy Systems					
Gasification Systems	0	0	0	5,500	+5,500
Advanced Turbines	0	0	0	10,000	+10,000
STEP (Supercritical CO2)	0	0	0	24,300	+24,300
Solid Oxide Fuel Cells	0	0	0	8,000	+8,000
Coal and Coal Biomass to Liquids	0	0	0	0	0
Total Advanced Energy Systems	**0**	**0**	**0**	**47,800**	**+47,800**
Crosscutting Research and Analysis					
Computational Sciences	0	0	0	10,000	10,000
Education and Outreach					
University Coal Research	0	0	0	2,000	+2,000
HBCUs and Other Minority Institutions	0	0	0	1,000	+1,000
Special Recruitment Programs	0	0	0	700	+700
International Activities	0	0	0	1,100	+1,100
Subtotal Education and Outreach	*0*	*0*	*0*	*4,800*	*+4,800*
Energy Evaluation and Analysis	0	0	0	850	+850
Extreme Environment Materials	0	0	0	23,150	+23,150
Sensors and Controls	0	0	0	4,750	+4,750
Water Management R&D	0	0	0	15,800	+15,800
Total Crosscutting Research and Analysis	**0**	**0**	**0**	**59,350**	**+59,350**
Total CCS and Advanced Power Systems	**0**	**0**	**0**	**368,377**	**+368,377**

SBIR/STTR:

- FY 2015 Transferred: SBIR $9,476; STTR: $1,307
- FY 2016 Projected: SBIR $10,481; STTR: $1,571
- FY 2017 Request: SBIR $10,576; STTR: $1,486

Fossil Energy Research and Development
Funding by Congressional Control ($K)
(Comparable)[4]

	FY 2015 Enacted	FY 2015 Current [5]	FY 2016 Enacted	FY 2017 Request	FY 2017 vs FY 2016
CCS and Advanced Power Systems					
Carbon Capture					
Post-Combustion Capture Systems	76,000	73,641	89,000	97,200	+8,200
Pre-Combustion Capture Systems	12,000	11,628	12,000	12,000	0
Natural Gas Carbon Capture	0	0	0	31,000	+31,000
Advanced Combustion Systems	28,000	27,131	30,000	30,152	+152
Total Carbon Capture	**116,000**	**112,400**	**131,000**	**170,352**	**+39,352**
Carbon Storage					
Storage Field Management	66,000	63,953	66,000	44,875	-21,125
Advanced Storage R&D	23,500	22,770	21,500	28,000	+6,500
Carbon Use and Reuse	2,000	1,937	10,000	0	-10,000
Risk and Integration Tools	8,500	8,236	8,500	18,000	+9,500
Total Carbon Storage	**100,000**	**96,896**	**106,000**	**90,875**	**-15,125**
Advanced Energy Systems					
Gasification Systems	25,000	24,224	25,000	5,500	-19,500
Advanced Turbines	15,000	14,534	15,000	10,000	-5,000
STEP (Supercritical CO_2)	10,000	9,690	15,000	24,300	+9,300
Solid Oxide Fuel Cells	30,000	29,069	30,000	8,000	-22,000
Coal and Coal Biomass to Liquids	5,000	4,845	5,000	0	-5,000
Total Advanced Energy Systems	**85,000**	**82,362**	**90,000**	**47,800**	**-42,200**
Crosscutting Research and Analysis					
Computational Sciences	24,000	23,256	24,000	10,000	-14,000
Education and Outreach					
University Coal Research	3,000	2,907	2,000	2,000	0
HBCUs and Other Minority Institutions	900	872	1,000	1,000	0
Special Recruitment Programs	700	700	700	700	0
International Activities	1,100	1,100	1,100	1,100	0
Subtotal Education and Outreach	*5,700*	*5,579*	*4,800*	*4,800*	*0*

[4] FY 2015 and FY 2016 funds are shown in the FY 2017 structure.

[5] Funding reflects FY 2015 SBIR/STTR funds which were transferred from FER&D to Science.

	FY 2015 Enacted	FY 2015 Current [5]	FY 2016 Enacted	FY 2017 Request	FY 2017 vs FY 2016
Energy Evaluation and Analysis	1,500	1,500	1,400	850	-550
Extreme Environment Materials	7,000	6,782	10,000	23,150	+13,150
Sensors and Controls	4,500	4,360	4,500	4,750	+250
Water Management R&D	7,000	6,783	6,000	15,800	+9,800
Total Crosscutting Research and Analysis	**49,700**	**48,260**	**50,700**	**59,350**	**+8,650**
Total, CCS and Advanced Power Systems	**350,700**	**339,918**	**377,700**	**368,377**	**-9,323**

SBIR/STTR:

- FY 2015 Transferred: SBIR $9,476; STTR: $1,307
- FY 2016 Projected: SBIR $10,481; STTR: $1, 571
- FY 2017 Request: SBIR $10,576; STTR: $1,486

CCS and Advanced Power Systems Explanation of Major Changes ($K)

	FY 2017 vs FY 2016
CCS and Advanced Power Systems	
Carbon Capture: An increase in Post-Combustion Capture funding will support one additional (three total) large scale carbon capture pilots. Pre-Combustion Capture funding supports continued testing of pre-combustion bench and pilot scale systems at the NCCC in FY 2017. Natural Gas Carbon Capture funding will support a FEED study and initial construction of one large-scale pilot facility to test advanced post-combustion capture CO_2 technology or an advanced combustion system that enables CO_2 capture on a natural gas power system. Advanced Combustion Systems supports two additional FEED studies for large-scale pilots (four total): two chemical looping projects, and two pressurized oxy-combustion pilots, which will avoid single point failure and allow more industrial partnership opportunities.	**+39,352**
Carbon Storage: Storage Field Management includes sufficient funding for the RCSPs, small-scale characterization and field projects, and fit-for-purpose testing. The FY 2017 Budget Request for Storage Field Management is reduced from the FY 2016 Enacted level primarily because by the beginning of FY 2017, five of the RCSP projects are anticipating to transition to post-injection monitoring, which is less costly than injection operations. The requested funding increase for Advanced Storage R&D would support high priority targeted research and development needs such as wellbore integrity, detection of CO_2 and fluid leakage from the wellbore, induced seismicity, reservoir fluid and pressure migration technologies, and advancing MVAA tool development. Risk and Integration Tools is increased from the FY 2016 Enacted level to support NRAP's increased efforts to utilize risk assessment models to address risk management and reduce uncertainty of leakage and induced seismicity which support the Carbon Storage subprogram goals. No funding is requested for Carbon Use and Reuse.	**-15,125**
Advanced Energy Systems: In FY 2017, the Gasification Systems activity will not release any new FOAs. A slightly lower number of Phase 1 biogasification projects will move to Phase 2 in 2017, compared to the number that will move to Phase 2 in FY 2016. Advanced Turbines funding will be slightly reduced for projected combustion and materials development activities. Development of SCO_2 turbomachinery and associated components for directly-fired SCO_2 power cycles will be supported. Solid Oxide Fuel Cells funding will be used to continue pilot testing of projects and systems. STEP funding is increased in order to initiate the design and construction of the STEP facility in 2017, the solicitation for which will be issued and awarded in FY 2016. FY 2017 funding will support the initial funding of long lead time components, reducing the risk of schedule slip due to late delivery of critical components.	**-42,200**

	FY 2017 vs FY 2016
Crosscutting Research and Analysis: Funding for Computational Sciences decreases as no funding is provided for the National Risk Assessment Partnership (NRAP). All funds for NRAP will be provided through the Carbon Storage subprogram. Support for the initial Carbon Capture and Simulation Initiative (CCSI) ends as this toolset is expected to be commercialized in 2016. Funding will support the development of tools to optimize data handling in the design of advanced energy systems fitted with carbon capture along with multi-scale, multi-physics simulation capabilities. Education and Outreach funding will allow for continued support of projects under the University Coal Research program and the HBCUs and Other Minority Institutions program. Energy Evaluation and Analysis will support analyses of potential environmental impacts of fossil fuel use and large-scale deployment of different generations of CCS. The increase in funding for Extreme Environment Materials will support code certification of high temperature materials, digital data management, informatics, reliability and access to data, and R&D focused on technology development of advanced materials and component testing of high temperature materials for directly-fired supercritical carbon dioxide (sCO_2) and high steam environments. Sensors and Controls will focus on obtaining data in harsh environments and the transient control of transformational advanced energy systems. Water Management R&D funding supports FER&D's share of the Clean Energy Research Center's (CERC) Energy-Water track and field testing of advanced desalination technology for water produced through CCS.	**+8,650**
Total, CCS and Advanced Power Systems	**-9,323**

CCS and Advanced Power Systems
Carbon Capture

Description

The Carbon Capture subprogram is focused on the development of post-combustion and pre-combustion CO_2 capture and novel compression technologies for new and existing fossil fuel-fired power plants and industrial sources, as well as advanced combustion systems which will facilitate carbon capture. Significant improvements are required to reduce parasitic energy load and cost of carbon capture and storage (CCS). In addition, many technologies that will be available in the near-term will need to be scaled up and/or applied to fossil fuel-powered generation systems. Post-combustion CO_2 capture technology research and development (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 synthesis gas. Advanced combustion systems include oxy-combustion, chemical looping, and other advanced combustion systems that generate a pure stream of CO_2 that would require limited additional effort to purify for injection and storage.

In FY 2017, a new activity is being added to the Carbon Capture subprogram, Natural Gas Carbon Capture. Most of the technical challenges to capturing CO2 apply to both coal-fired and gas-fired systems. For example, the various technical issues associated with the chemistry and physics of sorbents, solvents, and membrane systems for the capture of CO_2 are applicable to both systems. Similarly, both coal and natural gas fired systems are concerned with footprint, water consumption, parasitic load, integration, and flexibility to meet demand.

In FY 2017, the Post-Combustion and Pre-Combustion Capture activities will continue to address these common challenges for carbon capture from fossil fuel fired power systems, as well as issues specific to coal capture, including integration with air pollution control systems for particulates, SO_2, NO_X, and Mercury. The new Natural Gas Carbon Capture activity will address the R&D challenges specific to removing CO_2 from natural gas power plants that include higher oxygen content, lower CO_2 concentration, and higher mass flow rates.

Post-Combustion

The Post-Combustion activity focuses specifically on developments related to second generation and transformational technologies that capture CO_2 after the fuel is combusted 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. These second generation technologies aim to achieve CO_2 capture at a cost of electricity (COE) at least 20% less than state-of-the-art (SOTA) solvent systems (~$40/tonne captured). 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 that can significantly reduce the cost of capture, targeting a COE at least 30% less than SOTA (~$25/tonne). These transformational technologies will be able to 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 research and development milestones have been achieved since 2008 in laboratory through pilot-scale testing of a broad spectrum of CO_2 capture approaches including advanced solvents, sorbents, and membranes and through multiple, small-scale (0.5-1 MWe) slipstream tests of the most promising of these second generation CO_2 capture technologies that began in 2010. The FY 2017 Budget Request will support detailed design and construction of three large pilot scale (10+ MWe) projects, two of which were selected in 2016 and one which will be selected in 2017, preparing these technologies for commercial demonstration. FY 2017 activities will also continue to support R&D on second generation technologies at the bench and pilot scales and on transformational technologies at the laboratory scale. Funding will also support testing of technologies for post-combustion systems at the National Carbon Capture Center (NCCC).

Pre-Combustion

The Pre-Combustion activity focuses on the development of transformational technologies for pre-combustion capture that achieve a 30% reduction in the COE relative to SOTA capture technologies such as Rectisol® and Selexol®. FY 2017 funding will continue to support laboratory, bench, and small slipstream-scale tests of transformational technologies, such as

advanced solvents, sorbents, and membranes, including process intensification efforts that incorporate two or more technology concepts. Funding will support further testing of technologies for pre-combustion capture systems at the NCCC in FY 2017.

Natural Gas Carbon Capture

The Natural Gas Carbon Capture activity will focus on optimizing capture technologies for the specific technical challenges for carbon capture from natural gas power systems, such as a lower concentration of CO_2 and higher oxygen content. This activity will test and validate carbon capture technologies for new and existing natural gas fired power plants. Funding in FY 2017 will support the FEED study and initial construction of one additional large-scale pilot test (10+ MWe) of advanced post-combustion capture technology or an advanced combustion system and components that will be optimized for and run on a natural gas power plant. Funding will also be used to test existing post-combustion capture systems on natural gas that are currently field testing technologies from the bench to small slipstream pilot-scale. In addition, the Carbon Capture Simulation Initiative (CCSI) toolset will be modified to address the issues and challenges associated with natural gas-based systems.

R&D activities in FY 2017 will 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 the R&D effort, a Request for Information (RFI) and at least one public meeting will be held to gather input from stakeholders concerning the steps necessary to ensure that technologies are ready for demonstration in the near-term. The goals for this effort are aligned with the second generation goals for the Carbon Capture subprogram of which this activity is now an integral part.

Advanced Combustion

The Advanced Combustion 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 or less. 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 can be improved by lowering the cost of oxygen supplied to the system and by increasing the overall system efficiency. This activity targets both of these improvements in FY 2017 by sponsoring cost-shared research for three key technologies: (1) oxy-combustion, (2) chemical looping combustion, and (3) fundamentals associated with advanced concepts such as pressure gain combustion. The FY 2017 Budget Request will provide full funding for the Front End Engineering and Design (FEED) studies for two additional large pilots. This is in addition to two FEED studies that will be fully funded in FY 2016. This will allow for the support of a total of two chemical looping pilot projects and two pressurized oxy-combustion pilot projects. Supporting two projects in each area of advanced combustion avoids a single point failure for each technology and allows more industrial partnership opportunities.

Activities and Explanation of Changes

FY 2016 Enacted (Restructured Funding)	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
Carbon Capture $131,000,000	**$170,352,000**	**+$39,352,000**
Post-Combustion Capture Systems $89,000,000	**$97,200,000**	**+$8,200,000**
• Supports at least two large scale pilot projects, selected in FY 2016 from the Phase I preliminary design awards made in FY 2015, for post combustion capture that are applicable to both coal and natural gas power systems. These activities validate the performance and operations of second generation capture technologies on coal and natural gas power systems in order to gather data and knowledge to support future full scale demonstration. • Supports lab, bench, and small-scale slipstream transformational carbon capture projects selected in FY 2015 focused on developing advanced second generation post-combustion capture technologies and adapting technologies for natural gas power systems. • Supports projects selected in FY 2014 for second generation post-combustion capture systems that are field testing technologies from the bench to small slipstream pilot-scale.	• Funding will be used to support the detailed design and construction of three large (10+MWe) scale pilot projects for post combustion capture technologies. Two projects were awarded in prior years and one will be selected in FY 2017. CCSI toolsets for each of the technologies will be developed. These activities will validate the performance and operation of second generation carbon capture technologies on fossil fuel fired power systems in order to gather data and knowledge necessary for future full scale demonstration. • Funding will be used to support a small-scale slipstream transformational carbon capture project selected in FY 2015. • Funding will be used to support the Discovery of Carbon Capture Substances and Systems (DOCCSS) initiative focused on the use of computational chemistry, rapid synthesis and testing, and manufacturing to accelerate the discovery of transformational capture technologies. • Funding will support testing of post-combustion bench and pilot scale systems at the NCCC.	• The increase in funding is required to support one additional large scale pilot and fund construction and operation of the previously selected pilots. The funding increase also provides for development of transformational technologies at the computational, laboratory, and bench scales.
Pre-Combustion Capture Systems $12,000,000	**$12,000,000**	**$0**
• Continue advanced laboratory scale and small slipstream R&D for transformational pre-combustion capture technologies.	• Advanced computational, laboratory scale and small slipstream research and development for pre-combustion capture technologies will continue. Funding will be used to support the projects selected in FY 2015 for pre-combustion capture systems that are field testing technologies from the bench to small slipstream pilot-scale.	• None.

Activities and Explanation of Changes

FY 2016 Enacted (Restructured Funding)	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
• Support projects selected in FY 2014 that are field testing technologies from the bench to small slipstream pilot-scale. • Support previously selected laboratory and bench scale projects which are focused on developing advanced pre-combustion capture technologies.	• Funding will support testing of pre-combustion bench and pilot scale systems at the NCCC.	
Natural Gas Carbon Capture $0	**$31,000,000**	**+$31,000,000**
• Not applicable.	• Funding will support a FEED study and initial construction for one large (10+ MWe) pilot project optimized for a natural gas power plant. • Funding will be used to test existing post-combustion capture systems on natural gas that are currently field testing technologies from the bench to small slipstream pilot-scale. • Funding will support the development of toolsets in the CCSI. The program will issue a Request for Information (RFI) and host at least one meeting to gather input from stakeholders on the most cost-effective natural gas capture technologies ready for demonstration by 2020.	• Funding will support the FEED study and initial construction of a large pilot facility to capture CO_2 from a natural gas power system. The increase in funding supports a new emphasis on reducing the costs and technical challenges of natural gas carbon capture by leveraging the work that has been accomplished in developing second generation carbon capture technologies at bench, small pilot, and large pilot scales. Leveraging these existing systems significantly reduces the cost of R&D and accelerates the rate of CCS technology development for natural gas power systems. The funding will also support the development of a CCSI toolset for natural gas power systems, speeding the commercialization of technologies for carbon capture. 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.

Activities and Explanation of Changes

FY 2016 Enacted (Restructured Funding)	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
Advanced Combustion Systems $30,000,000	**$30,152,000**	**+$152,000**
• Continues the development of "transformational" technologies that will be ready for demonstration in the next 10 years using high performance materials that allow for high temperature operations. • Fully funds two FEED studies (one oxy-combustion, one chemical looping) for advanced combustion systems.	• A solicitation in FY 2017 will fully fund two additional FEED studies (one oxy-combustion, one chemical looping) for future construction and operations of large pilots for advanced combustion systems.	• Increase in funding for Advanced Combustion supports FEED studies for two additional large pilot projects, four total: two chemical looping projects, and two pressurized oxy-combustion pilots. These second projects avoid a single point failure for each technology and provide opportunities more industrial partnership opportunities.

CCS and Advanced Power Systems
Carbon Storage

Description

The overall goal of the Carbon Storage subprogram 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 geologic 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 subprogram will improve storage efficiency, reduce overall cost, decrease subsurface uncertainties, and identify ways to mitigate potential risks of implementing Carbon Capture and Storage (CCS).

The Department of Energy's (DOE) Subsurface Science, Technology, Engineering and RD&D (Subsurface) crosscut 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 enhance renewable energy supply, ensure material impact on climate change via CO_2 storage, and dramatically mitigate environmental impacts from energy-related activities and operations. The Carbon Storage subprogram significantly contributes to the Department's Subsurface activities related to subsurface technologies. Therefore, much of the work being conducted by the Office of Fossil Energy under the Carbon Storage subprogram is being coordinated with other DOE offices through the Subsurface crosscut to maximize the value of this research across DOE offices.

Storage Field Management (formerly Storage Infrastructure)

In FY 2017 the Storage Infrastructure activity is renamed Storage Field Management to better reflect that this subprogram validates technologies and best practices in the field for the characterization, injection, post-injection monitoring, and reservoir and operations management related to geologic storage. This activity focuses on development and validation of technologies, evaluation of carbon storage infrastructure needs, 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 apply monitoring, verification, accounting, and assessment technologies (MVAA) for various storage reservoirs. These projects aim to improve our understanding of CO_2 injection, fluid flow and pressure migration, and geochemical impacts from CO_2 injection, and develop a "commercial toolbox" for cost-effective monitoring in all storage types.

In FY 2017, field activities will continue to address specific technical research questions and regional barriers to CCS deployment. This includes projects that investigate active reservoir management as a method to better control or "steer" the CO_2 plume and pressure fronts within a reservoir. The Brine Extraction Storage Tests (BEST) projects are an example of active reservoir management in that these tests will withdraw fluids from deep saline aquifers to evaluate the subsequent changes in reservoir pressure and fluid flow. Selected BEST projects will continue into the field validation phase, examining engineering strategies/approaches for managing formation pressure, predicting and monitoring the differential pressure plume movement in the subsurface, and validating differential pressure plume predictions. Additionally, FY 2017 activities will include continuation of up to two commercial-scale (greater than 50 million metric tons) characterization projects selected in FY 2016 that will conduct detailed characterization, design, simulations, and monitoring to qualify and permit the site. The RCSPs will also continue implementation of large-scale injection projects that 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 onshore and offshore characterization activities are focused on identifying regional opportunities for CCS, CO_2 sources, and priority opportunities for field sites. 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 strategies. Non-proprietary information

collected from these projects is made available to the public through the DOE's National Carbon Sequestration Database and Geographic Information System (NATCARB), Best Practices Manuals, and updates to the Carbon Storage Atlas.

Advanced Storage R&D

The Advanced Storage R&D activity is focused on 1) developing and validating storage simulation and risk assessment technologies, 2) developing robust technologies to monitor the transport and fate of injected CO_2, and 3) advanced wellbore technologies to detect and mitigate wellbore issues from short/long term exposure of 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. Advanced Storage R&D activities involve 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 reservoir fluid flow and pressure 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-scales.

Developing and validating MVAA technologies will increase confidence in stakeholders (e.g. operators, regulators and the public) that monitoring technologies can effectively monitor the transportation 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. FY 2017 activities include research focused on developing and demonstrating tools in the field for improved mapping and characterization of fractures and faults, and developing novel tools for quantification of plume volume in the subsurface. Additionally, FY 2017 activities include development of laboratory- and bench-scale technologies, through the Department's Subsurface crosscut, for identifying and obtaining new subsurface signals, ensuring wellbore integrity, and increasing understanding of stress state and induced seismicity. Technological advances in these areas improve our ability to ensure storage permanence and optimize storage capacity.

Technologies developed in the above areas at laboratory- and bench-scale, and validated in field tests in FY 2017 through the Advanced Storage R&D 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.

Carbon Use and Reuse

The Carbon Use and Reuse activity focuses on technologies, other than enhanced hydrocarbon recovery, that have the potential to reduce CO_2 emissions by developing beneficial uses for captured CO_2. These beneficial uses include the conversion of CO_2 to chemicals, plastics, building materials, curing for cement, and the integration of carbon utilization technologies with fossil fuel power plants, such as biological conversion systems (i.e. algae). The primary objective of carbon use and reuse technology development is to lower the near-term cost of CCS through the creation of value-added products from CO_2. Existing projects selected in FY 2016 will continue; no new projects will be selected in FY 2017.

Risk and Integration Tools (formerly Sub-Disciplinary Storage R&D)

In FY 2017, the Sub-Disciplinary Storage R&D activity is renamed Risk and Integration Tools to reflect that this activity centers primarily on risk assessment and validation of system models and their integration for quantifying risks. The Risk and Integration Tools activity supports the Carbon Storage subprogram through targeted research to support program activities and technology validation in field projects. FY 2017 activities in this area focus on risk assessment and model validation for long-term and system-wide modeling including uncertainty quantification; integration of monitoring within risk assessment models, development of capabilities to test risk assessment and monitoring capabilities, studies on storage performance and efficiency, and evaluations of mitigation options. FY 2017 funding will continue to support the National Risk Assessment Partnership (NRAP) with a focus on verifying and validating (with field data) their integrated assessment and reduced order models, monitoring network design and basin-scale (multi-site) storage risk tools, and risk-based testing of monitoring and mitigation approaches.

Additionally, FY 2017 will include continued development of the Energy Data Exchange (EDX) system, which will be expanded from an NETL-centric resource to an Office of Fossil Energy-wide intramural and extramural resource supporting subsurface science R&D. EDX has proven to be an effective tool for coordinating 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.

Activities and Explanation of Changes

FY 2016 Enacted (Restructured Funding)	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
Carbon Storage $106,000,000	**$90,875,000**	**-$15,125,000**
Storage Field Management (formerly Storage Infrastructure) $66,000,000	**$44,875,000**	**-$21,125,000**
• 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, additional RCSP projects will have transitioned into post-injection monitoring to understand CO_2 long-term storage. • Continue to support the existing small-scale field tests to evaluate methodologies and technologies to ensure safe and permanent storage of CO_2. • Continue offshore storage site characterization research projects from the FY 2015 solicitation. • Continue support and/or selection of small-or large-scale and fit-for-purpose field projects. • Continue projects selected in FY 2014 and FY 2015, with FY 2014 and FY 2015 funding, to evaluate associated CO_2 storage in enhanced oil recovery (EOR) fields/operations and improve EOR technologies to increase storage efficiency.	• In FY 2017 Storage Infrastructure will be renamed Storage Field Management to better reflect that this subprogram validates technologies and best practices in the field for the characterization, injection, post-injection monitoring, reservoir and operations management related to geologic storage. $_2$. • Funding will support up to two site characterization projects (>50 million metric tons) to conduct characterization, design, simulations, and monitoring to reduce risk and increase certainty in obtaining and meeting Class VI regulatory requirements. • Phase II of the Brine Extraction Storage Test (BEST) field validation, examining engineering strategies/approaches for managing formation pressure, predicting and monitoring the differential pressure plume movement in the subsurface, and validating differential pressure plume predictions, will be supported. • Collaboration with international sites (e.g., Shell Quest; METI Tomakomai) will be supported to increase knowledge sharing and enhance domestic technology development.	• The decrease in funding is due to the fact that by the start of FY 2017, five of the RCSP projects will have or anticipate transitioning to post-injection monitoring, which is less costly than injection operations. The FY 2017 funding is sufficient to maintain RCSP activities, including continued post-injection monitoring, and initiate on- and off-shore field tests and technology validation efforts, as well as maintain focus on the Brine Extraction Storage Test field activities and commercial-scale characterization activities.

FY 2016 Enacted (Restructured Funding)	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
Advanced Storage R&D $21,500,000 • In FY 2016, Geologic Storage Technologies was renamed to Advanced Storage R&D and now also incorporates the MVAA 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. • Continue existing projects on wellbore integrity and stress state of subsurface in support of DOE's cross-functional SubTER Technical Team. • Continue to develop MVAA tools and technologies to increase efficiency of injecting and monitoring CO_2 in subsurface. • Select new projects on geologic storage or MVAA technologies that will obtain new subsurface signals from geologic formations to provide a clearer picture of the subsurface to improve characterization and tracking of CO_2 post injection. • Continued support for NRAP to validate system models and quantify uncertainty around risks related to the long-term behavior of storage sites for developing risk management protocols.	**$28,000,000** • Funding will support new and existing projects on plume behavior, stresses, geomechanical deformation, leakage quantification, simulations and reservoir performance and storage efficiency for saline field projects; as well as mechanical and flow properties for reservoirs, seals, and fracture networks on various reservoirs. Research will include development of advanced flow models that reduce cost and uncertainty while increasing accuracy that can predict basin-scale impacts (geomechanical/reservoir), including pressure mitigation approaches, and coupled geochemical/geomechanical impacts. • Funding will support new and existing research focused on developing and demonstrating in the field, tools for improved mapping and characterization of fractures and faults; and develop novel tools for quantification of plume volume in subsurface. • Funding will support new and existing research on technologies that can detect and mitigate wellbore issues from short/long term exposure of CO_2 with a focus on offshore environments and foam cement potential.	**+$6,500,000** • Existing and additional funding maintains monitoring, verification, accounting, and assessment (MVAA) field tool development projects and supports development of laboratory-and bench-scale technologies for identifying and obtaining new subsurface signals, ensuring wellbore integrity, and increasing understanding of stress state and induced seismicity.
Carbon Use and Reuse $10,000,000 • Select up to 7 new projects focused on lab and bench-scale R&D in mineralization of CO_2 and biological and chemical conversion pathways.	**$0** • Existing applied R&D projects selected with FY 2016 funding will be continued.	**-$10,000,000** No new projects will be selected in FY 2017. Existing projects selected in FY 2016 will continue.

FY 2016 Enacted (Restructured Funding)	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
Risk and Integration Tools (formerly Sub-Disciplinary Storage R&D) $8,500,000	**$18,000,000**	**+$9,500,000**
• 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. • Continue development of Energy Data Exchange (EDX), which supports the Carbon Storage Program's goals of addressing data management and technology transfer.	• In FY 2017 Sub-Disciplinary Storage R&D will be renamed Risk and Integration Tools to reflect that this activity centers primarily on risk assessment and validation of system models and their integration for quantifying risk. • Research focused on risk assessment and model validation for long-term and system-wide modeling including uncertainty quantification; integration of monitoring within risk assessment models; development of capabilities to test risk assessment and monitoring capabilities; studies on conformance; and evaluation of mitigation options will be supported. Funding will verify and validate (with field data) integrated assessment models and reduced order models; monitoring network design tools; tools for basin-scale (multi-site) storage risk; risk-based testing of monitoring and mitigation approaches. • Expansion of EDX from a NETL-centric resource to an Office of Fossil Energy-wide intramural and extramural resource in support of subsurface science R&D will be supported.	• The FY 2017 Request for Risk and Integration Tools is increased from FY 2016 Enacted funding due to increased efforts for NRAP to utilize their risk assessment models for addressing risk management and uncertainty reduction on leakage and induced seismicity that are supportive of the Carbon Storage subprogram goals. Increase also supports continued efforts to expand EDX to an Office of Fossil Energy-wide intramural and extramural resource supporting subsurface science R&D, to include development of EDX as a platform for data sharing and management.

CCS and Advanced 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, advanced turbines, solid oxide fuel cells, and supercritical CO_2 (sCO_2) and the associated Supercritical Transformational Electric Power (STEP) project.

Gasification Systems

This activity focuses on technology developments to reduce the cost of coal gasification (through lowering technology capital costs and increasing plant efficiency and availability) to support integration with carbon capture and storage (CCS). Research activities in FY 2017 aim to develop lower-cost technologies and build on pilot scale research and development (R&D) projects in gasification to develop models to improve polygeneration of products that 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; and encourage more efficient high-pressure operation of dry feed gasifiers. Funding will also support further development of hydrogen production technologies to lower the capital requirements and increase the efficiency of integrated gasification combined cycle (IGCC) and polygeneration applications. In addition, this 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, develop solutions to improve plant reliability, and ultimately to lead toward improved gasification system designs.

A major cost element in gasification plants is converting raw syngas into the gas composition required for the plant's output of electricity and other products. The technologies being developed by the program improve the efficiency of moderate to high temperature processes and clean syngas of contaminants, enabling more efficient integration of carbon capture technologies. Research efforts in FY 2017 will take advantage of recent breakthroughs in advanced manufacturing, reactor modeling, modular systems and coal conversion science. These projects will help to improve and develop toolsets that will drive down the costs and time required for Nth of a kind plants. Funding will not support further testing of technologies for gasification systems at the National Carbon Capture Center (NCCC).

Advanced Turbines

In FY 2017 this activity will focus 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 research and development to develop advanced turbine technology for the integral electricity-generating component of fossil fuel power plants. In FY 2017, turbine research and development related to directly-fired sCO_2 based power cycles will continue to be a priority in this subprogram. The directly-fired sCO_2 turbine is targeted to be available for integration into the STEP facility in the 2022 timeframe.

Continuation of the existing FY 2016 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.

STEP Supercritical CO_2

As part of the proposed FER&D restructuring the STEP effort, which was formerly a separate subprogram, is now an activity within AES. This provides a more streamlined budget structure and reflects the fact that supercritical CO_2 fuel cycles are part of a broader portfolio of new fossil-fuel energy conversion systems integrated with CCS that may be capable of producing competitively priced electricity. FY 2017 funding will be used to initiate the design and construction of the STEP facility.

This facility will enable evaluation of 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.

The FY 2017 Budget Request continues the Department's coordinated efforts in research, development, and demonstration of transformative Supercritical CO_2 (sCO_2) Brayton cycle energy conversion technology. Recognizing that the near-term deployment and potential market applications for commercial sCO_2 power cycles are primarily in the fossil energy area, the STEP pilot facility is being managed by the Office of Fossil Energy.

In FY 2016 the Department proposes to continue its engagement with the appropriate stakeholders gathering information, with the goal of developing an effective solicitation for the public-private cost-shared 10 MWe STEP facility. As part of this engagement, an RFP for conceptual plans, technical approach, cost and schedule relevant to a 10 MWe facility was awarded in FY 2016. Information from this RFP will inform the solicitation for the design, construction, and base operation of the STEP facility. The STEP facility FOA is proposed to be issued and awarded by the end of FY 2016.

The sCO2 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 sCO_2 fuel cycle that could also provide significant benefits for CCS by reducing the costs and parasitic load of carbon capture and CO2 compression. In FY 2017 a public program plan will be developed that lays out a R&D path for developing the directly-fired Brayton cycle by 2030.

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. However, once the indirect-fire cycle has successfully operated and been tested through the necessary suite of transient and steady state conditions, FER&D will begin the transition to testing key elements of the directly-fired sCO_2 power cycle. The directly-fired sCO_2 turbine, which is being funded under the Advanced Turbines activity, could be available for integration into the STEP facility in the 2022 timeframe.

Solid Oxide Fuel Cells (SOFC)

This 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 water use in central power generation applications. In FY 2017 the activity will focus on stack and system development and help develop smaller, highly efficient, ultra-low emission, fuel flexible SOFC technology that can exploit domestic fossil fuel resources, maintain sound environmental stewardship, and contribute to a secure, low carbon 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 in communities or commercial centers. The program's long-term focus is on coal or natural gas fueled central station generation, with transformational SOFC technology integrated with CCS that is ready to be deployed at the commercial scale in the 2030-2040 timeframe.

Coal and Coal-Biomass to Liquids

No funding is requested for this activity.

Activities and Explanation of Changes

FY 2016 Enacted (Restructured Funding)	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
Advanced Energy Systems $90,000,000	**$47,800,000**	**-$42,200,000**
Gasification Systems $25,000,000	**$5,500,000**	**-$19,500,000**
• Funding supports continued testing of advanced oxygen production technology, multiphase reacting flow model development applicable to commercial gasification systems, and refractory development activities.	• In FY 2017, small-scale R&D will continue. Funds support the move to Phase 2 of bio-gasification projects that have shown success.	• No new funding will be provided for advanced O_2 separations R&D to develop new materials and processes for the separation of oxygen from air beyond current cryogenic air separation units and a limited number of Phase 1 bio-gasification projects will move to Phase 2. Projects selected previously will continue to the next phase; no new Funding Opportunity Announcements (FOAs) will be released. No funding will be provided for NCCC gasification testing.
Advanced Turbines $15,000,000	**$10,000,000**	**-$5,000,000**
FY 2016 funding is for the development of component technologies for high pressure ratio and high temperature turbine technologies. This includes: • Identification and development of innovative turbomachinery components for advanced combustion turbines in combined cycle applications. • Continued research through the University Turbines System Research (UTSR) program on high temperature, high pressure combustion and materials development. • Continued turbine R&D related to directly-fired sCO_2 based power cycles. • Phase 2 down-selection process of a suite of projects for development and testing at the laboratory/bench scale.	FY 2017 funding will be used for the development of component technologies for high pressure ratio and high temperature turbine technologies. This includes: • Development of the directly-fired sCO_2 turbine will be a central focus in 2017 in order to prepare this critical component to be ready for integration into the STEP facility in the 2022 timeframe. • Continued research through the University Turbines System Research (UTSR) program for high temperature, high pressure combustion and materials development. • Additional innovative component development for IGCC. • Continuation of Phase 2 down-selects from FY 2016. • Initiation of NETL in-house activities in pressure gain combustion.	• This decrease in funding reduces the number of Phase 2 down-selects that can proceed. Research on pressure gain combustion, which has significant potential for efficiency improvements, will be supported in FY 2017.

FY 2016 Enacted (Restructured Funding)	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
STEP (Supercritical CO_2) $15,000,000	**$24,300,000**	**+$9,300,000**
• In FY 2016 this subprogram will issue a competitive FOA, cost shared with industry, for the 10 MWe Supercritical Transformational Electric Power (STEP) pilot scale facility. This facility will enable DOE 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.	• Funding will support design and construction activities for the STEP facility and will provide funding for ordering long lead time components. This reduces risk of schedule slip due to late delivery of critical components (e.g. heater, turbine). Recognizing that the near-term deployment and potential market applications for commercial sCO_2 power cycles are primarily in the fossil energy area, the STEP pilot scale facility is being managed by the Office of Fossil Energy. In FY 2017 a program plan will be developed that lays out a R&D path for developing the directly-fired Brayton cycle, the ultimate goal for FER&D.	• The increase in funding will be used to initiate the design and construction of the STEP facility. The increase in funding will ensure sufficient funds for the ordering of long lead time components for the STEP facility, reducing the risk of schedule slip. It will also enable development of a program plan for the directly-fired sCO_2 fuel cycle.
Solid Oxide Fuel Cells $30,000,000	**$8,000,000**	**-$22,000,000**
• Funding accelerates 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, CO_2 exhaust stream to reduce the costs of carbon capture and storage.	• FY 2017 activities will focus on continuation of pilot scale systems as well as stack and systems developments.	• Reduction in funding reflects a re-scoping of some R&D to focus more narrowly on the most promising next generation SOFC technologies. Continued testing includes a more aggressive test plan (transients, load follow, additional hours).
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 adoption 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 is requested. Existing projects will be continued with prior year appropriations.

CCS and Advanced Power Systems
Crosscutting Research and Analysis (formerly Crosscutting Research)

Description

Crosscutting Research and Analysis fosters the development of innovative systems for improving availability, efficiency, and environmental performance of advanced energy systems integrated with carbon capture and storage (CCS). The subprogram targets research gaps identified in the rest of the CCS and Advanced Power Systems portfolio that have potential to be solved through computational means or by examination through university research programs. It also includes technologies that can apply to a variety of different power systems. The Crosscutting Research and Analysis portfolio encompasses the following activities: 1) Computational Sciences, 2) Education and Outreach, 3) Energy Evaluation and Analysis, 4) Extreme Environment Materials, 5) Sensors and Controls, and 6) Water Management Research & Development (R&D).

The name of this subprogram is being revised to Crosscutting Research and Analysis to better reflect the activities that comprise the portfolio.

Computational Sciences

The Computational Sciences activity develops immersive, interactive visualization technology as well as data communication optimization methods to improve the design and operation of advanced power systems with CCS. This activity builds computer-aided design tools for the Advanced Energy Systems subprogram so that novel concepts can be explored and analysis can be conducted on pre-commercial systems. Computational Sciences further supports first principle and physics-based modeling of phenomenon for complex energy conversion and carbon capture processes and techniques to transform these computationally intensive models into reduced order, fast, user-enabled models for the purposes of study, development, and validation. Furthermore, these tools will be used to optimize data handling and exploit information technology in the design of advanced energy systems with carbon capture. In FY 2017 there are two significant changes: (1) no funding is provided for the National Risk Assessment Partnership (NRAP). All funds for NRAP will be provided through the Carbon Storage subprogram. (2) Support for the initial Carbon Capture and Simulation Initiative (CCSI) ends. CCSI was launched in early 2011 to develop, demonstrate, and deploy advanced computational tools and validated multi-scale models to reduce the time required to develop and scale up new carbon capture technologies. Guided by substantial input from a multidisciplinary industry advisory board along the way, commercial licensing of CCSI is expected in FY 2016 at which time programmatic support will end. In FY 2017 activities will include:

a. *MFIX (Multiphase Flow with Interphase eXchanges)* is a computer code developed at the National Energy Technology Laboratory (NETL) 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. These activities are intended to accelerate CCS technology development and to enable commercial deployment of second-generation carbon capture and storage technologies.
b. *Multi-scale, multi-physics simulation capabilities* will continue to be developed 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 processes utilized in advanced power generation systems.
c. *Integration of computational and experimental techniques* will continue to be a central focus. This activity will develop and demonstrate coupled computational and experimental techniques, integration methods, and infrastructure necessary to balance the various advantages and disadvantages of different materials research approaches and deliver emergent R&D. Methods enabling concurrent computational and experimental investigation of new materials will be developed, including techniques and standards supporting feedback between researchers and tools during experimentation and simulation.
d. *Multi-scale experimental and computational predictive tools for materials, including multi-material components, to enable design for controlled lifetimes and reliabilities* are targeted for advancement. FER&D will work to develop the validated, science-based predictive tools that accurately describe a component's performance at service conditions. Models will also consider the impacts of multi-material interfaces on overall component performance, including the material's chemical and structural integrity. In addition, advanced characterization tools and rapid test and characterization methodologies will be developed to validate model predictions and to reduce uncertainty.

Education and Outreach

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 Research and Development (FER&D) and the CCS and Advanced Power Systems program. The scope of FY 2017 research areas will include concepts related to advanced power generation with carbon capture specifically focused on computational based R&D; advanced high performance materials; novel sensing and control concepts; and advanced power cycle concepts that support CCS. 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.

HBCUs and Other Minority Institutions

The Historically 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 and education programs related to advanced energy systems with CCS. This is an area consistent with the goals of FER&D and the CCS and Advanced Power Systems program. The scope of FY 2017 research areas will include concepts related to advanced power generation with carbon capture focused in the areas of computational based R&D; advanced high performance materials; novel sensing and control concepts; and advanced power cycle concepts that support CCS. Grants awarded under this program are intended to maintain and upgrade the educational, training and research capabilities of HBCUs/OMIs in the fields of energy science and technology, with project results being used to further DOE's commitment to fossil energy research.

Special Recruitment Programs

The Office of Fossil Energy developed the Mickey Leland Energy Fellowship (MLEF) program to support and 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 education program that offers undergraduate, graduate, and post-graduate students majoring in science, technology, engineering, and mathematics 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. In FY 2017, a diverse group of undergraduate, graduate, and Ph.D. students in science, technology, engineering, and mathematics majors will be recruited and selected to participate in the 10 week MLEF program. All participants in the MLEF program will complete a hands-on-research project under the mentorship of an Office of Fossil Energy scientist, researcher, or program official. This activity is moved within Crosscutting Research and Analysis' Education and Outreach in order to have all educational and training activities appear under the same subprogram.

International Activities

This subactivity coordinates international activities within the Office of Fossil Energy that fall under the Office of the Deputy Assistant Secretary for Clean Coal and Carbon Management. It also serves as a catalyst to: foster opportunities for U.S. firms competing in international energy markets; develop overseas deployment opportunities for U.S. carbon capture and storage and associated power technologies; develop and promote international partnerships for the deployment of emerging technologies related to greenhouse gas abatement; coordinate with international functions within the U.S. Government (e.g., Department of State, U.S. Agency for International Development, U.S. Trade and Development Agency); and coordinate with and seek opportunities to partner with State and Tribal governments and engage industry, universities and non-governmental organizations (NGOs) on the responsible use of fossil fuels nationally and internationally.

Energy Evaluation and Analysis

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 technologies. This activity 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 integrated with CCS. In FY 2017, these analyses will include technical and economic studies such as benefit-cost analysis and CCS deployment projections.

Of particular interest in FY 2017 is the analyses of potential environmental impacts of fossil fuel use and large-scale deployment of different generations of CCS.

Extreme Environment Materials

Materials R&D encompasses the spectrum of fundamental materials design for advanced ultra-supercritical and supercritical CO_2 (sCO_2) environments through qualification of functional materials that support the next generation of advanced power generation integrated with CCS. In FY 2017 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. This activity will conduct research and development focused on technology development of advanced materials and component testing of high temperature materials for directly-heated sCO_2 and Advanced Ultra-Supercritical high steam environments. This work is being coordinated with other offices through the DOE Advanced Materials crosscut to maximize the value of this research across DOE programs.

Corrosion remains a central challenge for energy infrastructure, transmission, generation, and storage. Forms of corrosion and degradation in extreme environments include uniform attack, selective leaching, intergranular corrosion, stress corrosion, galvanic, erosion-corrosion, pitting, creep, fatigue and crevice corrosion. In addition, the Quadrennial Technology Review (QTR) identified the manufacturing of materials for harsh service environments as a priority technical area for development, including materials for high-temperatures, pressures, and chemical environments. The primary existing control strategy for corrosion is with protective oxide layers, reducing temperature, adding inhibitors, coatings, cathode protection, and microstructure tailoring and alloy development. The field is on the threshold of important breakthroughs, building on emerging advances across many fields of science and technology. This area of focus for FER&D through the Advanced Materials crosscut is especially well matched with the Materials Genome Initiative. FER&D's efforts will address the following research areas:

a. *Extreme Environment Materials Development and Testing*: Research and development will be focused on technology development of advanced materials and component testing of high temperature materials for directly-heated sCO_2 and Advanced Ultra-Supercritical high steam environments.
b. *Code Certification of High Temperature Materials*: Methods will be developed to understand the effects of process and production and to understand the effects of processes to increase throughput to predictively scale-up materials from proof-of-concept, small-scale to full scale development processes. This will ensure that born-qualified (development of a material using computational modeling that can be code certified/qualified) predictive materials development can be achieved at ever increasing volumes and rates from milligrams to kilograms to metric tonnes.
c. *Digital data management, informatics, reliability and access*: Develop digital data repositories by material class that can be networked and are machine discoverable and accessible to allow algorithms to crawl the broad sets of data and identify unique trends or correlations. Methods will be developed to analyze the large volume of data generated during the manufacture and testing of materials components and to incorporate that learning to improve the predictive capability of simulations that are developed, as well as to reduce uncertainty. Methods will also be developed to quantify the remaining uncertainty in materials performance and to drive down the risks associated with market deployment. FER&D will develop and harmonize digital-data storage standards to be extensible, accessible and interoperable to ensure utility and access in both the near term and long range. Issues relating to open-source and/or open-access standards, data privacy, intellectual property integrity, cyber secure integrity and experimental integrity for datasets both within and between materials and applications need to be addressed to ensure utility and public value from the resulting research.

Sensors and Controls

This activity focuses on the development of real-time measurements critical to the operation and optimization of advanced power systems integrated with CCS. 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 2017 this activity will continue research and development on transformational research in process control and optimization centered 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 the application of additive manufacturing towards constructing complex components (e.g. turbine blades) with embedded sensing capability, and direct power extraction (DPE). DPE refers to technology aimed at directly converting the thermal or kinetic energy of a working fluid into electrical energy. By avoiding an intermediate conversion of energy into mechanical energy (e.g. the movement of turbine blades), maximum cycle efficiencies can be extended well beyond current limitations imposed by the material limitations of mechanical parts.

Water Management R&D

Water Management R&D supports sustainability and improved water efficiency focusing on treatment and use of non-traditional water. FY 2017 activities include field testing of promising technologies and processes for treating water produced by injection of carbon dioxide in deep saline aquifers. In FY 2017, R&D efforts in this activity will be coordinated with other offices throughout DOE in support of DOE's Energy-Water Nexus crosscut in order to maximize the value of this research across DOE programs. This R&D will focus on exploiting the opportunity for water-limited cooling provided by the supercritical carbon dioxide fuel cycle and innovative multi-stage filtration technologies including membrane-based, evaporative, chemical, electrochemical and biological systems developed for the purpose of producing water through CCS. The FY 2017 Request includes complementary investments in multiple technology areas. The 2nd DOE QTR highlights several areas where technology advances could positively impact the challenges faced in the energy-water nexus, including desalination. The FY 2017 FER&D activities include:

a. *Energy-Optimized Treatment, Management, and Beneficial Use of Non-Traditional Water*: will advance targeted treatment technologies and will invest in focused R&D on multistage water purification methods for high total dissolved water sources for projected beneficial uses, including thermoelectric cooling and other industrial applications. FY 2017 activities also include field testing of promising technologies and processes for treating water produced by injection of carbon dioxide in deep saline aquifers. Desalinization R&D within FER&D will be coordinated with desalinization R&D in the Office of Energy Efficiency and Renewable Energy, including the new desalinization hub.
b. *Water-Efficient Cooling for Electricity Generation*: will pursue increased efficiency in heat exchangers and cooling systems to reduce the need for water for cooling in thermoelectric power plants.
c. *Data, Modeling and Analysis (DMA):* will gather and analyze data to characterize energy-water relationships on a state level in coordination with other offices within DOE.

Activities and Explanation of Changes

FY 2016 Enacted (Restructured Funding)	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
Crosscutting Research and Analysis $50,700,000	**$59,350,000**	**+$8,650,000**
Computational Sciences $24,000,000	**$10,000,000**	**-$14,000,000**
• Provides support for National Risk Assessment Partnership (NRAP) modeling projects. Funding will enable development of key products such as tools for risk-profile determination of carbon storage sites and post-injection site care technical decision support. • 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. • Provides first principle and physics based modeling of phenomenon for complex energy conversion and carbon capture processes. • Maintains funding for Carbon Capture and Simulation Initiative (CCSI) modeling projects. • Implements the next generation of enabling computational formats for domain specific solution sets.	• Funding will support the development of models to assess risk and impact of operation of advanced power systems with carbon capture and sequestration. • Implements the next generation of enabling computational formats for domain specific solution sets, enhancing both speed and capabilities. • Uses fundamental models to reduce risk of employing novel concepts by developing a framework for uncertainty quantification and model hierarchy. • Maintains funding for toolsets developed under CCSI.	• Decrease in funding represents the transition of support for NRAP into the Carbon Storage subprogram and the conclusion of CCSI project.
Education and Outreach $4,800,000	**$4,800,000**	**$0**
University Coal Research (UCR) $2,000,000 and *HBCUs and Other Minority Institutions $1,000,000* • 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.	*University Coal Research $2,000,000* • Select and award up to 4-6 university-based research projects focused on developing concepts related to advanced power generation with carbon capture capability. *HBCUs and Other Minority Institutions $1,000,000* • Select and award up to 3-5 university-based research projects focused on developing concepts related to advanced power generation with carbon capture capability.	• No change.

FY 2016 Enacted (Restructured Funding)	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
Special Recruitment Programs $700,000 • A diverse group of undergraduate, graduate, and Ph.D. students in science, technology, engineering and mathematics will be recruited and selected to participate in the MLEF program. *International Activities $1,100,000* • Organize the 2016 CLSF Ministerial conference and coordinate international activities within the Office of Fossil Energy that fall under the Office of the Deputy Assistant Secretary for Clean Coal and Carbon Management.	*Special Recruitment Programs $700,000* • A diverse group of undergraduate, graduate, and Ph.D. students in science, technology, engineering and mathematics will be recruited and selected to participate in the MLEF program. *International Activities $1,100,000* • Organize the 2017 CLSF Ministerial conference and coordinate international activities within the Office of Fossil Energy that fall under the Office of the Deputy Assistant Secretary for Clean Coal and Carbon Management.	
Energy Evaluation and Analysis $1,400,000	**$850,000**	**-$550,000**
• Carry out analyses of options and barriers for incorporating CCS on gas-fueled power plants.	• Carry out analyses of potential environmental impacts of fossil fuel use and large-scale deployment of different generations of CCS.	• Rescoping of projects to align with mission needs and other high priority objectives.
Extreme Environment Materials $10,000,000	**$23,150,000**	**+$13,150,000**
• Supports modeling and acceleration of new classes of alloys required for advanced power systems. • Refocuses materials development on high-temperature component parts needed for a directly fired-supercritical carbon dioxide fuel cycle. While the focus of this activity will shift in FY 2016, materials development for a sCO_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 sCO_2 fuel cycle will be used to support the Supercritical Transformational Electric Power	• Extreme Environment Materials development and testing will focus on technology development of advanced materials and component testing of high temperature materials for directly-heated sCO_2 and Advanced Ultra-Supercritical (AUSC) high steam environments. • Support for research on code certification of high temperature materials will focus on development of methods to understand the effects of processes to increase throughput to predictively scale-up materials from proof-of-concept laboratory discovery experiments through small-scale development processes. • Development of digital data repositories by material class that can be networked and are	• Increased funding supports materials development and testing of sCO_2 and AUSC materials and the development of a code certification process to accelerate the certification of extreme environment materials and informatics.

FY 2016 Enacted (Restructured Funding)	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
(STEP) pilot for which a solicitation is to be issued in FY 2016.	machine discoverable and accessible for algorithms to crawl the broad sets of data and identify unique trends or correlations.	
Sensors and Controls $4,500,000	**$4,750,000**	**+$250,000**
• Developing sensor technologies critical to the operation and optimization of advanced power systems. • Developing control systems for advanced power systems such as oxycombustion and chemical looping.	• Development of sensors focused on measurements in the high temperature, high pressure, and/or corrosive environments of a power system or underground injection system. • Continues R&D on transformational research in process control and optimization centered on self-organizing information networks and distributed intelligence. • Explores other novel concepts such as DPE and the application of additive manufacturing toward construction of complex components (e.g. turbine blades) with embedded sensing capability.	• Provides additional funding for testing technologies in relevant test environments to elevate technology readiness levels.
Water Management R&D $6,000,000	**$15,800,000**	**+$9,800,000**
• Research focuses on treatment of non-traditional water produced through CCS.	Funding will support: • Innovative multi-stage filtration technologies including membrane-based, evaporative, chemical, electrochemical and biological systems. • Demonstration of highly efficient heat exchangers and other transformational cooling systems. • Development of treatment technologies for water produced through CO_2 injection in deep saline aquifers, and field testing of these treatment technologies in coordination with the Brine Extraction Storage Test. • Continues support for the Water Energy track within U.S. China Clean Energy Research Center (CERC).	• Supports R&D to increase efficiency of heat exchangers and cooling systems to reduce the need for water for cooling in thermoelectric power plants. • Additionally, supports field testing of treatment of produced water resulting from CO_2 injection.

CCS and Advanced 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 2015 Annual Performance Report.

	FY 2015	FY 2016	FY 2017
Performance Goal (***Measure***)	***CCS Demonstrations — Initiate operation of CCS demonstration projects - Initiating operation of CCS demonstration projects will help to establish that carbon capture, compression of CO_2 and injection, combined with long term monitoring, verification, accounting, and assessment (MVAA), can be performed at commercial scale at both power plants and industrial sites while continuing to maintain reliable plant operations.***		
Target	One CCS project initiated	Three CCS projects initiated operation[1]	Four CCS projects initiated operation[1]
Result	Four projects initiated, one now operating[2]	Not Applicable	Not Applicable
Endpoint Target	Operations initiated at a minimum of four commercial CCS demonstrations by 2019, including the Clean Coal Power initiative (CCPI) and the Industrial CCS Demonstration projects (funded by both annual appropriations and the American Recovery and Reinvestment Act). Two of the four demonstrations to initiate operations by 2019 will be CCPI projects and two would be ICCS projects.[3]		
Performance Goal (***Measure***)	***Carbon Capture and Advanced Energy Systems — Achieving the target shows that the CCS and Advanced Power Systems program is continuing to make progress in meeting its goal of developing cost-effective, reliable CCS technologies for pre-combustion, post-combustion, natural gas carbon capture, and advanced combustion capture applications.***		
Target	\$51 per tonne CO_2 Captured	\$49 per tonne CO_2 Captured	\$47 per tonne CO_2 Captured
Result	\$50.90 per tonne CO_2 Captured	Not Applicable	Not Applicable
Endpoint Target	Advanced Energy Systems with CO_2 capture at no more than \$40 per tonne of CO_2 captured ready for demonstration by 2020 and less than \$40 per tonne of CO_2 captured ready for demonstration by 2030.		
Performance Goal (***Measure***))	***Carbon Storage — Inject CO_2 in large-volume field test sites to demonstrate the formations' capacity to permanently and safely store carbon dioxide.***		
Target	6 MMTs injected (since 2009)	7 MMTs injected (since 2009)	8 MMTs injected (since 2009)
Result	8.3 MMT	Not Applicable	Not Applicable

[1] Beginning in FY 2016 transition to measuring projects placed into operation to conform to Endpoint Target.
[2] Air Products and Chemicals Inc. project has been operational since December 2012 at an oil refinery hydrogen production facility capturing CO_2 for Enhanced Oil Recovery.
[3] Two CCPI demonstration projects initiating operation would be Kemper and Petra Nova and two ICCS projects would be Air Products and Chemicals Inc. and Archer Daniels Midland Co. (ADM).

Endpoint Target	Inject 9.0 million metric tons[4] of CO_2 between January 2009 and 2020 in large-volume field test sites representing different storage classes to demonstrate and monitor for the formations' capacity to permanently and safely store carbon dioxide. A long-term goal is to ensure the cost-effective ability to measure and account for the injected CO_2 to ensure 99 percent storage permanence in all storage types while minimizing the environmental footprint of carbon storage activities.

[4] This performance goal is measured based on activities carried out under the Carbon Storage subprogram; it does not include CO_2 injected through the CCS Demonstrations.

Fuel Supply Impact Mitigation (*formerly Natural Gas Technologies*)

Overview

The mission of the Fuel Supply Impact Mitigation program is to support DOE missions in energy, environment, and national security. The program is comprised of three subprograms: Environmentally Prudent Development, Emissions Mitigation and Quantification, and Gas Hydrates. Environmentally Prudent Development supports research efforts that address high-priority challenges to safe and prudent development of unconventional oil and gas resources. The Emissions Mitigation and Quantification subprogram develops technologies and communicates results to stakeholders to mitigate methane emissions from natural gas transmission, distribution, and storage facilities. This subprogram also conducts research to better quantify methane emissions across the natural gas value chain. Gas Hydrates supports research to evaluate the occurrence, nature, and behavior of naturally occurring gas hydrates and the resulting resource, hazard, and environmental implications.

Highlights of the FY 2017 Budget Request

The name of this program is being changed in order to reflect the FER&D-wide elimination of categorization of activities by fuel type. Fuel Supply Impact Mitigation, the new name, reflects the fact that this program is focused on addressing certain environmental impacts of fossil fuel supply and delivery. In addition, in FY 2017 the former Emissions Mitigation from Midstream Infrastructure and Emissions Quantification from Natural Gas Infrastructure subprograms are combined into a single Emissions Mitigation and Quantification subprogram to enable more effective program management and execution.

The Fuel Supply Impact Mitigation program will focus on continued implementation of priority research and development, as part of a multiagency effort with the Department of the Interior (DOI) and the Environmental Protection Agency (EPA), to ensure that unconventional oil and gas development is conducted in a manner that is environmentally sound and protective of human health and safety. In FY 2017, the Environmentally Prudent Development subprogram will continue research in water quality, water availability, air quality, induced seismicity, and mitigating the impacts of development (e.g. wellbore integrity) in collaboration with DOI and EPA.

The Emissions Mitigation and Quantification subprogram will continue research on natural gas infrastructure focused on reducing methane emissions from pipelines, storage facilities, and related equipment. Priority research areas include advanced composite materials, non-reactive coatings with embedded sensors, and pipeline inspection and repair.

The Emissions Mitigation and Quantification subprogram will also support emissions quantification research focused on updating and improving component-level emission factors and on better characterizing the regional variability of methane emissions across the natural gas value chain. The goal is to improve the quality and reliability of data that is being reported in the Greenhouse Gas Reporting System and the Greenhouse Gas Inventory, with an emphasis on understanding regional variation and reducing uncertainty in emissions estimates.

The Gas Hydrates subprogram, through public sector-led efforts, will continue to evaluate the occurrence, nature, and behavior of naturally occurring gas hydrates and the resulting resource, hazard, and environmental implications. In FY 2017, the program intends to conduct investigations, in consultation with the United States Geological Survey, to confirm the nature and regional context of gas hydrate deposits in the Gulf of Mexico, and the physical properties and characteristics of gas hydrate-bearing sediments.

FY 2017 Crosscuts ($K)

	Subsurface	Total
Environmentally Prudent Development	7,000	7,000

Within the FY 2017 Budget Request, the Environmentally Prudent Development subprogram supports one DOE Crosscut: Subsurface Technology and Engineering RD&D (Subsurface). The Environmentally Prudent Development subprogram will support the Subsurface crosscut by developing technology to address challenges in the subsurface through research in wellbore integrity, stress state and induced seismicity, permeability manipulation, and new subsurface signals to dramatically mitigate environmental impacts from energy-related activities and operations.

Fuel Supply Impact Mitigation
Funding ($K)

	FY 2015 Enacted	FY 2015 Current[1]	FY 2016 Enacted	FY 2017 Request	FY 2017 vs FY 2016
Fuel Supply Impact Mitigation					
Environmentally Prudent Development	10,121	9,807	11,200	13,000	+1,800
Emissions Mitigation and Quantification	0	0	12,000	11,000	-1,000
Gas Hydrates	15,000	14,534	19,800	2,500	-17,300
Total, Fuel Supply Impact Mitigation	**25,121**	**24,341**	**43,000**	**26,500**	**-16,500**

SBIR/STTR:

- FY 2015 Transferred: SBIR $685: STTR: $94
- FY 2016 Projected: SBIR $1,214: STTR: $182
- FY 2017 Request: SBIR $797: STTR: $113

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

Fuel Supply Impact Mitigation
Explanation of Major Changes ($K)

	FY 2017 vs FY 2016
Fuel Supply Impact Mitigation	**+1,800**
Environmentally Prudent Development: The increase in funding will support increased research in induced seismicity and wellbore integrity and will allow for continued research in water quality, water availability, air quality, and mitigating the impacts of development.	
Emissions Mitigation and Quantification: This subprogram budget line consolidates the Emissions Mitigation from Midstream Infrastructure and Emissions Quantification from Natural Gas Infrastructure subprogram budget lines. The small decrease in funding limits the scope of quantification efforts to key component-level emission factors.	**-1,000**
Gas Hydrates: The decrease in funding is due to the completion of the initial phase of the Gulf of Mexico field research and the conclusion of DOE support for collaborative agreements with other nations and the State of Alaska. The subprogram will continue to conduct resource characterization investigations to confirm the nature and regional context of gas hydrate deposits in the Gulf of Mexico. This will include analysis and modeling of data obtained through the initial phase.	**-17,300**
Total, Fuel Supply Impact Mitigation	**-16,500**

Fuel Supply Impact Mitigation

Description

Environmentally Prudent Development

The Environmentally Prudent Development subprogram will focus on the continued implementation of priority research and development, together with the EPA and DOI, to address high-priority challenges to safe and prudent development of unconventional oil and gas resources. This research and development is consistent with recommendations from the White House's "Blueprint for a Secure Energy Future" and the Secretary of Energy Advisory Board's recommendations.

The subprogram will ensure that the Federal government's understanding of risks associated with unconventional oil and 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.

The subprogram 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 and this research will be coordinated with the Departmental Subsurface Science, Technology and Engineering RD&D crosscut.

Emissions Mitigation and Quantification

This subprogram includes the former Emissions Mitigation from Midstream Infrastructure and the Emissions Quantification from Natural Gas Infrastructure subprograms.

Natural gas transmission, storage and distribution emissions represented 14 percent of total U.S. anthropogenic methane emissions and approximately 56 percent of Natural Gas System related methane emissions in 2013[2]. The Department is committed to developing advanced, cost-effective technologies to mitigate methane emissions from natural gas transmission, distribution, and storage facilities. This subprogram will continue efforts focused on reducing methane emissions from pipelines, storage facilities, and related equipment. Priority research areas include advanced composite materials, non-reactive coatings with embedded sensors, and pipeline inspection and repair.

This subprogram will also support emissions quantification research focused on updating and improving component-level emission factors and on better characterizing the regional variability of methane emissions across the natural gas value chain. The goal is to improve the quality and reliability of data that is being reported in the Greenhouse Gas Reporting System and the Greenhouse Gas Inventory, with an emphasis on understanding regional variation and reducing uncertainty in emissions estimates.

Gas Hydrates

The Gas Hydrates subprogram, through public sector-led efforts, will continue to evaluate the occurrence, nature, and behavior of naturally occurring gas hydrates and the resulting resource, hazard, and environmental implications. In FY 2017, the program intends to conduct investigations, in coordination with the U.S. Geological Survey, to confirm the nature and regional context of gas hydrate deposits in the Gulf of Mexico, and the physical properties and characteristics of gas hydrate-bearing sediments. Analysis of the data obtained from prior Gulf of Mexico field research will be conducted. This will build on limited knowledge that was gained from previous seismic analysis.

[2] 2014 US EPA Greenhouse Gas Inventory.

Activities and Explanation of Changes

FY 2016 Enacted (Restructured Funding)	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
Fuel Supply Impact Mitigation $43,000,000	**$26,500,000**	**-$16,500,000**
Environmentally Prudent Development $11,200,000	**$13,000,000**	**+$1,800,000**
• 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). • Assess and develop technology options for treatment and use of co-produced water from oil and gas wells.	• 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.	• The funding primarily allows for continued support for research in water quality, water availability, air quality, induced seismicity, and mitigating the impacts of shale gas development.
Emissions Mitigation and Quantification $12,000,000	**$11,000,000**	**-$1,000,000**
• Solicit and select projects that develop advanced, cost-effective technologies to detect and mitigate methane emissions from natural gas transmission, distribution, and storage facilities. • Communicate results on methane emissions mitigation to stakeholders. • Research projects focused on better quantifying methane emissions from the natural gas value chain.	• Continue mitigation efforts focused on reducing methane emissions from pipelines, storage facilities, and related equipment. • Priority research areas include advanced composite materials, non-reactive coatings with embedded sensors, and pipeline inspection and repair. • The emissions quantification research effort will update and improve component-level emission factors to improve the quality and reliability of data that is being reported in the Greenhouse Gas Reporting System and Greenhouse Gas Inventory.	• Limits the scope of quantification efforts to key component-level emission factors.
Gas Hydrates $19,800,000	**$2,500,000**	**-$17,300,000**
• Through the research project funded through the FY 2014 FOA, conduct field investigations in the Gulf of Mexico to confirm the nature and regional context of gas hydrate deposits, and the physical properties and characteristics of gas hydrate-bearing sediments. Collect and analyze pressurized and unpressurized core samples and perform	• Analysis, including numerical modeling of complex datasets obtained through resource characterization field work, will be conducted to extract key findings and to enhance capabilities to predict field scale response of hydrate formations to perturbations. • Gulf of Mexico resource characterization collaboration with Mexico could benefit resource assessments.	• The decrease in funding is due to the completion of the initial phase of the Gulf of Mexico field research and the conclusion of DOE support for collaborative agreements with other nations and the State of Alaska.

FY 2016 Enacted (Restructured Funding)	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
pressure perturbation experiments. Some work may be done in collaboration with Mexico, which will benefit their resource assessment and characterization plans. • All projects fully funded through the FY 2012 and FY 2013 FOAs will be completed in FY 2016. • Provide resource characterization support in Alaska by assessing the presence and nature of methane hydrates on the North Slope. • Issue a new Funding Opportunity Announcement focused on fundamental R&D including resource characterization and climate effects.		

Unconventional Fossil Energy Technologies from Petroleum – Oil Technologies

Overview

The mission of the Unconventional Fossil Energy Technologies from Petroleum – Oil Technologies program 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 2017 no funding is requested for the Unconventional Fossil Energy Technologies program. Although no funding was requested in FY 2016, $20.321 million was appropriated for oil and natural gas research in unconventional, offshore, and small producers. This funding also provided for the second phase of a study on crude oil by rail safety. The DOE R&D projects designed to address crude oil by rail safety issues will be supported with this funding. In FY 2017 Fossil Energy's efforts to address high priority challenges to safe and prudent development of unconventional oil and gas resources will continue under the Environmentally Prudent Development subprogram under the Fuel Supply Impact Mitigation (formerly Natural Gas Technologies) budget line.

Highlights of the FY 2017 Budget Request

No activity is requested for FY 2017.

Unconventional Fossil Energy Technologies
Funding ($K)

	FY 2015 Enacted	FY 2015 Current[1]	FY 2016 Enacted	FY 2017 Request	FY 2017 vs FY 2016
Unconventional Fossil Energy Technologies	4,500	4,360	20,321	0	-20,321

Unconventional Fossil Energy Technologies

Activities and Explanation of Changes

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
Unconventional Fossil Energy Technologies $20,321,000	**$0**	**-$20,321,000**
• 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 2017 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 Fuel Supply Impact Mitigation (formerly Natural Gas Technologies) budget line.	• In FY 2017, no funding is requested for the Unconventional Fossil Energy Technologies program.

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

NETL Research and Operations

Overview

The NETL Research and Operations program supports National Energy Technology Laboratory (NETL) research activities. The program is comprised of the following subprograms: (1) Research and Development (2) Site Operations (3) Program Oversight and (4) Feasibility of Recovering Rare Earth Elements (REE).

Research and Development funding supports salaries/benefits and travel for NETL staff directly associated with conducting both intramural and extramural research activities for Fossil Energy Research and Development (FER&D) programs. The Research and Development subprogram provides salaries and benefits for the staff of scientists, engineers, and technical project managers who perform R&D activities at NETL. The Site Operations subprogram includes funding for Federal employees and contractors who perform site operations at the laboratories. This includes funding for (1) building operations such as utility funding, janitorial support, trash, recycling, etc.; and (2) grounds maintenance including mowing, snow removal, etc. The Program Oversight subprogram includes funding for Federal employees and contractors performing research-enabling functions such as legal, finance, procurement, information technology, and human resources that are necessary for the performance of NETL activities. In contrast, funding for the conduct of activities performed by field offices (for example management of the lab, communications, procurement, and certain IT activities) is included in the Program Direction budget line in order to increase consistency with the manner in which other national laboratories are funded. The Feasibility of Recovering Rare Earth Elements subprogram was established by Congress to perform an assessment and analysis of the feasibility of economically recovering rare earth elements from coal and coal byproduct streams such as fly ash, coal refuse, coal refuse, and aqueous effluent.

Highlights of the FY 2017 Budget Request

The NETL Research and Operations program is new for FY 2017. This restructuring of NETL operational lines is proposed to better describe NETL's funding requirements, increase consistency with other national laboratories, and increase transparency in how funds are utilized, promoting enhanced visibility into cost drivers and more efficient resource allocation decisions.

This program includes a portion of the funds that were part of the former NETL Coal Research and Development program as well as some of the funding from the NETL portion of Program Direction. Included in the Budget Request is $3 million for workforce development initiatives to address risks inherent in NETL's workforce demographics. This $3 million includes $1 million to increase the number of federal researchers at NETL and reduce reliance on contractors in areas of enduring mission.

No funding is requested by FER&D for REE in FY 2017. This activity, funded by Congress in FYs 2014 through 2016, explores the feasibility of REE extraction from coal and coal byproducts. Activities will continue in FY 2017 through prior year appropriations but this activity is not a priority for 2017 funding.

NETL Research and Operations
Funding ($K)

	FY 2015 Enacted	FY 2015 Current	FY 2016 Enacted	FY 2017 Request	FY 2017 vs FY 2016
NETL Research and Operations					
Research and Development	47,827	47,827	52,688	52,668	-20
Site Operations	16,106	16,106	15,199	14,305	-894
Program Oversight	9,096	9,096	9,097	9,097	0
Rare Earth Elements	15,000	15,000	15,000	0	-15,000
Total, NETL Research and Operations	**88,029**	**88,029**	**91,984**	**76,070**	**-15,914**
Federal FTEs	**414**	**414**	**412**	**421**	**+9**

NETL Research and Operations
Explanation of Major Changes ($K)

	FY 2017 vs FY 2016
NETL Research and Operations: A decrease of $15,914,000 from the FY 2016 Enacted is primarily due to not requesting funding for research related to the Feasibility of Recovering Rare Earth Elements.	**-15,914**
Total, NETL Research and Operations	**-15,914**

NETL Research and Operations
Activities and Explanation of Changes

FY 2016 Enacted (Restructured Funding)	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
NETL Research and Operations $91,984,000	**$76,070,000**	**-$15,914,000**
Research and Development $52,688,000	**$52,668,000**	**-$20,000**
• Research and Development funding at NETL provides for internal and external research and development activities, including salaries/benefits and travel for researchers and program/project managers associated with the fossil programs. • Funding addresses demographic risks in NETL's workforce, enabling prudent recruitment and training in strategic competency areas. Specific components include: (1) a human capital technical competency evaluation; and (2) expansion of a consistent pipeline to increase Federal research including internship programs, career technical ladders, and diversity-focused recruiting.	• Research and Development funding at NETL will be used to provide for internal and external research and development activities, including salaries/benefits and travel for researchers and program/project managers associated with the fossil programs. • Funding will also continue to address demographic risks in NETL's workforce, enabling prudent recruitment and training in strategic competency areas. Specific components include: (1) expansion of a consistent pipeline to increase Federal research including internship programs, career technical ladders, and diversity-focused recruiting; and (2) professional development programs to strengthen skills, specialized training including advanced degree and post-doctorate programs, and leadership development.	• Minor decrease associated with slightly reduced-contractor support.

FY 2016 Enacted (Restructured Funding)	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
Site Operations $15,199,000	**$14,305,000**	**-$894,000**
• Site Operations funding at NETL is to support operating NETL's laboratories and research sites. Funding will provide for operations personnel along with support contractors for building operations including utilities, grounds maintenance, etc.	• Site Operations funding at NETL will be used to support operating NETL's laboratories and research sites. Funding will provide for operations personnel along with support contractors for building operations including utilities, grounds maintenance, etc.	• Decrease associated with slightly reduced contractor support.
Program Oversight $9,097,000	**$9,097,000**	**$0**
• Program oversight funding at NETL supports salaries/benefits for Federal employees performing research-enabling support functions necessary for the performance of NETL activities.	• Program oversight funding at NETL will be used for salaries/benefits for Federal employees performing research-enabling support functions necessary for the performance of NETL activities.	• No change
Rare Earth Elements $15,000,000	**$0**	**-$15,000,000**
• Supports geological and characterization activities needed for finding rare earth assays associated with coal and coal byproducts, which can support commercial U.S. domestic production. • Continued pilot scale technology development resultant from the FY 2015 Funding Opportunity Announcement. • Funds in-house research activities to explore the feasibility of viable production economics.	• No funding is requested in FY 2017.	• This activity was funded by Congress in FYs 2014-2016 to explore the feasibility of REE extraction from coal and coal byproducts. No funding is requested in FY 2017.

NETL Infrastructure

Overview

The NETL Infrastructure program supports the upkeep of a lab footprint valued at $600 million in three geographic locations -- Morgantown, WV; Pittsburgh, PA; and Albany, OR. These sites include 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. The requested funding will support infrastructure repairs and improvements for both laboratory/research facilities and site-wide/general purpose facilities. Priorities for funding are established: (1) to ensure compliance with life safety standards; (2) to maintain critical lab research infrastructure; (3) to further implement the lab consolidation plan for NETL's Albany site; (4) to comply with High Performance Sustainable Building goals, including Labs 21 compliance; and (5) to maintain critical site-wide Information Technology infrastructure. This budget line also includes costs for operating and maintaining research facilities and other site-wide facilities, such as support services and other related costs for building maintenance and information technology infrastructure.

The program is comprised of the following subprograms: (1) Laboratory Facilities (2) Site-wide Facilities (3) Safeguards and Security and (4) Environmental Restoration. Laboratory Facilities includes construction, modification and repair of new and existing laboratories and funding for the NETL High-Performance Computer, Joule. This subprogram also includes funding for an advanced visualization center that serves the Office of Fossil Energy's research and development needs by enabling and promoting collaboration with academia, other national laboratories, and industry. The Site-wide Facilities subprogram supports construction, modification and repair of new and existing general-purpose buildings and site-wide infrastructure. The Safeguards and Security subprogram provides funds to ensure protection of workers (physical and cyber), the public, the environment, facilities, and operations in performing the Fossil Energy (FER&D) mission of NETL. This subprogram supports actions and projects to ensure compliance with Environmental, Security, Safety & Health regulations and Orders, and to correct 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. The Environmental Restoration subprogram supports NETL's Resource Conservation and Recovery Act (RCRA) and Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) obligations at all NETL sites.

Highlights of the FY 2017 Budget Request

The NETL Infrastructure program is new for FY 2017. This restructuring of NETL operational lines is proposed to better describe NETL's funding requirements, increase consistency with other national laboratories, and increase transparency in how funds are utilized, promoting enhanced visibility into cost drivers and more efficient resource allocation decisions.

This budget line includes the former Supercomputer, and Plant & Capital Equipment programs as well as the vast majority of the former Environmental Restoration line. It also includes portions of the NETL Coal Research and Development and Program Direction budget lines. The funding that moved from NETL Coal Research and Development and Program Direction into this new NETL Infrastructure line is associated with contractor site support activity and materials associated with maintenance and infrastructure needs. The shifts between the new budget structure and the previous budget structure are shown in the crosswalk that is included in the Budget Structure Crosswalks section of the FER&D narrative.

The FY 2017 Budget Request includes an increase in funding of $29.1 million over FY 2016 Enacted. This increase funds: (1) site-wide upgrades to enhance safety and reliability of laboratory operations; (2) laboratory and site-wide funding to curb the increase in deferred maintenance; (3) the full cost of compliance with Federal and State regulations and DOE Orders; and (4) the purchase of new processors for a refresh of Fossil Energy's Joule high performance computer.

Site-wide upgrades, totaling $6.3 million, include $1.7 million for upgrading the primary electrical distribution system at the Morgantown, WV site, modernizing end of life equipment and eliminating electrical arc flash hazards. Transformer A and its associated switching are beyond service life and have recently experienced failures that impacted all facility operations. Spare parts are no longer available. These site-wide upgrades also include $3.6 million to replace the fire and potable water supply lines serving a portion of the NETL Pittsburgh, PA site. These water lines are approximately 50 years old and have required increased maintenance. Replacing these lines will reduce this maintenance burden. In addition, these lines are a single point of failure that could have a major impact on NETL operations should a failure occur. In addition, $1.0 million is for the demolition of the NETL Albany Building 2. NETL Albany Building 2 is a 13,563 square foot multi-story structure that

has no mission dependence and has not been occupied for 25 years. The building has degraded severely in the past several years, is access restricted for safety reasons, and is rapidly becoming a safety liability. In addition, in Site-wide Facilities, $900,000 is requested to avoid an increase in deferred maintenance.

In Laboratory Facilities an additional $1.2 million is included to avoid an increase in deferred maintenance.

Fully funding Environmental, Safety, Security & Health compliance costs requires an increase in funding of $4.3 million. In prior years, carryover funding was available to offset the shortfall in current year budget authority. This carryover funding now has been depleted. The full cost of compliance with Federal, State, DOE and other regulatory statutes is $12.9 million.

The FY 2017 Budget Request includes support for the Supercomputer, Joule. Joule is a unique and collaborative tool tailored for science and engineering calculations in support of FER&D research. It advances FER&D and NETL missions by creating complex model simulations for advanced energy technology development, such as combustion modeling, carbon capture physics, and geological dynamics of CO_2 injection. These types of simulations help overcome technical development barriers quickly, reliably, and cost-effectively. Joule's design balances computational requirements, efficiency, usability, and collaboration techniques to deliver a premier system to NETL and its partners. This crucial research asset is used by more than 50% of the research teams at NETL and has a utilization rate above 90%.

Joule was commissioned in FY 2012. Given the rapid advances in computing technology, high-performance computers 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 is designed to cover the cost of replacing all of the out-of-warranty high-speed processors. 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 from 0.5 pFLOPS to 5 pFLOPS, a 10-fold increase. While the increase in funding is significant, it allows NETL to obtain and maintain a world-class supercomputer capable of using the most advanced software to enable key energy research while also maintaining the equipment under warranty.

High performance computing has become an essential element of DOE's mission-relevant research, development, and demonstration (RD&D) portfolio. Demand for high performance computing to support effective RD&D at NETL is increasing, and will continue to increase in the coming years. In FY 2016 NETL is initiating several new simulation-intensive research projects, to include the Radically Engineered Modular Systems and the Carbon Capture Simulation Initiative, and in FY 2017, NETL is planning, in collaboration with its FE HQ counterparts, to begin laying a foundation targeted at putting NETL in a position to leverage exascale applications that will be available in the 2023 timeframe. These focus on multiphase flow simulation for carbon capture, risk management in geological carbon storage, and risk mitigation and improved efficiency of energy and water extraction. These efforts will all require the capability in the next-generation high performance computing facility in order to develop code suitable for exascale computing. Without a multi-PFLOPS resource at NETL, the exascale effort will be thrown off pace and critical research towards enabling sustainable fossil energy utilization will be slowed.

FY 2017 Crosscuts ($K)

	Cybersecurity	Total
NETL Infrastructure	4,872	4,872

Within the FY 2017 Budget Request, the NETL Infrastructure 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 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 2017 Budget Request for NETL Infrastructure, $4.872 million will be used to support these crosscutting cyber activities. Cybersecurity is funded under the Safeguards and Security subprogram.

NETL Infrastructure
Funding ($K)

	FY 2015 Enacted	FY 2015 Current	FY 2016 Enacted	FY 2017 Request	FY 2017 vs FY 2016
NETL Infrastructure Summary					
Laboratory Facilities					
Joule, High-Performance Computer	0	0	0	16,500	+16,500
Other Laboratory Facilities	16,147	16,147	17,196	18,389	+1,193
Total Laboratory Facilities	**16,147**	**16,147**	**17,196**	**34,889**	**+17,693**
Site-wide Facilities	**12,401**	**12,401**	**10,811**	**18,018**	**+7,207**
Safeguards & Security	**9,100**	**9,100**	**8,648**	**12,926**	**+4,278**
Environmental Restoration					
CERCLA	200	200	600	525	-75
RCRA	1,697	1,697	1,695	1,697	+2
Total Environmental Restoration	**1,897**	**1,897**	**2,295**	**2,222**	**-73**
Total, NETL Infrastructure	**39,545**	**39,545**	**38,950**	**68,055**	**+29,105**

NETL Infrastructure
Explanation of Major Changes ($K)

	FY 2017 vs FY 2016
NETL Infrastructure: An increase of $29,105,000 from the FY 2016 Enacted funding level is for infrastructure related items such as the demolition of Albany Building 2, replacing aging fire and potable water lines in Pittsburgh, upgrading the primary power distribution system in Morgantown, and ensuring no increase in deferred maintenance at each of NETL's sites. Additional funding will also ensure full compliance with all environmental, safety and health regulations at the Lab sites. Finally, the increased funding will provide for the replacement of FE's high-performance computer processors, resulting in a significant capacity upgrade and reduced maintenance costs.	**+29,105**
Total, NETL Infrastructure	**+29,105**

NETL Infrastructure

Activities and Explanation of Changes

FY 2016 Enacted (Restructured Funding)	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
TOTAL NETL Infrastructure $38,950,000	**$68,055,000**	**+29,105,000**
Laboratory Facilities $17,196,000	**$34,889,000**	**+17,693,000**
• Funding is to support the upkeep of the lab infrastructure. Priorities for funding are established to ensure compliance with life safety standards, to maintain critical lab infrastructure, to further implement the lab consolidation plan for Albany, and Labs 21 compliance.	• Funding will support the upkeep of the lab infrastructure. Priorities for funding are established to ensure compliance with life safety standards, to maintain critical lab infrastructure, to further implement the lab consolidation plan for Albany, and Labs 21 compliance. • Funding will provide for the replacement of the processing units in the high performance computer. This refresh will upgrade the processing speed to 5 pFLOPS, a 10-fold increase.	• Additional funding will provide for the replacement of the processing units in the high performance computer. This refresh will upgrade the processing speed to 5 pFLOPS, a 10-fold increase. • Additional funding will also be used to avoid an increase in deferred maintenance.

Site-wide Facilities $10,811,000	**$18,018,000**	**+7,207,000**
• Site-wide facilities funding at NETL is to support the upkeep of the multiple site footprints. Priorities for funding are established to ensure compliance with life safety standards, to maintain critical site-wide infrastructure, to further implementation of the footprint consolidation plan for NETL's Albany site, to comply with High Performance Sustainable Building goals, and to maintain critical IT infrastructure.	• Site-wide facilities funding at NETL will support the upkeep of the multiple site footprints. Priorities for funding are established to ensure compliance with life safety standards, to maintain critical site-wide infrastructure, to further implementation of the footprint consolidation plan for NETL's Albany site, to comply with High Performance Sustainable Building goals, and to maintain critical IT infrastructure.	• Additional funding will be utilized for site-wide upgrades to enhance safety and reliability of laboratory operations, including replacing aging fire and potable water lines, upgrading an electrical power distribution system, and demolition of Albany Building 2. • Funding will also be used to avoid an increase in deferred maintenance.
Safeguards & Security $8,648,000	**$12,926,000**	**+4,278,000**
• Safeguards & Security funding supports physical and information/cyber security along with health and safety activities. • Continue to implement and improve baseline regulatory compliance, integrated safety management, and ISO 14001 programs. Also, continue implementation of action in support of personnel, security, operational security, export/import controls, and the foreign national visitor and assignment programs.	• Safeguards & Security funding will support physical and information/cyber security along with health and safety activities. • Continue to implement and improve baseline regulatory compliance, integrated safety management, and ISO 14001 programs. Also, continue implementation of action in support of personnel, security, operational security, export/import controls, and the foreign national visitor and assignment programs.	• Additional funding will be used to fully fund health and safety requirements.
Environmental Restoration $2,295,000	**$2,222,000**	**-73,000**
• 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 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.	• Environmental Restoration funding at NETL will be used to fund regulatory requirements: CERCLA remedial activities include groundwater remediation at Rock Springs and a 10-year revegetation effort at Hoe Creek and RCRA remedial activities include asbestos and lead abatement activities; air pollution prevention and hazardous materials management and compliance activities as required by the State of Oregon related to groundwater contamination at the Albany site.	• Minor reduction resulting from a reduction in CERCLA requirements.

Plant and Capital Equipment
Capital Summary ($K)

	Total	Prior Years	FY 2015 Enacted	FY 2015 Current	FY 2016 Enacted	FY 2017 Request	FY 2017 vs FY 2016
Capital Operating Expenses Summary (including (Major Items of Equipment (MIE))							
Plant Projects (GPP and IGPP) (<$10M)	n/a	n/a	15,782	15,782	15,782	24,182	+8,400
Total, Capital Operating Expenses	**n/a**	**n/a**	**15,782**	**15,782**	**15,782**	**24,182**	**+8,400**
Plant Projects (GPP and IGPP) (Total Estimated Cost (TEC) <$10M)							
Total Plant Projects (GPP/IGPP) (Total Estimated Cost (TEC) <$5M)	n/a	n/a	15,782	15,782	15,782	24,182	+8,400
Total, Plant Projects (GPP/IGPP) (Total Estimated Cost (TEC) <$10M)	**n/a**	**n/a**	**15,782**	**15,782**	**15,782**	**24,182**	**+8,400**
Total, Capital Summary	**n/a**	**n/a**	**15,782**	**15,782**	**15,782**	**24,182**	**+8,400**

Program Direction

Overview

Program Direction provides for the Headquarters and NETL 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 guidance, contract administration, and budget formulation and execution duties.

The Headquarters staff is responsible for providing overall guidance, direction, and support for the program offices. NETL is responsible for developing project budgets, implementing financial assistance plans, and other programs and site support activities necessary to achieve their program objectives.

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 2017 Budget Request

Program Direction is part of the proposed Fossil Energy R&D restructuring. Program Direction funding for NETL continues to include functions such as legal, finance, procurement, information technology and human resources that are necessary for the performance of NETL activities. Program Direction funding no longer includes support for Federal employees performing research enabling functions. Fixed occupancy funding, such as building and laboratory repairs and information technology infrastructure, is included in the new NETL Infrastructure budget line. Operational costs such as grounds maintenance and utilities are included in the new NETL Research and Operations budget line.

There are no significant changes in scope of work or activities from FY 2016. Working Capital Fund (WCF) estimates for FY 2017 have increased over the FY 2016 estimates to fund the third year of OPM credit monitoring and projected inflation increases in existing WCF programs including corporate business systems, building occupancy, interagency transfers, and telecommunications. Fossil Energy R&D's share of this estimated increase is included in the Program Direction Budget Request. Also included is an increase to account for increased cost of background investigations.

Program Direction
Funding ($K)

	FY 2015 Enacted	FY 2015 Current	FY 2016 Enacted	FY 2017 Request	FY 2017 vs FY 2016
Program Direction Summary					
Washington Headquarters					
Salaries and Benefits	16,371	16,371	16,259	16,259	0
Travel	900	900	900	900	0
Support Services	85	85	66	66	0
Other Related Expenses	13,236	13,236	12,071	13,024	+953
Total, Washington Headquarters	**30,592**	**30,592**	**29,296**	**30,249**	**+953**
National Energy Technology Laboratory					
Salaries and Benefits	15,551	15,551	15,551	15,551	0
Travel	475	475	475	475	0
Support Services	10,460	10,460	9,030	9,030	0
Other Related Expenses	3,944	3,944	3,680	3,680	0
Total, National Energy Technology Laboratory	**30,430**	**30,430**	**28,736**	**28,736**	**0**
Import/ Export Authorization					
Salaries and Benefits	1,437	1,437	1,367	1,367	0
Travel	22	22	20	20	0
Support Services	0	0	0	0	0
Other Related Expenses	624	624	626	626	0
Total, Import/Export Authorization	**2,083**	**2,083**	**2,013**	**2,013**	**0**
Total Program Direction					
Salaries and Benefits	33,359	33,359	33,177	33,177	0
Travel	1,397	1,397	1,395	1,395	0
Support Services	10,545	10,545	9,096	9,096	0
Other Related Expenses	17,804	17,804	16,377	17,330	+953
Total, Program Direction	**63,105**	**63,105**	**60,045**	**60,998**	**+953**
Federal FTEs[1]	**237**	**237**	**237**	**237**	**0**

[1] Additional FTEs are funded within the NETL Research and Operations budget line.

	FY 2015 Enacted	FY 2015 Current	FY 2016 Enacted	FY 2017 Request	FY 2017 vs FY 2016
Support Services					
Technical Support					
Headquarters	85	85	66	66	0
NETL	0	0	0	0	0
Total, Technical Support	85	85	66	66	0
Management Support					
Headquarters	0	0	0	0	0
NETL	10,460	10,460	9,030	9,030	0
Total Management Support	10,460	10,460	9,030	9,030	0
Total, Support Services	**10,545**	**10,545**	**9,096**	**9,096**	**0**
Other Related Expenses					
Headquarters	13,236	13,236	12,071	13,024	+953
NETL	3,944	3,944	3,680	3,680	0
Import / Export Authorization	624	624	626	626	0
Total, Other Related Expenses	**17,804**	**17,804**	**16,377**	**17,330**	**+953**

Program Direction

Activities and Explanation of Changes

FY 2016 Enacted (Restructured Funding)	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
Program Direction $60,045,000	**$60,998,000**	**+$953,000**
Salaries and Benefits $33,177,000	**$33,177,000**	**No change**
The funding supports HQ Federal staff who provide 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 HQ 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.	No change
The funding supports the Federal staff at the National Energy Technology Laboratory who are performing traditional field office functions. The staff covered in this area provide for management of the Lab; communications and certain legal, Information Technology, financial assistance and finance activities. Federal staff performing similar activities for the research functions of the National Energy Technology Laboratory are funded in NETL Research and Operations in the Program Oversight subprogram.	The funding will support the Federal staff at the National Energy Technology Laboratory who are performing traditional field office functions. The staff covered in this area provide for management of the Lab; communications and certain legal, Information Technology, financial assistance and finance activities. Federal staff performing similar activities for the research functions of the National Energy Technology Laboratory are funded in NETL Research and Operations in the Program Oversight subprogram.	No change
Travel $1,395,000	**$1,395,000**	**No change**
Travel includes funding for trips for management meetings, training, etc. Instituted travel reduction to comply with the OMB directive for reduced travel from FY 2010 levels.	Travel will include funding for trips for management meetings, training, etc. Instituted travel reduction to comply with the OMB directive for reduced travel from FY 2010 levels.	No change.

FY 2016 Enacted (Restructured Funding)	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
Support Services $9,096,000	**$9,096,000**	**No change**
Support Services at Headquarters includes technical support, IT support, site operations support, administrative support, and grounds and maintenance support.	Support Services at Headquarters includes; technical support, IT support, site operations support, administrative support, and grounds and maintenance support.	No change.
Support services at NETL include IT and administrative support.	Support services at NETL will include IT and administrative support.	No change.
Other Related Expenses $16,377,000	**$17,330,000**	**+$953,000**
The activities supported by this line item include E-Government initiatives, Working Capital fund, computer systems and support, contractual services for HQ and environmental, security, safety, and health requirements at HQ.	The activities supported by this line item include E-Government initiatives, Working Capital fund, computer systems and support, contractual services for HQ and environmental, security, safety, and health requirements at HQ.	The funding change is primarily due to an increase in the amount of funds required to contribute to the Working Capital Fund and an increase for background investigations.
The activities supported by this line item include staff replenishment and development related activities, as well as general materials and supplies.	The activities supported by this line item will include staff replenishment and development related activities, as well as general materials and supplies.	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 2015 Actual Cost	FY 2015 Planned Cost	FY 2016 Planned Cost	FY 2017 Planned Cost
National Energy Technology Laboratory	15,831	13,539	13,945	14,363
Total, Direct-Funded Maintenance and Repair	**15,831**	**13,539**	**13,945**	**14,363**

Report on FY 2015 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 2015 to the amount planned for FY 2015, including Congressionally directed changes.

Total Costs for Maintenance and Repair ($K)

	FY 2015 Actual Cost	FY 2015 Planned Cost
National Energy Technology Laboratory	15,831	13,539
Total, Direct-Funded Maintenance and Repair	**15,831**	**13,539**

In review of the planned vs actual costs for FY 2015, National Energy Technology Laboratory utilized the additional $2,292K 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)[1]

	FY 2015 Enacted	FY 2015 Current[2]	FY 2016 Enacted	FY 2017 Request[3]	FY 2017 vs FY 2016
Basic	5,355	5,239	6,057	5,494	-563
Applied	198,143	193,858	224,113	203,290	-20,823
Development	332,024	324,844	375,540	340,649	-34,891
Subtotal, R&D	**535,522**	**523,941**	**605,710**	**549,433**	**-56,277**
Equipment	15,782	15,782	15,782	40,682	+24,900
Construction	0	0	0	0	0
Total, R&D	**551,304**	**539,723**	**621,492**	**590,115**	**-31,377**

[1] R&D reporting includes a proportional share of program direction (minus import/export), NETL Research and Operations, and NETL Infrastructure (minus CERCLA and RCRA). Plant and Capital Equipment and Supercomputer are counted as Equipment. This funding was not included in the R&D reporting in the FY 2016 and prior year budget justifications. This change is being made to better align with international standards on reporting funding for R&D. Since these activities are necessary in order for R&D to be performed, they are now included in the conduct of R&D.

[2] Funding reflects the SBIR/STTR amounts transferred to the Office of Science

[3] FY 2017 funding differs from the totals in the Budget. Totals in the Budget are based on $360 million in new Budget Authority. These estimates include $240 million in use of prior year balances, for a total program level of $600 million.

Fossil Energy Research and Development
Small Business Innovation Research/Small Business Technology Transfer (SBIR/STTR) ($K)

	FY 2015 Current/ Transferred	FY 2016 Enacted/ Projected Transfer	FY 2017 Request/ Projected Transfer	FY 2017 vs FY 2016
CCS and Advanced Power Systems (formerly Coal/CCS and Power Systems)				
SBIR	9,476	10,481	10,576	+95
STTR	1,307	1,571	1,486	-85
Fuel Supply Impact Mitigation (formerly Natural Gas Technologies)				
SBIR	685	1,214	797	-417
STTR	94	182	113	-69
Unconventional Fossil Energy Technologies				
SBIR	123	573	0	-573
STTR	17	86	0	-86
Total, SBIR/STTR	**11,702**	**14,107**	**12,972**	**-1,135**

Fossil Energy Research and Development[1]
Safeguards and Security ($K)

	FY 2015 Enacted	FY 2015 Current	FY 2016 Enacted	FY 2017 Request	FY 2017 vs FY 2016
Protective Forces	3,592	3,592	3,666	3,745	+79
Physical Security Systems	204	204	257	311	+54
Information Security	52	52	54	56	+2
Cyber Security	1,335	1,335	1,750	4,872	+3,122
Personnel Security	154	154	173	207	+34
Material Control and Accountability	660	660	680	700	+20
Program Management	213	213	220	226	+6
Security Investigations	0	0	0	0	0
Transportation Security	0	0	0	0	0
Research and Development	2,890	2,890	1,848	2,809	+961
Construction	0	0	0	0	0
Total, Safeguards and Security	**9,100**	**9,100**	**8,648**	**12,926**	**+4,278**

[1] In conjunction with its budget restructuring, NETL reviewed and revised its procedures for identifying costs for inclusion in the Safeguards and Security category. The result was a more holistic, comprehensive accumulation of costs than had previously been reported. FY 2015 Enacted increased from the level previously reported due to the inclusion of items such as shared site security costs incurred by NETL as a result of an interagency agreement and costs for administering the DOE Unclassified Foreign National program.

Department Of Energy

FY 2017 Congressional Budget

Funding By Appropriation By Site

($K)

Fossil Energy Research and Development	FY 2015 Current	FY 2016 Enacted	FY 2017 Request
Ames Laboratory			
CCS and Power Systems			
Cross Cutting Reasearch	925	1,255	0
CCS and Advanced Power Systems			
Advanced Energy Systems	0	0	500
Crosscutting Research and Analysis	0	0	750
Total, CCS and Advanced Power Systems	**0**	**0**	**1,250**
Total, Ames Laboratory	**925**	**1,255**	**1,250**
Argonne National Laboratory			
CCS and Advanced Power Systems			
Advanced Energy Systems	0	0	300
Total, Argonne National Laboratory	**0**	**0**	**300**
Idaho National Laboratory			
CCS and Advanced Power Systems			
Carbon Storage	0	0	386
Crosscutting Research and Analysis	0	0	125
Total, CCS and Advanced Power Systems	**0**	**0**	**511**
Total, Idaho National Laboratory	**0**	**0**	**511**
Lawrence Berkeley National Laboratory			
CCS and Power Systems			
Carbon Capture	0	500	0
Carbon Storage	1,354	1,295	0
Cross Cutting Reasearch	3,025	3,094	0
Total, CCS and Power Systems	**4,379**	**4,889**	**0**
Natural Gas Technologies			
Natural Gas Technologies	857	1,050	0
Fuel Supply Impact Mitigation			
Fuel Supply Impact Mitigation	0	0	850
CCS and Advanced Power Systems			
Carbon Storage	0	0	899
Total, Lawrence Berkeley National Laboratory	**5,236**	**5,939**	**1,749**
Lawrence Livermore National Laboratory			
CCS and Power Systems			
Cross Cutting Reasearch	3,025	1,350	0
CCS and Advanced Power Systems			
Carbon Capture	0	0	1,483
Total, Lawrence Livermore National Laboratory	**3,025**	**1,350**	**1,483**

Department Of Energy

FY 2017 Congressional Budget

Funding By Appropriation By Site

($K)

Fossil Energy Research and Development	FY 2015 Current	FY 2016 Enacted	FY 2017 Request
Los Alamos National Laboratory			
CCS and Power Systems			
Carbon Capture	686	0	0
Carbon Storage	953	1,163	0
Cross Cutting Reasearch	3,025	750	0
Total, CCS and Power Systems	**4,664**	**1,913**	**0**
Natural Gas Technologies			
Natural Gas Technologies	600	0	0
CCS and Advanced Power Systems			
Carbon Storage	0	0	1,162
Total, Los Alamos National Laboratory	**5,264**	**1,913**	**1,162**
National Energy Technology Lab			
CCS and Power Systems			
Carbon Capture	83,317	99,537	0
Carbon Storage	89,619	102,150	0
Advanced Energy Systems	98,228	104,000	0
Cross Cutting Reasearch	29,589	36,051	0
STEP (Supercritical CO2)	9,690	15,000	0
NETL Coal R&D	50,000	53,000	0
Total, CCS and Power Systems	**360,443**	**409,738**	**0**
Natural Gas Technologies			
Natural Gas Technologies	20,707	38,835	0
Fuel Supply Impact Mitigation			
Fuel Supply Impact Mitigation	0	0	23,254
Program Direction			
National Energy Technology Center Program Direction	87,504	83,893	28,736
Fossil Energy Environmental Restoration			
Fossil Energy Environmental Restoration	4,477	6,575	0
Unconventional Fossil Energy Technologies			
Unconventional Fossil Energy Technologies	3,268	16,721	0
NETL Research and Operations			
NETL Research and Operations	0	0	76,070
NETL Infrastructure			
NETL Infrastructure	0	0	68,055
CCS and Advanced Power Systems			
Carbon Capture	0	0	160,528
Carbon Storage	0	0	87,108
Advanced Energy Systems	0	0	45,241
Crosscutting Research and Analysis	0	0	40,698
Total, CCS and Advanced Power Systems	**0**	**0**	**333,575**
Total, National Energy Technology Lab	**476,399**	**555,762**	**529,690**

Department Of Energy

FY 2017 Congressional Budget

Funding By Appropriation By Site

($K)

Fossil Energy Research and Development	FY 2015 Current	FY 2016 Enacted	FY 2017 Request
Oak Ridge National Laboratory			
CCS and Power Systems			
Advanced Energy Systems	1,575	1,000	0
Cross Cutting Reasearch	1,800	1,805	0
Total, CCS and Power Systems	**3,375**	**2,805**	**0**
CCS and Advanced Power Systems			
Advanced Energy Systems	0	0	300
Crosscutting Research and Analysis	0	0	2,060
Total, CCS and Advanced Power Systems	**0**	**0**	**2,360**
Total, Oak Ridge National Laboratory	**3,375**	**2,805**	**2,360**
Pacific Northwest National Laboratory			
CCS and Power Systems			
Carbon Capture	1,266	963	0
Cross Cutting Reasearch	3,325	975	0
Total, CCS and Power Systems	**4,591**	**1,938**	**0**
Natural Gas Technologies			
Natural Gas Technologies	50	50	0
CCS and Advanced Power Systems			
Advanced Energy Systems	0	0	1,000
Total, Pacific Northwest National Laboratory	**4,641**	**1,988**	**1,000**
Sandia National Laboratories			
CCS and Power Systems			
Carbon Storage	184	270	0
Cross Cutting Reasearch	300	60	0
Total, CCS and Power Systems	**484**	**330**	**0**
Natural Gas Technologies			
Natural Gas Technologies	250	0	0
Unconventional Fossil Energy Technologies			
Unconventional Fossil Energy Technologies	800	2,700	0
CCS and Advanced Power Systems			
Carbon Storage	0	0	206
Total, Sandia National Laboratories	**1,534**	**3,030**	**206**

Department Of Energy

FY 2017 Congressional Budget

Funding By Appropriation By Site

($K)

Fossil Energy Research and Development	FY 2015 Current	FY 2016 Enacted	FY 2017 Request
Washington Headquarters			
CCS and Power Systems			
Carbon Storage	4,786	1,122	0
Cross Cutting Reasearch	2,546	4,660	0
Total, CCS and Power Systems	**7,332**	**5,782**	**0**
Natural Gas Technologies			
Natural Gas Technologies	1,877	3,065	0
Fuel Supply Impact Mitigation			
Fuel Supply Impact Mitigation	0	0	2,396
Program Direction			
Headquarters Program Direction	31,496	30,309	32,262
Fossil Energy Environmental Restoration			
Fossil Energy Environmental Restoration	1,420	1,420	0
Plant & Capital Equipment			
Plant & Capital Equipment	15,782	15,782	0
Special Recruitment Programs			
Special Recruitment Programs	700	700	0
Unconventional Fossil Energy Technologies			
Unconventional Fossil Energy Technologies	292	900	0
CCS and Advanced Power Systems			
Carbon Capture	0	0	8,341
Carbon Storage	0	0	1,114
Advanced Energy Systems	0	0	459
Crosscutting Research and Analysis	0	0	15,717
Total, CCS and Advanced Power Systems	**0**	**0**	**25,631**
Total, Washington Headquarters	**58,899**	**57,958**	**60,289**
Total, Fossil Energy Research and Development	**559,298**	**632,000**	**600,000**

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, [$17,500,000] *$14,950,000* 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. Post-sale activities continue in support of NPR-3 landfill remediation and closure.

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 2015 Enacted	FY 2015 Current[1]	FY 2016 Enacted	FY 2017 Request
19,950	20,640	17,500	14,950

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 operated Naval Petroleum Reserve 3 (NPR-3) and the Rocky Mountain Oilfield Testing Center (RMOTC), co-located near Casper, Wyoming. The implementation plan for selling the facility and closing out the office has been completed. DOE retains responsibility for Landfill IND-2 located at NPR-3 until a closure permit is issued by the Wyoming Department of Environmental Quality (WDEQ). DOE will oversee completion of remediation activities in FY 2017. Following remediation, ground water sampling will begin in compliance with Wyoming Department of Environmental Quality (WDEQ) requirements. The period of sampling will be specified by WDEQ following remediation. Ground water monitoring is expected to continue for five to eight years.

Highlights and Major Changes in the FY 2017 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 to obtain a status of No Further Action (NFA) required for 131 Areas of Concern (AOCs). Also included is the payment to former M&O contractor employees for post-employment medical and dental benefits.

NPR-3 will continue remediation activities for closure of the landfill with oversight by the Washington Headquarters office.

FY 2015 Key Accomplishments

NPR-1

- Investigated 63 AOCs with 840 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 of the reports include use of 1998 set-aside lands, re-vegetation plan and monitoring, and training by an on-site biologist during field activities.
- Closed out five additional AOCs, bringing total number of AOCs with NFA status to 22.
- Completed 13 work plans to investigate 17 AOCs.
- Completed California Environmental Quality Act (CEQA)/NEPA documentation for removal action.
- Removed and disposed of lead- and aresenic-contaminated soil from five AOCs.

NPR-3

- Completed transfer of NPR-3 to private industry January 30, 2015 for a sale price of $45.2 million.
- Completed disposal of personal property yielding approximately $5 million in proceeds. Some of these proceeds were obtained through the exchange sale process and are available, under certain criteria, for use at NPR-3 though FY 2016.

[1] Includes new budget authority and $690k in proceeds from the NPR-3 asset sale of personal property. These proceeds are available during FY 2015 and FY 2016 for the purchase or lease of replacement property. Any unused proceeds will be returned to the Treasury as miscellaneous receipts.

Naval Petroleum and Oil Shale Reserves
Funding by Congressional Control ($K)

	FY 2015 Enacted	FY 2015 Current	FY 2016 Enacted	FY 2017 Request	FY 2017 vs FY 2016 Request
Naval Petroleum and Oil Shale Reserves					
Production Operations	13,271	13,961	13,330	12,630	-700
Management	6,679	6,679	4,170	2,320	-1,850
Total, Naval Petroleum and Oil Shale Reserves	**19,950**	**20,640**	**17,500**	**14,950**	**-2,550**
Federal FTEs	**10**	**10**	**8**	**4**	**-4**

Production Operations

Overview

The NPR-1 program continues to close out the remaining environmental restoration and remediation activities for 131 AOCs, as required by the 2008 agreement between DOE and California's DTSC. DOE will continue the oversight of environmental remediation of the Elk Hills site and the work on records disposition.

The NPR-3 program will continue post-sale remediation activities for the closure of the landfill.

Highlights of the FY 2017 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. To this end, the ongoing field work investigation, initiated in FY 2014, indicated the presence of contaminated surface and sub-surface soil at 18 sumps and four former above-ground oil storage tanks. The FY 2017 request includes the following response to those findings: Remedial Action Work plans will be developed for ten sumps that exceed safe life and human health levels for consolidation and clean closure; contaminated soils from eight sumps will be dug, hauled, and consolidated as part of the clean closure process; the consolidated/contaminated soil will be disposed of in accordance with state and federal regulations; and, contaminated soil located at four former above-ground oil storage tanks will be remediated.

Environmental remediation work will continue for NPR-3 landfill mitigation per WDEQ requirements. DOE will oversee completion of remediation activities in FY 2017. Following remediation, ground water sampling will begin in compliance with WDEQ requirements. The period of sampling will be specified by WDEQ following remediation. Ground water monitoring is expected to continue for five to eight years. The final closure is dependent upon reaching agreement with the WDEQ regulatory requirements.

Production Operations
Funding ($K)

	FY 2015 Enacted	FY 2015 Current[2]	FY 2016 Enacted	FY 2017 Request	FY 2017 vs FY 2016
Production Operations					
NPR-1 Closeout	8,680	8,680	12,330	12,580	+250
NPR-3 Disposition	4,591	5,251	1,000	50	-950
Total, Production Operations	**13,271**	**13,961**	**13,330**	**12,630**	**-700**

[2] This includes $690K in asset sales that can be used for the lease or replacement personal property at NPR-3.

Production Operations
Explanation of Major Changes ($K)

	FY 2017 vs FY 2016
NPR-1 Closeout: The increase provides for some 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).	**+250**
NPR-3 Disposition: The decrease is due to the sale of NPR-3 and the completion of remediation of Landfill IND-2. Post-remediation ground water sampling will begin in compliance with WDEQ requirements.	**-950**
Total, Production Operations	**-700**

Activities and Explanation of Changes

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
Production and Operations $13,330,000	**$12,630,000**	**-$700,000**
NPR-1 Closeout $12,330,000	**$12,580,000**	**+$250,000**
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.	NPR-1 will continue the ongoing activities to attain release from the remaining environmental findings related to the sale of NPR-1 Elk Hills. Remedial Action Work plans will be developed for ten additional sumps that exceed safe life and human health levels for consolidation and clean closure. Contaminated soils from eight sumps will be dug, hauled, and consolidated as part of the clean closure process. The consolidated/contaminated soil will be disposed of in accordance with state and federal regulations. Contaminated soil located at four former above-ground oil storage tanks will be remediated.	Increased funding provides for some 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. The FY 2017 request will fund work on Remedial Action Work plans for ten sumps; contaminated soils from eight sumps will be disposed of in accordance with state and federal regulations; and, contaminated soil located at four former above-ground oil storage tanks will be remediated.
NPR-3 Disposition $1,000,000	**$50,000**	**-$950,000**
Completion of Phase III of the NPR-3 Disposition.	Completion of environmental remediation and beginning post-remediation monitoring activities required for closure of landfill.	Disposition completed; post-sale remediation monitoring activities for the landfill are ongoing.

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 2017 Budget Request

The NPR-1 Elk Hills funding supports Federal staff that provide oversight and monitor environmental clean-up 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 final office closeout was completed December 30, 2015; however, administrative oversight of the landfill closure will continue to be conducted by the Department of Energy Headquarters office.

Management
Funding ($K)

	FY 2015 Enacted	FY 2015 Current	FY 2016 Enacted	FY 2017 Request	FY 2017 vs FY 2016
Program Direction Summary					
Washington Headquarters					
Salaries and Benefits	525	525	525	525	0
Travel	50	50	50	50	0
Support Services	450	450	450	450	0
Other Related Expenses	1,045	1,045	1,045	1,045	0
Total, Washington Headquarters	**2,070**	**2,070**	**2,070**	**2,070**	**0**
NPR – Wyoming					
Salaries and Benefits	1,350	1,350	860	0	-860
Travel	70	70	35	10	-25
Support Services	2,634	2,634	905	75	-830
Other Related Expenses	555	555	300	165	-135
Total, NPR – Wyoming	**4,609**	**4,609**	**2,100**	**250**	**-1,850**
Total Program Direction					
Salaries and Benefits	1,875	1,875	1,385	525	-860
Travel	120	120	85	60	-25
Support Services	3,084	3,084	1,355	525	-830
Other Related Expenses	1,600	1,600	1,345	1,210	-135
Total, Program Direction	**6,679**	**6,679**	**4,170**	**2,320**	**-1,850**
Federal FTEs	**10**	**10**	**8**	**4**	**-4**

	FY 2015 Enacted	FY 2015 Current	FY 2016 Enacted	FY 2017 Request	FY 2017 vs FY 2016
Support Services and Other Related Expenses					
Support Services					
Technical Support					
Environmental, Safety, Security & Health	505	505	270	0	-270
Technical Services	1,450	1,450	450	450	0
Total, Technical Support	**1,955**	**1,955**	**720**	**450**	**-270**
Management Support					
Business Administration	704	704	360	75	-285
IT Support	425	425	275	0	-275
Total Management Support	**1,129**	**1,129**	**635**	**75**	**-560**
Total, Support Services	**3,084**	**3,084**	**1,355**	**525**	**-830**
Other Related Expenses					
Rent to Others	210	210	115	0	-115
Communications, Utilities & Misc.	170	170	90	0	-90
Other Services	1,185	1,185	1,120	1,210	+90
Operation and Maintenance of Equipment	10	10	5	0	-5
Supplies and Materials	25	25	15	0	-15
Total, Other Related Expenses	**1,600**	**1,600**	**1,345**	**1,210**	**-135**

Management

Activities and Explanation of Changes

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
Management $4,170,000	**$2,320,000**	**-$1,850,000**
Salaries and Benefits $1,385,000	**$525,000**	**-$860,000**
Continue monitoring (cultural resources mitigation, environmental clean-up, oversight and audit) activities at NPR 1 and NPR 3.	Continue monitoring (cultural resources mitigation, environmental clean-up, oversight and audit) activities at NPR 1 and NPR 3.	Reduction of salaries due to closure of NPR-3 office.
Travel $85,000	**$60,000**	**-$25,000**
Federal travel remains at prior reduced levels and will be available to accomplish disposition process and environmental cleanup.	Federal travel will be required for environmental cleanup at both sites.	Reduced travel activities due to closure of NPR-3.
Support Services $1,355,000	**$525,000**	**-$830,000**
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.	Support Services for environmental clean-up of NPR-1 and ongoing monitoring of NPR-3.	Reduction of services due to closure of NPR-3.
Other Related Expenses $1,345,000	**$1,210,000**	**-$135,000**
Funding provides for communication services, materials and supplies, services; lease of Casper office and NPR Headquarters other expenses. Office lease expired December 2015.	Funding provides for NPR Headquarters administrative services for NPR-3 and for post-employment medical and dental benefits for former M&O contractor employees at NPR 1.	Reduction of expenses due to closure of NPR-3.

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. 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 2015 Actual Cost	FY 2015 Planned Cost	FY 2016 Planned Cost	FY 2017 Planned Cost
Naval Petroleum and Oil Shale Reserves, NPR-3	490	490	0	0
Total, Direct-Funded Maintenance and Repair	490	490	0	0

Naval Petroleum and Oil Shale Reserves
Safeguards and Security ($K)

	FY 2015 Enacted	FY 2015 Current	FY 2016 Enacted	FY 2017 Request	FY 2017 vs FY 2016
Protective Forces	0	0	0	0	0
Physical Security Systems	4	4	0	0	0
Information Security	26	26	0	0	0
Cyber Security	0	0	0	0	0
Personnel Security	0	0	0	0	0
Material Control and Accountability	0	0	0	0	0
Program Management	57	57	0	0	0
Program Direction	0	0	0	0	0
Security Investigations	0	0	0	0	0
Transportation Security	0	0	0	0	0
Construction	0	0	0	0	0
Total, Safeguards and Security	**87**	**87**	**0**	**0**	**0**

Naval Petroleum and Oil Shale Reserves
Safeguards and Security ($K)

	FY 2015 Enacted	FY 2015 Current	FY 2016 Enacted	FY 2017 Request	FY 2017 vs FY 2016
Protective Forces	0	0	0	0	0
Physical Security Systems	4	4	4	0	-4
Information Security	26	26	26	0	-26
Cyber Security	0	0	0	0	0
Personnel Security	0	0	0	0	0
Material Control and Accountability	0	0	0	0	0
Program Management	57	57	57	0	-57
Security Investigations	0	0	0	0	0
Transportation Security	0	0	0	0	0
Construction	0	0	0	0	0
Total, Safeguards and Security	**87**	**87**	**87**	**0**	**-87**

Department Of Energy

FY 2017 Congressional Budget

Funding By Appropriation By Site

($K)

Naval Petroleum and Oil Shale Reserves	FY 2015 Current	FY 2016 Enacted	FY 2017 Request
Naval Petroleum Reserve No 1			
Naval Petroleum and Oil Shale Reserves			
Productions Operations	8,680	12,330	12,580
Management	1,000	1,000	1,000
Total, Naval Petroleum and Oil Shale Reserves	**9,680**	**13,330**	**13,580**
Total, Naval Petroleum Reserve No 1	**9,680**	**13,330**	**13,580**
Naval Petroleum Reserve No 3			
Naval Petroleum and Oil Shale Reserves			
Productions Operations	5,281	1,000	50
Management	4,609	2,100	250
Total, Naval Petroleum and Oil Shale Reserves	**9,890**	**3,100**	**300**
Total, Naval Petroleum Reserve No 3	**9,890**	**3,100**	**300**
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	**20,640**	**17,500**	**14,950**

Strategic Petroleum Reserve

Strategic Petroleum Reserve

Strategic Petroleum Reserve
Proposed Appropriation Language

For Department of Energy expenses necessary 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.), [$212,000,000] *$257,000,000*, to remain available until expended. *(Energy and Water Development and Related Agencies Appropriations Act, 2016.)*

Explanation of Changes

Increase reflects addition of corrosion control tasks, Major Maintenance Projects, preventive/corrective maintenance activities, replacement of communication and information technology hardware and software necessary to assure storage integrity and drawdown readiness at SPR's underground storage caverns.

Public Law Authorizations
Public Law 109-58, "Energy Policy Act of 2005"

Strategic Petroleum Reserve

($K)

FY 2015 Enacted	FY 2015 Current	FY 2016 Enacted	FY 2017 Request
200,000	200,000	212,000	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).

The SPR is now entering the fifth decade since its inception in 1976. SPR currently maintains 695 million barrels of crude oil, with a capacity to maintain 714 million barrels in 60 caverns located in four sites. The reduction in design capacity is due to two caverns being removed from service due to operational issues. The most recent acquisition of light, sweet crude oil followed the Test Sale that concluded on June 16, 2014. Section 161(g) of the Energy Policy and Conservation Act of 1975 requires acquisition of petroleum products within the 12-month period after completion of a test sale. The Secretary of Energy signed the authorization to acquire crude oil using test sale proceeds on March 13, 2015. A total of 4,194,296 barrels were acquired and deliveries concluded on July 16, 2015.

The FY 2017 Budget Request continues to address deferred maintenance as well as the operational activities required to assure SPR capabilities are maintained.

The Bipartisan Budget Act of 2015 requires the Department to submit to Congress a Strategic Review of the SPR by May, 2016. The Act also authorized DOE, subject to appropriation, to sell up to $2 billion in SPR oil to fund SPR infrastructure modernization. The results of the SPR Strategic Review will inform SPR infrastructure modernization and shall result in an FY 2017 budget amendment related to SPR modernization.

Highlights and Major Changes in the FY 2017 Budget Request

This FY 2017 funding level will provide the program with full SPR operational readiness and drawdown capability of 4.25MB/d. 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 2016 include: full funding for Protective Force positions at all sites; additional preventive/corrective maintenance related to corrosion; the addition of a custody transfer flow metering skid; and replacement of communication equipment that has exceeded its lifecycle.

FY 2015 Key Accomplishments

- Acquired 4,194,296 barrels of crude oil using proceeds from the 2014 Test Sale.
- Performed degas operations on 41.1 million barrels of crude oil at the West Hackberry site.

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 2017 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 2017 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	2,047	2,047

Strategic Petroleum Reserve
Funding by Congressional Control ($K)

	FY 2015 Enacted	FY 2015 Current	FY 2016 Enacted	FY 2017 Request	FY 2017 vs FY 2016
Strategic Petroleum Reserve					
Facilities Development and Operations	174,999	174,999	186,870	228,069	+41,199
Management	25,001	25,001	25,130	28,931	+3,801
Total, Strategic Petroleum Reserve	**200,000**	**200,000**	**212,000**	**257,000**	**+45,000**
Federal FTEs	**126**	**126**	**126**	**126**	**-0**

Strategic Petroleum Reserve

Overview

The SPR benefits the Nation by providing an insurance policy against interruptions in U.S. petroleum supplies whether originating from international supply-disruptions, 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 worth of net import protection of strategic and commercial stocks and have a commitment to participate with other stockholding nations in a coordinated release of stocks in the event of a major supply disruption. The 695 million barrels of inventory provided 138 days of net import protection as of December 31, 2014.

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 2017 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) and hydrogen sulfide above safe levels during oil movements through commercial distribution points.

Major Maintenance Backlog

The Major Maintenance construction program maintains the SPR's facilities, equipment, and physical systems in an efficient operating condition. FY 2017 is the fourth year of planned deferred major maintenance buy-down that is highly dependent upon funding availability. 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.

Cavern Integrity

The Casing Inspection and Cavern Remediation Program was developed in 2010 to remediate the anomalies in wellbore casings. This cavern remediation prevents the well and cavern from being removed from service and prevents potential environmental hazards. Based on experienced failures, the level of anticipated remediation activity will remain constant for FY 2016 and FY 2017.

Major changes from 2016 include full funding for Protective Force positions at all sites; additional preventive/corrective maintenance related to corrosion; the addition of a custody transfer flow metering skid; and replacement of communication equipment that has exceeded its lifecycle.

Strategic Petroleum Reserve

Funding ($K)

	FY 2015 Enacted	FY 2015 Current	FY 2016 Enacted	FY 2017 Request	FY 2017 vs FY 2016
Strategic Petroleum Reserve					
Facilities Development and Operations	174,999	174,999	186,870	228,069	+41,199
Management	25,001	25,001	25,130	28,931	+3,801
Total, Strategic Petroleum Reserve	**200,000**	**200,000**	**212,000**	**257,000**	**+45,000**

Strategic Petroleum Reserve
Explanation of Major Changes ($K)

	FY 2017 vs FY 2016
Facilities Development and Operations: The request supports full funding for Protective Force Officers ($1,195); preventive/corrective maintenance related to corrosion and lifecycle maintenance tasks ($7,860); the addition of a custody transfer flow metering skid ($17,000); supports increase to Major Maintenance Program ($4,474); supports well casing services to sustain workover schedule ($406); and upgrade/replacement of communication equipment, network storage, and data systems hardware and software ($10,264).	**+41,199**
Management: The increase provides for technical support to address geotechnical and infrastructure issues	**+3,801**
Total, Strategic Petroleum Reserve	**+45,000**

Strategic Petroleum Reserve
Facilities Development and Operations

Description

The Facilities Development and Operations subprogram funds activities to maintain the SPR operational readiness posture for successful drawdowns and operate the sites in a safe, secure, and environmentally acceptable manner. The U.S. reliance on petroleum combined with significant global reserves in regions of the world subject to political unrest have made the U.S. vulnerable to supply disruptions. The stockpile of petroleum products diminishes this vulnerability to the effects of disruptions in supplies.

SPR's underground storage caverns require maintenance to assure their storage capability and integrity. The aging critical assets and systems that must be maintained in order to achieve operational readiness have been identified and are funded in this subprogram.

Facilities Development and Operations

Activities and Explanation of Changes

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
Facilities Development and Operations		
$186,870	**$228,069**	**+$41,199**
Casing Inspections and Remediations • Five planned remediation workovers using two rigs.	*Casing Inspections and Remediations* • Provides casing services in support of workover schedule.	*Casing Inspections and Remediations (+$406)* • Additional casing services in support of well workovers.
Major Maintenance • Continues the major maintenance program and supports buy-down of delayed projects.	*Major Maintenance* • Continue approach to repair, replace, or upgrade equipment including Security, Environmental, Safety & Health (ESH), Drawdown and Non-Drawdown critical systems, also including a custody transfer flow metering skid at the Big Hill site.	*Major Maintenance (+$21,474)* • Addition supports buy-down of Major Maintenance Project backlog and includes the addition of a custody transfer flow metering skid.
	Maintenance • Provides maintenance of the SPR equipment and facilities to support drawdown readiness in a safe and environmentally compliant manner.	*Maintenance (+$7,860)* • Additional preventive/corrective maintenance related to corrosion and lifecycle maintenance (green room) tasks.
	Security • Protect and defend personnel, property and resources against assault, sabotage, vandalism, theft, trespass and compromise of sensitive as well	*Security (+$1,195)* • Full funding for Protective Force Officers at the four sites to meet full staffing requirements. This amount was previously funded with prior year

	as classified information.	balances.
	Data Systems & Support • Data Systems to support the mission of drawdown readiness, processing, sale and receipt of goods (oil), communications, reporting, providing protection from malware and computer viruses, and all other activity associated with the use of data and information systems.	*Data Systems & Support (+$10,264)* • Upgrade and replacement of communication equipment, network storage, and data systems hardware, and software.

Strategic Petroleum Reserve
Capital Summary[1] ($K)

	Total	Prior Years	FY 2015 Enacted	FY 2015 Current	FY 2016 Enacted	FY 2017 Request	FY 2017 vs FY 2016
Capital Operating Expenses Summary (including MIE)							
Capital Equipment > $500K (including MIE)	n/a	n/a	18,340	19,533	19,964	38,158	+18,194
Plant Projects (GPP >$10M)	n/a	n/a	0	0	0	0	+0
Total, Capital Operating Expenses	**n/a**	**n/a**	**18,340**	**19,533**	**19,964**	**38,158**	**+18,194**
Capital Equipment > $500K (including MIE)							
Total Non-MIE Capital Equipment (>$500K)	n/a	n/a	3,849	5,042	6,494	16,681	+10,187
Replace Crude Oil Header Piping (BC-792)	0	0	2,521	2,521	0	0	0
Convert BMT-2 to External Floating Roof (BM-740)	0	0	8,875	8,875	0	0	0
Replace Piping Headers (BM-1027)	0	0	1,435	1,435	0	0	0
Replace Brine Disposal Pipeline (WH-826A)	0	0	1,660	1,660	0	0	0
Replace Critical Loop Conductors/Cables (BH-1319)	0	0	0	0	2,557	0	-2,557
Replace sec 36’ Pipeline-Hildebrant Bayou (BH-756)	0	0	0	0	2,190	0	-2,190
Replace WHT-1 Flush Water & WHT-10 Seal Flush	0	0	0	0	2,055	0	-2,055
Rework 42-Inch Crude Oil Pipeline Mainline Valves	0	0	0	0	3,188	0	-3,188
Close Anhydrate Pond 9-Chloride Removal(BH-					1,431	0	-1,431
Replace RWIP Discharge Piping and Recycle Line (WH-					704	0	-704
Replace 24’ Brine disposal Pipeline GFE (WH-826A)					1,345	0	-1,345
Replace 24-Inch Brine Disposal Pipeline (WH-826)	0	0	0	0	0	5,582	+5,582
Big Hill Meter Skid (BH-1307)	0	0	0	0	0	15,895	+15,895
Total, Capital Equipment (including MIE)	**n/a**	**n/a**	**18,340**	**19,533**	**19,964**	**38,158**	**+18,194**
Plant Projects (GPP - Total Estimated Cost >$10M)							
Total, Plant Projects (GPP – Total Estimated Cost	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Total, Capital Summary	**n/a**	**n/a**	**18,340**	**19,533**	**19,964**	**38,158**	**+18,194**

[1] This list of projects is illustrative and can be adjusted based on operational requirements, priorities, and/or funding.

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 2017 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 2015 Enacted	FY 2015 Current	FY 2016 Enacted	FY 2017 Request	FY 2017 vs FY 2016
Program Direction Summary					
Washington Headquarters					
Salaries and Benefits	5,066	5,066	5,476	5,618	+142
Travel	150	150	100	200	+100
Support Services	1,570	1,570	1,660	4,211	+2,551
Other Related Expenses	821	821	500	548	+48
Total, Washington Headquarters	**7,607**	**7,607**	**7,736**	**10,577**	**+2,841**
Strategic Petroleum Reserve Project Management Office					
Salaries and Benefits	13,651	13,651	14,114	14,664	+550
Travel	507	507	469	481	+12
Support Services	197	197	471	477	+6
Other Related Expenses	3,039	3,039	2,340	2,732	+392
Total, SPR Project Management Office	**17,394**	**17,394**	**17,394**	**18,354**	**+960**
Total Management					
Salaries and Benefits	18,717	18,717	19,590	20,282	+692
Travel	657	657	569	681	+112
Support Services	1,767	1,767	2,131	4,688	+2,557
Other Related Expenses	3,860	3,860	2,840	3,280	+440
Total, Management	**25,001**	**25,001**	**25,130**	**28,931**	**+3,801**
Federal FTEs	**126**	**126**	**126**	**126**	**0**
Support Services					
Technical Support					
Economic & Environmental Analysis	560	560	560	560	+0
Total, Technical Support	560	560	560	560	+0

	FY 2015 Enacted	FY 2015 Current	FY 2016 Enacted	FY 2017 Request	FY 2017 vs FY 2016
Management Support					
Training and OPM Recruitment	197	197	209	213	+4
Technical Support	1,010	1,010	1,362	3,915	+2,553
Total Management Support	1,207	1,207	1,571	4,128	+2,557
Total, Support Services	**1,767**	**1,767**	**2,131**	**4,688**	**+2,557**
Other Related Expenses					
Rent to Others	726	726	559	591	+32
Communications, Utilities, Misc.	173	173	118	96	-22
Other Services	1,910	1,910	1,748	2,178	+430
Supplies and Materials	639	639	40	40	+0
Equipment	412	412	375	375	+0
Total, Other Related Expenses	**3,860**	**3,860**	**2,840**	**3,280**	**+440**

Management

Activities and Explanation of Changes

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
Management $25,130,000	**$28,931,000**	**+$3,801,000**
Salaries and Benefits $19,590,000	**$20,282,000**	**+$692,000**
Continue Management and oversight activities.	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.	Increase reflects escalation.
Travel $569,000	**$681,000**	**+$112,000**
Continue constrained travel.	Provides travel to assure capability to achieve Level 1 Performance criteria for drawdown and distribution of the Reserve.	Continue travel required to ensure the reserve is drawdown ready.
Support Services $2,131,000	**$4,688,000**	**+$2,557,000**
Activities support project-planning efforts to maintain technical, mission essential support capabilities.	Activities support project-planning efforts to maintain technical, mission essential support capabilities.	Increase provides for technical support to address geotechnical and infrastructure issues
Other Related Expenses $2,840,000	**$3,280,000**	**+$440,000**
Provides teleconferencing capabilities between sites; field site building leases; and contingency for DOE field employee evacuation expenses in the event of a hurricane.	Provides teleconferencing capabilities between sites; field site building leases; and contingency for DOE field employee evacuation expenses in the event of a hurricane.	Revised estimate of hurricane preparedness requirements.

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.

	FY 2015	FY 2016	FY 2017
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[2]
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	< 0.30 $ operating cost per barrel	$\leq$ 0.30 $ operating cost per barrel
Result	< 0.25 $ operating cost per barrel	TBD	TBD
Endpoint Target	Achieve $\leq$ $0.30 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	4.22 MMB/Day drawdown readiness rate	4.25 MMB/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.		

Strategic Petroleum Reserve
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 2015 Actual Cost	FY 2015 Planned Cost	FY 2016 Planned Cost	FY 2017 Planned Cost
Strategic Petroleum Reserve	48,541	46,386	46,018	74,127
Total, Direct-Funded Maintenance and Repair	**48,541**	**46,386**	**46,018**	**74,127**

Report on FY 2015 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 2015 to the amount planned for FY 2015, including congressionally directed changes.

Total Costs for Maintenance and Repair ($K)

	FY 2015 Actual Cost	FY 2015 Planned Cost
Strategic Petroleum Reserve	48,541	46,386
Total, Direct-Funded Maintenance and Repair	**48,541**	**46,386**

Strategic Petroleum Reserve
Safeguards and Security ($K)

	FY 2015 Enacted	FY 2015 Current	FY 2016 Enacted	FY 2017 Request	FY 2017 vs FY 2016
Protective Forces	18,732	18,732	18,859	23,191	+4,332
Physical Security Systems	939	939	957	1,016	+59
Information Security	247	247	205	242	+37
Cyber Security	1,464	1,464	1,299	2,047	+748
Personnel Security	661	661	587	602	+15
Material Control and Accountability	0	0	0	0	+0
Research and Development	0	0	5	6	+1
Program Management	1,524	1,524	1,494	1,074	-420
Security Investigations	0	0	0	0	+0
Transportation Security	0	0	0	0	+0
Construction	0	0	1,376	150	-1,226
Total, Safeguards and Security	**23,567**	**23,567**	**24,782**	**28,328**	**+3,546**

Strategic Petroleum Reserve – Petroleum Account

($K)

FY 2015 Enacted	FY 2015 Current	FY 2016 Enacted	FY 2017 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 2017 Budget Request

There is no request for FY 2017. Continued oversight and management for NGSR is funded by prior-year balances. These activities include annual independent audits, third-party quality assurance and inventory certifications of government-owned stocks commingled with commercial stocks, and sales platform readiness.

FY 2015 Key Accomplishments

- Pursuant to Section 161(g) of the Energy Policy and Conservation Act of 1975, 4.2 million barrels of crude oil was acquired for the Reserve using proceeds of the 2014 test sale. This acquisition increased the inventory to 695.1 million barrels.
- Maintained Northeast Gasoline Supply 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

Overview

The SPR Petroleum Account funds all SPR petroleum inventory acquisitions, associated transportation and custom duties, and incremental drawdown expenses as well as activities for the Northeast Gasoline Supply Reserve (NGSR). 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.

Following the completion of the 2014 Test Sale, DOE announced the creation of a gasoline reserve in locations near New York Harbor and in New England. This 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. As a component of the SPR, the NGSR was established in the SPR Petroleum Account. NGSR utilized $235 million of the $435 million in sales receipts for 4.5 years of commercial storage, acquisition of 1 million barrels of gasoline, and initial oversight and administration activities. The remaining Test Sale receipts were used to comply with Section 161(g) of the Energy Policy and Conservation Act of 1975. This section requires the Secretary of Energy to acquire petroleum products for the Reserve within the 12-month period beginning after the completion of a test sale under the same section 4.2 million barrels of crude oil was acquired for the Reserve which increased the inventory to 695.1 million barrels.

The Bipartisan Budget Act of 2015 (Public Law 114 – 74) Section 403 requires sale of SPR oil and Section 404 subject to appropriation, authorizes the additional drawdown and sale of SPR inventory as follows:

- Per Section 403, beginning in FY 2018 – 58 million barrels over eight consecutive fiscal years for Revenue Offsets. Proceeds will be deposited into the General Fund of the Treasury.
- Per Section 404, for the period encompassing FYs 2017 through 2020, the required volumes of SPR inventory to raise $2 billion in revenue to be deposited into the Energy Security and Infrastructure Modernization Fund.

The Fixing America's Surface Transportation Act (Public Law 114-94) directs the drawdown and sale of SPR inventory as follows:

- For FYs 2016 and 2017, the quantity of barrels of crude oil that the Secretary determines to be appropriate to maximize financial returns.
- Beginning in FY 2023, 66 million barrels over three consecutive fiscal years. Proceeds will be deposited into the General Fund of the Treasury. Sales under this Act shall cease once a total of $6.2 billion has been deposited in the Treasury.

Highlights and Major Changes in the FY 2017 Budget Request

There is no request for FY 2017. Funding requirements will be covered by the use of prior-year balances in the Petroleum Account. Continued oversight and administration activities for NGSR will also be funded with prior-year balances.

Strategic Petroleum Reserve – Petroleum Account
Explanation of Major Changes ($K)

	FY 2017 vs FY 2016
There is no request for FY 2016 or FY 2017. 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 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
SPR Petroleum Account $0	**$0**	**+$0**
NGSR		
Oversight and Management • 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* • 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* • FY 2016 and FY 2017 activities are funded with prior-year balances.
Petroleum Acquisition, Transportation and Drawdown	**$0**	**+$0**
Non-Emergency Drawdown • No activity	•	•

Department Of Energy

FY 2017 Congressional Budget

Funding By Appropriation By Site

($K)

Strategic Petroleum Reserve	FY 2015 Current	FY 2016 Enacted	FY 2017 Request
National Energy Technology Lab			
SPR Geotechnical Analytical Support			
SPR - Facilities Development	446	446	456
Total, National Energy Technology Lab	**446**	**446**	**456**
Oak Ridge National Laboratory			
SPR Econometric Modelling Support			
Management	490	490	490
Total, Oak Ridge National Laboratory	**490**	**490**	**490**
Sandia National Laboratories			
SPR Geotechnical Analytical Support			
SPR - Facilities Development	3,335	3,412	3,490
Total, Sandia National Laboratories	**3,335**	**3,412**	**3,490**
Strategic Petroleum Reserve - Bayou Choctow			
SPR Geotechnical Analytical Support			
SPR - Facilities Development	12,737	10,617	12,791
Total, Strategic Petroleum Reserve - Bayou Choctow	**12,737**	**10,617**	**12,791**
Strategic Petroleum Reserve - Big Hill			
SPR Geotechnical Analytical Support			
SPR - Facilities Development	20,866	27,446	47,455
Total, Strategic Petroleum Reserve - Big Hill	**20,866**	**27,446**	**47,455**
Strategic Petroleum Reserve - Bryan Mound			
SPR Geotechnical Analytical Support			
SPR - Facilities Development	26,067	19,363	16,736
Total, Strategic Petroleum Reserve - Bryan Mound	**26,067**	**19,363**	**16,736**
Strategic Petroleum Reserve - West Hackberry			
SPR Geotechnical Analytical Support			
SPR - Facilities Development	22,760	30,200	33,416
Total, Strategic Petroleum Reserve - West Hackberry	**22,760**	**30,200**	**33,416**
Strategic Petroleum Reserve Project Office			
SPR Geotechnical Analytical Support			
SPR - Facilities Development	88,788	95,386	113,725
SPR Econometric Modelling Support			
Management	17,394	17,394	18,354
Total, Strategic Petroleum Reserve Project Office	**106,182**	**112,780**	**132,079**

Department Of Energy

FY 2017 Congressional Budget

Funding By Appropriation By Site

($K)

Strategic Petroleum Reserve	FY 2015 Current	FY 2016 Enacted	FY 2017 Request
Washington Headquarters			
SPR Econometric Modelling Support			
Management	7,117	7,246	10,087
Total, Washington Headquarters	**7,117**	**7,246**	**10,087**
Total, Strategic Petroleum Reserve	**200,000**	**212,000**	**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] *$6,500,000* to remain available until expended.

Explanation of Changes

New budget authority of $6.5 million and $4 million in prior-year balances will be used to maintain commercial storage terminal contracts.

Public Law Authorizations

- P.L. 109-58, Energy Policy Act of 2005

Northeast Home Heating Oil Reserve

($K)

FY 2015 Enacted[1]	FY 2015 Current[1]	FY 2016 Enacted	FY 2017 Request[2]
1,600	1,600	7,600	6,500

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 2017 program will continue operation of the 1 million barrel Reserve with new storage terminal contracts going into effect in mid-FY 2016. The new storage contracts were originally planned for 2015, but in order to avoid a transition close to the start of the winter heating season, a six-month extension of the current storage contracts was executed through March 30, 2016.

Highlights and Major Changes in the FY 2017 Budget Request

FY 2017 activity will continue an acceptable and effective transition to the new storage terminal contracts. The Program will focus on oversight, management and quality analysis of the Reserve as well as ongoing information technology support for the Reserve's sales system.

FY 2015 Key Accomplishments

- Actively monitored Northeast heating oil supplies and terminal distribution as part of the assessment of the developing winter situation.

[1] Funding reflects rescission of $6,000,000 in prior-year balances.

[2] Does not include the use of $4,000,000 in prior-year balances for NEHHOR.

Northeast Home Heating Oil Reserve
Funding by Congressional Control ($K)

	FY 2015 Enacted	FY 2015 Current	FY 2016 Enacted	FY 2017 Request[3]	FY 2017 vs FY 2016
Northeast Home Heating Oil Reserve					
Northeast Home Heating Oil Reserve	7,600	7,600	7,600	6,500	-1,100
Subtotal, Northeast Home Heating Oil Reserve	**7,600**	**7,600**	**7,600**	**6,500**	**-1,100**
Rescission of Prior Year Balances	-6,000	-6,000	0	0	0
Total, Northeast Home Heating Oil Reserve	**1,600**	**1,600**	**7,600**	**6,500**	-1,100
Federal FTEs	**0**	**0**	**0**	**0**	**0**

[3] Does not include the use of $4,000,000 in prior-year balances for NEHHOR.

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 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 NEHHOR has been designed to augment commercial supplies during an emergency. The NEHHOR 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 NEHHOR is a valuable component of America's energy readiness efforts, separate from the Strategic Petroleum Reserve.

Highlights of the FY 2017 Budget Request

New commercial storage contracts have been awarded and are expected to go in effect on April 1, 2016. NEHHOR activity will consist of oversight, management, information technology sales system support, and quality analysis by an independent quality assurance and inspection service.

The re-solicitation process for the new commercial storage contracts began early in FY 2015 to explore storage opportunities and prospective cost range. To avoid a transition close to the start of winter heating season, a final six-month extension of the current storage contracts was executed until March 30, 2016. Storage costs associated with the newly awarded commercial storage contracts will require the use of $4 million in prior-year balances to supplement new FY 2017 budget authority.

Northeast Home Heating Oil Reserve
Funding ($K)

	FY 2015 Enacted	FY 2015 Current	FY 2016 Enacted	FY 2017 Request	FY 2017 vs FY 2016
Northeast Home Heating Oil Reserve					
Commercial Leases	7,600	7,600	7,600	6,000	-1,600
Information Technology Support	0	0	0	400	+400
Quality Control and Analysis	0	0	0	100	+100
Subtotal, Northeast Home Heating Oil Reserve	**7,600**	**7,600**	**7,600**	**6,500**	**-1,100**
Rescission of Prior Year Balances	-6,000	-6,000	0	0	0
Total, Northeast Home Heating Oil Reserve	**1,600**	**1,600**	**7,600**	**6,500**	**-1,100**

Northeast Home Heating Oil Reserve
Explanation of Major Changes ($K)

	FY 2017 vs FY 2016
Northeast Home Heating Oil Reserve: The decrease in new budget authority will be offset by the use of $4,000,000 in prior-year balances to cover storage cost increases associated with the newly awarded contracts, and to cover contract costs for Information Technology Support and Quality Control and Analysis. In FY 2016, prior-year balances were used to fund Information Technology Support and Quality Control and Analysis.	**-1,100**
Total, Northeast Home Heating Oil Reserve	**-1,100**

Department Of Energy

FY 2017 Congressional Budget

Funding By Appropriation By Site

($K)

Northeast Home Heating Oil Reserve Account	FY 2015 Current	FY 2016 Enacted	FY 2017 Request
Washington Headquarters			
Northeast Home Heating Oil Reserve			
Northeast Home Heating Oil Reserve	7,600	7,600	6,500
Total, Washington Headquarters	**7,600**	**7,600**	**6,500**
Total, Northeast Home Heating Oil Reserve Account	**7,600**	**7,600**	**6,500**

Elk Hills School Lands Fund

Elk Hills School Lands Fund

Elk Hills School Lands Fund

Explanation of Changes

The State of California's claim has been satisfied and paid. 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 2015 Enacted	FY 2015 Current	FY 2016 Enacted	FY 2017 Request
15,580	15,580	0	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" stipulates installments totaling nine percent of the net proceeds from the sale will 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.

Highlights and Major Changes in the FY 2017 Budget Request

The State of California's claim has been satisfied and paid. No additional funding is required.

Elk Hills School Lands Fund
Funding by Congressional Control ($K)

	FY 2015 Enacted	FY 2015 Current	FY 2016 Enacted	FY 2017 Request	FY 2017 vs FY 2016
Elk Hills School Lands Fund					
Elk Hills School Lands Fund	15,580	15,580	0	0	0
Total, Elk Hills School Lands Fund	**15,580**	**15,580**	**0**	**0**	**0**
Federal FTEs	**0**	**0**	**0**	**0**	**0**

Elk Hills School Lands Fund
Explanation of Major Changes ($K)

	FY 2017 vs FY 2016
Elk Hills School Lands Fund: 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 and made in FY 2015.	**0**
Total, Elk Hills School Lands Fund	**0**

Department Of Energy

FY 2017 Congressional Budget

Funding By Appropriation By Site

($K)

Elk Hills School Lands Fund	FY 2015 Current	FY 2016 Enacted	FY 2017 Request
State of California			
Elk Hills School Lands Fund			
Elk Hills School Lands Funds	15,580	0	0
Total, State of California	**15,580**	**0**	**0**
Total, Elk Hills School Lands Fund	**15,580**	**0**	**0**

Advanced Technology Vehicles Manufacturing Loan Program

Advanced Technology Vehicles Manufacturing Loan Program

Advanced Technology Vehicles Manufacturing Loan Programs Office
Proposed Appropriation Language

For Department of Energy administrative expenses necessary in carrying out the Advanced Technology Vehicles Manufacturing Loan Program, [$6,000,000] *$5,000,000*, to remain available until September 30, [2017] *2018.*

Explanation of Changes

$5,000,000 is requested for administrative expenses in FY 2017. This budget request is needed to process and underwrite an increasing volume of loan applications. The Department of Energy's (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 and FY 2017. 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. 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

Advanced Technology Vehicles Manufacturing Loan Programs Office

($K)

FY 2015 Enacted	FY 2015 Current	FY 2016 Enacted	FY 2017 Request
$4,000	$4,000	$6,000	$5,000

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 2017 Budget Request

$5,000,000 is requested for administrative expenses in FY 2017. This budget request 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.

The Department of Energy's (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 2017. The appropriation will cover ATVM's administrative expenses, including salaries for its full time employees as well as the forecasted costs of outside advisors for financial, legal, engineering, credit, and market analysis for underwriting activities. The ATVM appropriation must cover the costs for originating new loans as well as monitoring existing loans.

Advanced Technology Vehicles Manufacturing Loan Programs Office
Funding by Congressional Control ($K)

	FY 2015 Enacted	FY 2015 Current	FY 2016 Enacted	FY 2017 Request	FY 2017 vs FY 2016
Advanced Technology Vehicles Manufacturing Loan Program					
Administrative Operations, ATVM	4,000	4,000	6,000	5,000	-1,000
Total, Advanced Technology Vehicles Manufacturing Loan Program	**4,000**	**4,000**	**6,000**	**-1,000**	**-1,000**
Federal FTEs	**14**	**14**	**14**	**16**	**2**

Advanced Technology Vehicles Manufacturing Loan Programs Office
Administrative Operations
Funding ($K)

	FY 2015 Enacted	FY 2015 Current	FY 2016 Request	FY 2017 Request	FY 2017 vs FY 2016
Administrative Operations					
Salaries & Benefits	2,450	2,450	2,500	2,860	360
Travel	250	250	150	130	-20
Support Services	1,000	1,000	2,600	1,390	-1,210
Other Related Expenses	300	300	750	620	-130
Total, Administrative Operations	**4,000**	**4,000**	**6,000**	**5,000**	**-1,000**

Administrative Operations
Explanation of Major Changes ($K)

	FY 2017 vs FY 2016
Administrative Operations	
Salaries and Benefits: Provide salaries and benefits for 16 full time equivalent employees (FTEs) 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 for two additional FTEs.	+360
Travel: Supports the travel of staff members for site visits, training, and attending meetings and conferences. Decease to match reduction in anticipated travel requirements.	-20
Support Services: Funds outside expertise in finance, legal, engineering, technology, credit analysis, and market assessments. Decease to match reduction in support services.	-1,210
Other Related Expenses: Supports DOE Working Capital Fund and LPO federal staff training. Decrease to match reduction in working capital and training activities.	-130
Total, Administrative Operations	**-1,000**

Administrative Operations

Activities and Explanation of Changes

FY 2016 Request	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
Administrative Operations $6,000,000	**$5,000,000**	**-$1,000,000**
Salaries and Benefits $2,500,000	**$2,860,000**	**+$360,000**
• Provide salaries and benefits to 14 full time equivalent employees to administer the following functions to the office: Director, Legal, Loan Origination, Management Operations, Environmental Compliance, Portfolio Management, Risk Management, and Technical and Project Management.	• To provide salaries and benefits to 16 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.	• The increase is for two additional FTEs in FY 2017."
Travel $150,000	**$130,000**	**-$20,000**
• Continuation of FY 2015 activities. Supports the travel of staff members for site visits, training, and attending meetings and conferences.	• Continuation of FY2016 activities. Supports the travel of staff members for outreach to applicants, site visits, as well as attending meetings and conferences.	• The decrease will reduce anticipated travel activities.
Support Services $2,600,000	**$1,390,000**	**-$1,210,000**
• Continuation of FY 2015 activities. Provides range of contract services including administrative support, subject matter experts, legal services, information technology, and publications.	• Continuation of FY2016 activities. 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.	• The decrease will reduce support services such as: outside expertise in finance, legal, engineering, technology, credit analysis, and market assessments.
Other Related Expenses $750,000	**$620,000**	**-$130,000**
• Continuation of FY 2015 activities. Supports DOE Working Capital Fund, DOE IT services and expenses, and ATVM federal staff training.	• Continuation of FY2016 activities. Supports only the direct costs for ATVM that will be billed to LPO via DOE Working Capital Fund, such as the cost of publishing a Federal Register Notice.	The decrease will reduce working capital expenses and training activity for ATVM federal staff.

Advanced Technology Vehicles Manufacturing Loan Programs Office
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 2015	FY 2016	FY 2017
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	To be reported at end of fiscal year		
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	290 million gallons	290 million gallons	290 million gallons
Result	To be reported at end of fiscal year		
Endpoint Target	Achieve 290 million gallons per year savings through 2016.		

Department Of Energy

FY 2017 Congressional Budget

Funding By Appropriation By Site

($K)

Advance Technology Vehicles Man Loan Program	FY 2015 Current	FY 2016 Enacted	FY 2017 Request
Washington Headquarters			
Energy Transformation Acceleration Fund			
Administrative Expenses	4,000	6,000	5,000
Total, Washington Headquarters	**4,000**	**6,000**	**5,000**
Total, Advance Technology Vehicles Man Loan Program	**4,000**	**6,000**	**5,000**

Title 17 Innovative Technology Loan Guarantee Program

Title 17 Innovative Technology Loan Guarantee Program

Innovative Technology Loan Programs Office
Proposed Appropriation Language

Subject to section 502 of the Congressional Budget Act of 1974, commitments to guarantee loans under title XVII of the Energy Policy Act of 2005, shall not exceed a total principal amount of $4,000,000,000 for eligible projects, to remain available until committed, Provided, That these amounts are in addition to those provided in any other Act: Provided further, That [Such] 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] $37,000,000 is appropriated from fees collected in prior years pursuant to section 1702(h) of the Energy Policy Act of 2005 which are not otherwise appropriated, to remain available until September 30, [2017] 2018 :Provided further, That if the amount in the previous proviso is not available from such fees, an amount for such purposes is also appropriated from the general fund so as to result in a total amount appropriated for such purpose of no more than $37,000,000: Provided further, That [$25,000,000] [of the] fees collected pursuant to such section 1702(h) [of the Energy Policy Act of 2005] for fiscal year 2017 shall be credited as offsetting collections under this heading and shall not be available until appropriated [to this account to cover administrative expenses and shall remain available until expended, so as to result in a final fiscal year 2016] [appropriation from the general fund estimated at not more than $17,000,000]: [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 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.

Explanation of Changes

$37,000,000 is requested for administrative expenses in FY 2017. These administrative expenses are expected to be offset by an estimated $27,000,000 in collections from applicants and borrowers for a net appropriation of $10,000,000 to support administrative expenses. In addition, the LPO is requesting $4,000,000,000 in new loan guarantee authority under the Title XVII program due to the strong market response to the Advanced Fossil Energy Projects Solicitation and the Renewable Energy and Efficient Energy Projects Solicitation. LPO forecasts that all remaining loan guarantee authority made available under these solicitations will be closed or committed by the end of FY 2016. LPO has applications in the application pipeline for Title XVII. Additional loan authority under Title XVII for LPO will further signal to the market that LPO is focused on continuing to fund innovative technologies that meet the program mission. LPO anticipates that the market will respond to future, new conditional commitments with an increasing volume of applications.

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
- P.L. 113-76, Consolidated Appropriations Act, 2014
- P.L. 113-164 Continuing Appropriations Resolution, 2015

Innovative Technology Loan Programs Office

($K)

FY 2015 Enacted	FY 2015 Current	FY 2016 Enacted	FY 2017 Request
$17,000	$17,000	$17,000	$10,000

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; 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 LGP'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 2017 Budget Request

The LPO has closed over $24 billion in loan guarantees and holds over $2 billion in conditional commitments. LPO issued the Advanced Fossil Energy Projects Solicitation, the Renewable Energy and Efficient Energy (REEE) Projects Solicitation, and the Advanced Nuclear Energy Projects Solicitation in FY 2014 and FY 2015. Over the course of FY 2016 and FY 2017, LPO will review applications and work to obligate the remaining loan guarantee authority under these solicitations.

Innovative Technology Loan Programs Office
Funding by Congressional Control ($K)

	FY 2015 Enacted	FY 2015 Current	FY 2016 Enacted	FY 2017 Request	FY 2017 vs FY 2016
Title 17 Innovative Technology Loan Guarantee Program					
Administrative Operations	42,000	42,000	42,000	37,000	-5,000
Offsetting Receipts	-25,000	-25,000	-25,000	-27,000	-2,000
Total, Title 17 Innovative Technology Loan Guarantee Program	**17,000**	**17,000**	**17,000**	**10,000**	**-7,000**
Federal FTEs	**100**	**100**	**120**	**118**	**0**

Administrative Operations
Funding ($K)

	FY 2015 Enacted	FY 2015 Current	FY 2016 Request	FY 2017 Request	FY 2017 vs FY 2016
Administrative Operations					
Salary & Benefits	15,250	15,250	20,000	19,693	-307
Travel	500	500	800	600	-200
Support Services	21,850	21,850	18,000	14,000	-4,000
Other Related Expenses	4,400	4,400	3,200	2,707	-493
Total, Administrative Operations	**42,000**	**42,000**	**42,000**	**37,000**	**-5,000**

Administrative Operations
Explanation of Major Changes ($K)

	FY 2017 vs FY 2016
Administrative Operations	
Salaries and Benefits: Provide salaries and benefits to 118full 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. Decrease to match expected salary requirements.	**-307**
Travel: Supports the travel of staff members for site visits, training, and attending meetings. Decrease to match reduction in anticipated travel.	**-200**
Support Services: Provides range of contract services including administrative support, subject matter experts, legal services, information technology, and publications. Decease to match reduction in support services	**-4,000**
Other Related Expenses: Supports DOE Working Capital Fund, DOE COE expenses, and LPO federal staff training. Decrease to match reduction in working capital and training activities.	**-493**
Total, Administrative Operations	**-5,000**

Administrative Operations

Activities and Explanation of Changes

FY 2016 Request	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
Administrative Operations $42,000,000	**$37,000,000**	**-$5,000,000**
Salaries and Benefits $20,000,000	**$19,693,000**	**-$307,000**
• 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.	• To provide salaries and benefits to 118full 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.	• The decrease will reduce two FTEs in FY 2017.
Travel $800,000	**$600,000**	**-$200,000**
• Continuation of FY 2015 activities. Supports the travel of staff members for site visits, training, and to attend consultations.	• Continuation of FY2016 activities. Supports the travel of staff members for outreach to applicants, site visits, as well as attending meetings and conferences.	• The decrease will reduce anticipated travel activities.
Support Services $18,000,000	**$14,000,000**	**-$4,000,000**
• Continuation of FY 2015 activities. Provides range of contract services including administrative support, subject matter experts, legal services, information technology, and publications.	• Continuation of FY2016 activities. 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.	• The decrease will reduce support services such as: outside expertise in finance, legal, engineering, technology, credit analysis, and market assessments.
Other Related Expenses $3,200,000	**$2,707,000**	**$-493,000**
• Continuation of FY 2015 activities. Supports DOE Working Capital Fund, Energy IT Services - Desktop Services, expenses, and LGP federal staff training.	• Continuation of FY2016 activities. Supports only the direct costs for Title 17 that will be billed to LPO via DOE Working Capital Fund, such as the cost of publishing a Federal Register Notice, expenses, and LGP federal staff training.	• The decrease will reduce working capital expenses and training activity for ATVM federal staff.

Innovative Technology Loan Programs Office
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 2015 Annual Performance Report.

	FY 2015	FY 2016	FY 2017
Performance Goal (Measure)	**CO_2 Reductions of Projects Receiving Loan Guarantees - Estimated annual CO_2 emissions reductions of projects receiving loan guarantees that have achieved commercial operations compared to "business as usual" energy generation**		
Target	≥ 16,400,000 mt CO_2	≥ 21,200,000 mt CO_2	≥ 21,900,000 mt CO_2
Result	To be reported at end of Fiscal Year		
Endpoint Target	Achieve 21,200,000 mt of avoided CO_2 emissions per year by the end of FY 2016.[1]		
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	≥ 4.0 GW	≥ 4.0 GW	≥ 4.0 GW
Result	To be reported at end of Fiscal Year		
Endpoint Target	Achieve 4.0 GW of annual electricity generation capacity by FY 2016.		

[1] *The quantities will be an all-time Cumulative vs an annual cumulative*.] 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 LPO 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 2017 Congressional Budget

Funding By Appropriation By Site

($K)

Innovative Tech Loan Guarantee Prog	FY 2015 Current	FY 2016 Enacted	FY 2017 Request
Washington Headquarters			
Administrative Operations			
Administrative Operations	42,000	42,000	37,000
Total, Washington Headquarters	**42,000**	**42,000**	**37,000**
Total, Innovative Tech Loan Guarantee Prog	**42,000**	**42,000**	**37,000**

Office of Indian Energy

Office of Indian Energy

Office of Indian Energy
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] $22,930,000, to remain available until expended. Provided that, of the amount appropriated under this heading, [$3,510,000] $4,800,000 shall be available until September 30, 2018, 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

($K)

FY 2015 Enacted	FY 2015 Current	FY 2016 Enacted	FY 2017 Request
0	0	0	22,930

Funding by Congressional Control (Comparable) ($K)

	FY 2015 Enacted	FY 2015 Current	FY 2016 Enacted	FY 2017 Request	FY 2017 vs FY 2016
Office of Indian Energy					
Tribal Energy Program	14,729	14,729	12,800	18,130	+5,330
Program Direction	1,271	1,271	3,200	4,800	+1,600
Total, Office of Indian Energy	**16,000**	**16,000**	**16,000**	**22,930**	**+6,930**
Federal FTEs	**7**	**7**	**9**	**15**	**+6**

Overview

The Energy Policy Act of 2005 established the Office of Indian Energy Policy and Programs (IE) to promote Indian tribal energy development, efficiency and use; reduce or stabilize energy costs; enhance and strengthen Indian tribal energy and economic infrastructure relating to natural resourced development and electrification; and to bring electrical power and service to Indian land and homes, where 14.2 percent of tribal households lack access to basic electricity, and providing opportunities for the development of significant energy resources that remain undeveloped in 2016 due to a variety of factors, including lack of access to capital, absence of tribal capacity for energy and economic development, and a complicated legal and regulatory structure governing the use of Indian lands.

To meet the statutory mandate, IE coordinates programmatic activities across DOE related to the development of energy resources on Indian lands and works with other state and federal Government agencies, Indian Tribes, Alaska Native Village and Regional Corporations and organizations to promote Indian energy policies and initiatives. IE performs these functions consistent with the federal government's statutory obligations concerning the federal/tribal trust responsibility, Tribal self-determination policy, and government-to-government relationship with Indian Tribes.

IE accomplishes its mission through technical assistance, direct and remote education, policy research and analysis, and financial assistance to Indian Tribes, Alaska Native Village and Regional corporations, and Tribal Energy Resource Development Organizations. Subject matter experts assist Tribes with deploying energy projects, as well as high-level technical support for energy planning, project development, transmission interconnection, utility formation and intertribal coordination to improve energy systems and economic conditions on tribal lands, contributing to domestic energy production, enhancing national energy security and resilience of remote, rural tribal communities. Research and analysis involves surveying energy needs of, and energy resources on Tribal lands, including available infrastructure support, and developing 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 and building the essential governmental and business capacity within and between tribes to foster sustainable tribal energy programs and infrastructure within tribal communities.

Highlights and Major Changes in the FY 2017 Budget Request
Through FY 2016, funding for the Office of Indian Energy Policy and Programs was provided within the Departmental Administration appropriation. In FY 2017, funding for this office is requested as a separate appropriation, which appropriately aligns the budget structure with IE's mission and activities.

In FY 2017, $23 million is requested to fund the Office of Indian Energy Policy and Programs. The funding request includes the following: $18 million provides technical assistance and competitive grant programs to support clean energy development, energy efficiency improvements, electrification projects, remote community renewable energy hybrid systems, micro grid deployment, energy-water project support, and other greenhouse gas emission mitigation technologies for Indian Tribes, consistent with US commitments to the international COP21 agreement; and $4.8 million to support 15 FTEs (+6 FTE), plus other program direction and administrative costs.

This request also supports key clean energy components for tribal communities and strategic federal facilities and policies as set forth in the National Strategy for the Arctic Region (NSAR). This ten-year strategy places significant energy planning, deployment, and leadership targets on the Office of Indian Energy as articulated in the NSAR Implementation Plan, including the development and implementation of a 10 Year Renewable Energy Plan for Alaska and the Arctic Region.

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 Budget Request continues crosscutting programs which coordinate across the Department and seeks 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. The Office of Indian Energy Policy and Programs contains the following crosscuts:

Grid Modernization (Grid): U.S. prosperity and energy innovation in a global clean energy economy depends upon 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 building on analysis and findings of the QER; ensure the development of a secure and resilient grid; and collaborate with stakeholders to test and demonstrate combinations of promising new technologies.

Energy-Water Nexus (EWN):
There is increasing urgency to address the energy-water nexus in an integrated way due to changing precipitation and temperature patterns, accelerated drawdown of critical water supplies, population growth and regional migration trends, and the introduction of new technologies that could shift water and energy demands. 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.

FY 2017 Crosscuts ($K)

	Grid	EWN	Total
Tribal Energy Program	**1,000**	**1,000**	**2,000**
Total, Crosscuts	**1,000**	**1,000**	**2,000**

FY 2015 Key Accomplishments

- Consolidation of DOE/EERE's Tribal Energy Program into the Office of Indian Energy Policy and Programs, creating a single portal for tribes into the Department, and the appointment of a new Director and Deputy Director.
- During his 2015 Glacier conference, the President announced the release of *Tribal Energy System Vulnerabilities to Climate Change and Extreme Weather*, a groundbreaking climate change report produced by this Office.
- Awarded $6 million to eleven tribal communities to deploy renewable energy and energy efficiency. These projects are expected to result in over 5 megawatts of new clean energy and save those communities over $1.2 million per year.
- Launched two new funding initiatives: Remote Alaskan Communities Energy Efficiency Competition and National Intertribal Technical Assistance Energy Provider Network.
- This Office hosted the 2015 National Tribal Energy Summit, which drew 500 participants representing over 90 Indian tribes. The Summit featured the Secretary's Roundtable on Finance and, in collaboration with DOE's Office of Fossil Energy, a Special Fossil Roundtable at the Summit, during which Tribes with fossil energy resources requested the creation of a Tribal Fossil Energy Working Group to facilitate the responsible development of tribal fossil resources.
- This Office builds experience and capacity with Native American youth by participating in both the Washington Internships for Native Students (WINS) and the Native American Student Internships at Sandia National Laboratories.
- Through the White House Council on Native American Affairs/Energy Subcommittee, this Office supports the Policy Working Group; the Financial and Technical Assistance Working Group; the Regulatory Process Working Group; the Capacity Building and Workforce Development Working Group; and the Federal Procurement Working Group.
- Agreement in concept for an MOU with the Department of Interior's Office of Indian Energy and Economic Development to be more efficient and responsive in the delivery of tribal energy programs and service.

Office of Indian Energy
Funding by Congressional Control ($K)

	FY 2015 Enacted	FY 2015 Current	FY 2016 Enacted	FY 2017 Request	FY 2017 vs FY 2016
Office of Indian Energy					
Tribal Energy Program	0	0	0	18,130	+18,130
Program Direction	0	0	0	4,800	+4,800
Total, Office of Indian Energy	**0**	**0**	**0**	**22,930**	**22,930**
Federal FTEs	**0**	**0**	**0**	**15**	**+15**

Funding by Congressional Control (Comparable) ($K)

	FY 2015 Current	FY 2015 Current	FY 2016 Enacted	FY 2017 Request	FY 2017 vs FY 2016
Office of Indian Energy					
Tribal Energy Program	14,729	14,729	12,800	18,130	+5,330
Program Direction	1,271	1,271	3,200	4,800	+1,600
Total, Office of Indian Energy	**16,000**	**16,000**	**16,000**	**22,930**	**+6,930**
Federal FTEs	**7**	**7**	**9**	**15**	**+6**

Office of Indian Energy
Proposed Budget Structure Change

The Office of Indian Energy was initiated out of the Office of Congressional and Intergovernmental Affairs and funded within the Departmental Administration (DA) appropriation. However, IE reports directly to the Under Secretary for Science and Energy and is fully integrated into the portfolio of science and energy programs. To meet growing domestic energy demand and provide a consistent, reliable foundation for the Department to ensure implementation of IE's mission and activities, including substantial grant programs for deployment of energy systems and new technologies, a separate appropriation is essential to align those programs and priorities that no longer fit with the Departmental management and oversight functions of the other offices in the DA appropriation. To better align Departmental program management structure and IE's office mission and activity scope with the budget, as well as to improve Congressional transparency, the FY 2017 Budget proposes IE's budget as a separate appropriation, consistent with the FY 2016 request.

Budget Structure Crosswalk ($K)
Proposed FY 2017 Budget Structure

	Proposed FY 2017 Budget Structure Office of Indian Energy		Total
FY 2016 Budget Structure	**Program Direction**	**Tribal Energy Program**	
Departmental Administration			
Office of Indian Energy			
Program Direction	4,800	18,130	22,930
Total	**4,800**	**18,130**	**22,930**

Tribal Energy Program

Overview

While Federally recognized Indian Tribes comprise just one percent of the US population, Indian Lands represent enormous renewable energy potential. In *Geospatial Analysis of Renewable Energy Technical Potential on Tribal Lands*[1] (2013), the National Renewable Energy Laboratory (NREL) reports that Indian Lands contain 5% of the total renewable energy generation potential of the entire nation and that solar electricity generation potential on Indian Lands alone could meet the total annual US electricity demand. The Tribal Energy Program's financial and technical assistance to Tribes, Alaska Native villages and corporations is critical in advancing sustainable energy innovation and deployment on Tribal lands, reducing energy costs, and assisting economic development in tribal communities where unemployment and poverty rates far exceed national averages.

The Tribal Energy Program offers technical and financial assistance opportunities to the 567 federally recognized Tribal governments and other federal agencies to overcome barriers to deploying small- to medium-scale clean energy generation projects (used for heat and electric power), as well as energy efficiency projects that result in reduced or stabilized energy costs, and more efficient energy usage. The Program supports technology innovations such as deploying micro-grids and wind/diesel hybrid systems to address the inadequate electricity infrastructure in tribal areas. Program activities continue to support DOE objectives, including reduced energy use and increased clean energy generation capacity, and leverage participation in the innovative DOE crosscut activities for micro grid and energy-water projects. Additionally, the Office addresses Tribal government priorities for energy sufficiency and associated economic development, as part of the President's "all of the above" strategy for creating new jobs and developing opportunities 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 funds clean energy development and deployment; energy efficiency; greenhouse gas emission mitigation strategies and technologies; and other innovative projects to address electrification needs on Indian lands.

Highlights of the FY 2017 Budget Request

In FY 2017, the Office of Indian Energy continues its intertribal and deployment grant programs. The Intertribal effort leverages energy expertise at the regional level to achieve more focused and efficient use of limited government resources. In addition, the Intertribal effort provides tribes with an efficient mechanism to respond to recent initiatives including new emission restrictions and renewable energy development opportunities under the Clean Power Plan and develop targeted local and regional clean energy solutions for climate impacts identified in the Vulnerabilities Report and the National Strategy for the Arctic.

Although there are no significant changes in the types of Technical Assistance in FY 2017, the level of effort is expected to double in response to the greatly increased number of requests for Technical Assistance and increased quality of applications for financial assistance as a result of the US leadership of the Arctic Council and this Office's outreach at events such as the Tribal Energy Summit and the White House Tribal Nations Conference.

Within the FY 2017 Budget Request, the Tribal Energy Program supports two Departmental Crosscuts: Grid Modernization and Energy-Water Nexus. The goal of the Grid crosscut efforts will be focused on micro grid 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 micro grid technology demonstration projects that can be leveraged into tribal utilities and tribal community energy development efforts. Funding will be $1 million for these grid activities.

[1] Doris, E., *Geospatial Analysis of Renewable Energy Technical Potential on Tribal Lands*. DOE/IE-0013 (Feb, 2013).

IE will also support outreach and demonstration projects for energy-water projects identified by the crosscut efforts that are most relevant to Indian tribes. Initial focus will be on energy-water technologies that improve energy efficiencies of drinking water and waste water systems on tribal lands—an area contemplated in the energy-water demonstration projects proposals. IE anticipates funding up to $1 million for these energy-water activities.

Tribal Energy Program
Funding ($K)

	FY 2015 Enacted	FY 2015 Current	FY 2016 Enacted	FY 2017 Request	FY 2017 vs FY 2016
Tribal Energy Program					
Technical Assistance[2]	0	0	0	6,000	+6,000
Tribal Energy Deployment Program (formerly Tribal Energy Grant Program)[3]	0	0	0	7,130	+7,130
Intertribal Energy Program	0	0	0	5,000	+5,000
Total, Tribal Energy Program	**0**	**0**	**0**	**18,130**	**+18,130**

Tribal Energy Program
Funding (Comparable) ($K)

	FY 2015 Enacted	FY 2015 Current	FY 2016 Enacted	FY 2017 Request	FY 2017 vs FY 2016
Tribal Energy Program					
Technical Assistance	3,739	3,739	2,900	6,000	+3,100
Tribal Energy Deployment Program (formerly Tribal Energy Grant Program)	7,990	7,990	4,900	7,130	+2,230
Intertribal Energy Program	3,000	3,000	5,000	5,000	+0
Total, Tribal Energy Program	**14,729**	**14,729**	**12,800**	**18,130**	**+5,330**

[2] In FY 2016, Technical Assistance was funded within the Departmental Administration Appropriation.
[3] In FY 2016, Tribal Energy Deployment Grants Program was funded within the Departmental Administration Appropriation.

Activities and Explanation of Changes

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
Tribal Energy Program $0 ($12,800,000)	**$18,130,000**	**+$18,130,000 (+$5,330,000)**
Technical Assistance $0 ($2,900,000)	**$6,000,000**	**+$6,000,000 (+$3,100,000)**
Technical Assistance programs include education and training programs to disseminate information to Indian Country through on-line training, regional/national workshops, webinars, and printed guides and materials and to support tribal energy development and capacity-building priorities. In addition, Technical Assistance is provided to Tribes through the Strategic Technical Assistance Response Teams (START), 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. 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. 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.	Technical Assistance programs include education and training programs to disseminate information to Indian Country through on-line training, regional/national workshops, webinars, and printed guides and materials and to support tribal energy development and capacity-building priorities. In addition, Technical Assistance is provided to Tribes through the Strategic Technical Assistance Response Teams (START), 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. 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. 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.	The FY 2017 reflects the recent increase in request from Indian Country for Technical Assistance and anticipates that the number of requests will double, principally as a result of: • New national, state, and local energy and environmental regulations, policies and incentives that affect tribes, including the extension of the Production Tax Credit for renewable energy, regulations on energy facilities under the Clean Power Plan, and US commitments to increase renewable energy and reduce pursuant to COP21; • Leveraging relationships with regional and national tribal organizations and across the federal government pursuant to enhanced cooperation between DOE and other federal agencies including DOI, USDA and others; • Outreach efforts including the National Tribal Energy Summit and implementation of the National Strategy for the Arctic Region;

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
Maintain internships at DOE National Laboratories and field sites for Native American graduate students interested in careers in the energy sector. New technical assistance initiatives will include remote community renewable energy hybrid system deployment support, micro grid and water energy project outreach support, and increased efforts to assist tribes and Alaska Native villages with climate change mitigation, adaption, and resiliency efforts.	Maintain internships at DOE National Laboratories and field sites for Native American graduate students interested in careers in the energy sector. These funds support increased technical assistance, energy system improvements and deployment and follow-on studies based on the recommendations of DOE research and outreach, including a survey of over 30 native communities for the DOE-IE *Tribal Energy System Vulnerabilities to Climate Change and Extreme Weather* report, the recent Rural Alaska Utility Study, and the National Tribal Energy Summit participation of over 500 participants from over 90 tribes across CONUS and Alaska.	• Enhanced private sector partnerships and growing requests for tribal access to lending for energy projects, including efficiency efforts with tribal housing authorities, outreach to corporations, trade groups, utilities, and other industries, as well as federal and state entities; • More efficient, effective, and responsive delivery of assistance made possible by recent deployment of federal personnel in Alaska and the Arctic and planned increased federal personnel at Headquarters. • New requests for seasonal or small-scale, low-impact hydro generation in rural communities to offset high diesel costs.
Tribal Energy Deployment Program (formerly Tribal Energy Grant Program) **$0 ($4,900,000)**	**$7,130,000**	**+$7,130,000 (+$2,230,000)**
Competitive grant program to support clean energy and energy efficiency deployment on tribal lands and in Alaska Native villages.	The FY 2017 request will continue existing Energy Deployment Programs, including $2 million for energy crosscut projects. The Tribal Energy Deployment Program will include the following topics: • Conservation and efficiency in housing and other buildings • Demonstration of innovative technologies • Micro-grids in remote or islanded communities • Climate change resiliency • Distribution-scale	The reduction in funding from the FY 2016 Enacted to the FY 2017 Request will result in approximately 4-5 fewer awardees.

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
	• Energy-Water Nexus	
Intertribal Energy Program $0 ($5,000,000)	**$5,000,000**	**+$5,000,000 (+$0)**
The Intertribal Energy Program assists tribes in building capacity to develop and manage their own energy programs and to leverage their tribal expertise for more focused and efficient delivery of programs to tribes. This program leverages the outreach and networking capability of existing regional Intertribal organizations to help IE deliver technical assistance and other energy-specific expertise. Through up to 10 competitive awards, the funds support one energy expert in each of the intertribal organizations who will further the IE reach into Indian Country by: • Responding to local and regional energy needs of tribes and surrounding non-tribal communities, utilities and industry. • Promoting Indian tribal energy development, efficiency, and use, by coordinating energy solutions. • Reduce or stabilize energy costs by providing a network of regional and national energy professionals who will deliver technical assistance and technical information to Tribes in their area. • Enhance and strengthen Tribal energy and economic infrastructure relating to electrification with increased access to financial assistance offerings. • Establish programs to assist Intertribal organizations in meeting energy education, research and development, planning, and management needs while building human capacity, leadership, and management expertise. • Support and implement regional research projects. • Build a network of communication hubs that will inform DOE IE regarding needs in regional areas.	The Intertribal Energy Program assists tribes in building capacity to develop and manage their own energy programs and to leverage their tribal expertise for more focused and efficient delivery of programs to tribes. This program leverages the outreach and networking capability of existing regional Intertribal organizations to help IE deliver technical assistance and other energy-specific expertise. Through up to 10 competitive awards, the funds support one energy expert in each of the intertribal organizations who will further the IE reach into Indian Country by: • Responding to local and regional energy needs of tribes and surrounding non-tribal communities, utilities and industry. • Promoting Indian tribal energy development, efficiency, and use, by coordinating energy solutions. • Reduce or stabilize energy costs by providing a network of regional and national energy professionals who will deliver technical assistance and technical information to Tribes in their area. • Enhance and strengthen Tribal energy and economic infrastructure relating to electrification with increased access to financial assistance offerings. • Establish programs to assist Intertribal organizations in meeting energy education, research and development, planning, and management needs while building human capacity, leadership, and management expertise. • Support and implement regional research projects. • Build a network of communication hubs that will inform DOE IE regarding needs in regional areas.	There is no significant change in this activity.

Program Direction

Overview

Program Direction provides federal staff who are responsible for the management and execution of IE's programs and activities, as well as the associated support contractors, rent, supplies, and travel, among other related expenses. The 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, and provide day-to-day management of national technical assistance, educational activities, and capacity building programs.

In FY 2016, there are 5 FTEs at Washington, D.C. Headquarters, 3 FTEs in Alaska, and 1 FTE in Golden, Colorado. The Headquarters staff includes executive leadership, program management of the technical assistance delivered within the contiguous US, policy analysis, operational management, and administrative support. The Golden, Colorado, staff perform grant management functions for IE financial assistance programs.

Three Alaska-based FTEs 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, and implement the US commitments to clean energy from the 2015 COP21 proceedings in Paris.

Highlights of the FY 2017 Budget Request

The increase in FY 2017 supports 6 new FTEs: 3 to support executive leadership, policy analysis, and operations; 2 to support technical assistance delivered within CONUS, and 1 to support grant management in Golden, Colorado. The additional Program Direction cost to support these staff members is $1.6 million.

Program Direction
Funding ($K)

	FY 2015 Enacted	FY 2015 Current	FY 2016 Enacted	FY 2017 Request	FY 2017 vs FY 2016
Program Direction Summary					
Washington Headquarters					
Salaries and Benefits	0	0	0	2,606	+2,606
Travel	0	0	0	390	+390
Support Services	0	0	0	560	+560
Other Related Expenses	0	0	0	544	+544
Total, Washington Headquarters	**0**	**0**	**0**	**4,100**	**+4,100**
Golden					
Support Services	0	0	0	700	+700
Total, Golden	**0**	**0**	**0**	**700**	**+700**
Total Program Direction					
Salaries and Benefits	0	0	0	2,606	+2,606
Travel	0	0	0	390	+390
Support Services	0	0	0	1,260	+1,260
Other Related Expenses	0	0	0	544	+544
Total, Program Direction	**0**	**0**	**0**	**4,800**	**+4,800**
Federal FTEs	**0**	**0**	**0**	**15**	**+15**
Support Services					
Management Support					
Administrative Support Contract	0	0	0	560	+560
Grant Program Management	0	0	0	700	+700
Total Management Support	**0**	**0**	**0**	**1,260**	**+1,260**
Total, Support Services	**0**	**0**	**0**	**1,260**	**+1,260**
Other Related Expenses					
Energy IT Services - Desktop Services	0	0	0	270	+270
WCF	0	0	0	200	+200
Other Services	0	0	0	74	+74
Total, Other Related Expenses	**0**	**0**	**0**	**544**	**+544**

Program Direction
Funding (Comparable) ($K)

	FY 2015 Enacted	FY 2015 Current	FY 2016 Enacted	FY 2017 Request	FY 2017 vs FY 2016
Program Direction Summary					
Washington Headquarters					
Salaries and Benefits	844	844	1,389	2,606	+1,217
Travel	234	234	251	390	+139
Support Services	152	152	470	560	+90
Other Related Expenses	40	40	430	544	+114
Total, Washington Headquarters	**1,271**	**1,271**	**2,540**	**4,100**	**+1,560**
Golden					
Support Services	0	0	660	700	+40
Total, Golden	**0**	**0**	**660**	**700**	**+40**
Total Program Direction					
Salaries and Benefits	844	844	1,389	2,606	+1,217
Travel	234	234	251	390	+139
Support Services	152	152	1,130	1,260	+130
Other Related Expenses	40	40	430	544	+114
Total, Program Direction	**1,271**	**1,271**	**3,200**	**4,800**	**1,600**
Federal FTEs	**7**	**7**	**9**	**15**	**+6**
Support Services					
Management Support					
Administrative Support Contract	152	152	470	560	+90
Grant Program Management	0	0	660	700	+40
Total Management Support	**152**	**152**	**1,130**	**1,260**	**+130**
Total, Support Services	**152**	**152**	**1,130**	**1,260**	**+130**
Other Related Expenses					
Energy IT Services - Desktop Services	0	0	250	270	+20
WCF	0	0	150	200	+50
Other Services	0	0	30	74	+10
Total, Other Related Expenses	**0**	**0**	**430**	**544**	**+114**

Program Direction

Activities and Explanation of Changes

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
Program Direction $0 ($3,200,000)	**$4,800,000**	**+$4,800,000 (+$1,600,000)**
Salaries and Benefits $0 ($1,389,000)	**$2,606,000**	**+$2,606,000 (+$1,217,000)**
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.	Salaries and Benefits funding supports 15 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.	The 6 new FTEs include: • 2 for Operations • 2 for CONUS Programs • 1 for Financial Assistance Programs • 1 for Administration
Travel $0 ($251,000)	**$390,000**	**+$390,000 (+$139,000)**
Travel funding provides for necessary program management functions at field locations, and increased outreach activity for Arctic region	Travel funding provides for necessary program management functions at field locations, and increased outreach activity for rural locations and the Arctic region.	Supports travel requirements for Headquarters and field site staff conducting management and oversight of increased program activity.
Support Services $0 ($1,130,000)	**$1,260,000**	**+$1,260,000 (+$130,000)**
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.	Funding for administrative and management support at the Golden Field Site and Washington Headquarters.	No significant change.
Other Related Expenses $0 ($430,000)	**+$544,000**	**+$544,000 (+$114,000)**
Maintain funding 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 FTEs, increased Working Capital Fund requirements, and employee credit monitoring.

Department of Energy
FY 2017 Congressional Budget
Funding by Appropriation by Site
($K)

Indian Energy Policy and Programs	FY 2015	FY 2016	FY 2017
Golden Field Office			
Indian Energy Policy and Programs			
Tribal Energy Deployment Program	7,990	4,900	7,130
Intertribal Energy Program	3,000	5,000	5,000
Program Direction	0	660	700
Total, Golden Field Office	**10,990**	**10,560**	**12,830**
National Renewable Energy Laboratory			
Indian Energy Policy and Programs			
Technical Assistance	2,300	898	2,550
Total, National Renewable Energy Laboratory	**2,300**	**898**	**2,550**
Sandia National Laboratories			
Indian Energy Policy and Programs			
Technical Assistance	750	725	750
Total, Sandia National Laboratories	**750**	**725**	**750**
Washington Headquarters			
Indian Energy Policy and Programs			
Technical Assistance	689	1,077	2,400
Program Direction	1,271	2,540	4,100
Total, Washington Headquarters	**1,960**	**3,617**	**6,500**
Western Area Power Administration			
Indian Energy Policy and Programs			
Technical Assistance	0	200	300
Total, Western Area Power Administration	**0**	**200**	**300**
Total, Indian Energy Policy and Programs	**16,000**	**16,000**	**22,930**

Department Of Energy

FY 2017 Congressional Budget

Funding By Appropriation By Site

($K)

Indian Energy Policy and Programs	FY 2015 Current	FY 2016 Enacted	FY 2017 Request
Golden Field Office			
Indian Energy Policy and Programs			
Program Direction	0	660	700
Tribal Energy Program	10,990	9,900	12,130
Total, Indian Energy Policy and Programs	**10,990**	**10,560**	**12,830**
Total, Golden Field Office	**10,990**	**10,560**	**12,830**
National Renewable Energy Laboratory			
Indian Energy Policy and Programs			
Technical Assistance	2,300	898	2,550
Total, National Renewable Energy Laboratory	**2,300**	**898**	**2,550**
Sandia National Laboratories			
Indian Energy Policy and Programs			
Technical Assistance	750	725	750
Total, Sandia National Laboratories	**750**	**725**	**750**
Washington Headquarters			
Indian Energy Policy and Programs			
Program Direction	1,271	2,540	4,100
Technical Assistance	689	1,077	2,400
Total, Indian Energy Policy and Programs	**1,960**	**3,617**	**6,500**
Total, Washington Headquarters	**1,960**	**3,617**	**6,500**
Western Area Power Administration			
Indian Energy Policy and Programs			
Technical Assistance	0	200	300
Total, Western Area Power Administration	**0**	**200**	**300**
Total, Indian Energy Policy and Programs	**16,000**	**16,000**	**22,930**

Office of Technology Transitions

Office of Technology Transitions

Office of Technology Transitions
Proposed Appropriation Language

For Department of Energy expenses necessary for technology transitions and commercialization activities in carrying out the purposes of the Department of Energy Organization Act (42 U.S.C. 7101 et seq.), section 1001 of the Energy Policy Act of 2005 (42 U.S.C. 16391), and the Stephenson-Wydler Technology Innovation Act of 1980 (15 U.S.C. 3701 et seq.), $8,400,000, to remain available until September 30, 2018.

Explanation of Change

This is a new appropriation.

Public Law Authorizations

- Public Law 109–58, "Energy Policy Act of 2005," Title V
- 15 U.S. Code § 3708(b & c) - Administrative arrangements – Corporation & Administrative authorization
- 15 U.S. Code § 3710(a) - Utilization of Federal technology
- 42 U.S. Code § 2121(a) - Authority of Commission
- 42 U.S. Code § 16391(e) - Establishes the Energy Technology Commercialization Fund
- 42 U.S. Code § 16391 - Improved technology transfer of energy technologies & Technology Transfer Coordinator

Office of Technology Transitions
Funding Summary ($K)

FY 2015 Enacted	FY 2015 Current	FY 2016 Enacted	FY 2017 Request
0	0[1]	0	8,400

Overview

The mission of the Office of Technology Transitions (OTT) is to expand the commercial impact of the Department of Energy's (DOE) portfolio of Research, Development, Demonstration and Deployment (RDD&D) activities over the short, medium and long term. The OTT's work includes implementing the key responsibilities and duties assigned to the statutorily-created Technology Transfer Coordinator (see 42 U.S. Code § 16391), program management of the Technology Commercialization Fund (TCF), development of the statutory Technology Transfer Execution Plan and Annual Technology Transfer Report, and the implementation and management of the Clean Energy Investment Center (CEIC).

The OTT is led by the Department's Technology Transfer Coordinator, the principal advisor to the Secretary of Energy on all matters related to technology transfer, commercialization, and lab-to-market initiatives. The Coordinator serves a corporate role to develop and implement a strategic plan to ensure the Department's transition of technologies to the market. This includes coordinating early-stage technology transition activities within Departmental programs, later-stage applied technology research and development, and eventual deployment and commercialization of energy technologies by the private sector. These activities span the work of the National Laboratories and external stakeholders conducting research funded by the Department.

Technology transfer is a national priority as evidenced by enacted legislation and policy initiatives. OTT activities accomplish priorities set out in policy documents such as: (1) Climate Action Plan: Deploying Clean Energy, Unlocking Long-Term Investment in Clean Energy Innovation; (2) Cross-Agency Priority Goal on Lab-to-Market: Accelerating and improving the transfer of new technologies from the laboratory to the commercial marketplace; and (3) Presidential Memorandum 2011: Accelerating Technology Transfer and Commercialization of Federal Research in Support of High-Growth Businesses. The OTT activities align with the Department's Strategic Goal #1, Objective #3: "Deliver the scientific discoveries and major scientific tools that transform our understanding of nature and strengthen the connection between advances in fundamental science and technology innovation."

One way in which the OTT fulfills this goal is by executing the Technology Commercialization Fund (TCF), which Congress authorized in Section 1001 of the Energy Policy Act of 2005 (42 U.S. Code § 16391(e)) as follows:

> "The Secretary shall establish an Energy Technology Commercialization Fund, using 0.9 percent of the amount made available to the Department for applied energy research, development, demonstration, and commercial application for each fiscal year based on future planned activities and the amount of the appropriations for the fiscal year, to be used to provide matching funds with private partners to promote promising energy technologies for commercial purposes."

Beginning in FY 2017, 0.9% of funding for the applied energy programs' research and development activities will be transferred into a TCF, managed by the OTT. The estimated FY 2017 transfer is approximately $20 million based on the Department's FY 2017 request; however this funding level will be calculated from the FY 2017 enacted budget.

The TCF will be used to provide catalytic seed-stage funding for high-potential national laboratory-based energy technology not yet transferred to the private sector. The TCF funding will focus on early commercialization activities such as market analysis, customer development, prototype development, testing and validation. To further facilitate transition to the private sector, laboratories will conduct all these activities in cost-shared collaboration with a private sector partner or partners. In FY 2017 the OTT will make use of the TCF to fund a broad spectrum of promising energy technologies from across DOE's program areas and the National Laboratories.

[1] Starting in FY 2015, and throughout FY 2016, funding to start up and operate OTT (Salaries and Benefits, Travel, Technology Transition Activities, Support Services, and Other Related Expenses) to execute its mission of technology transitions is provided via an assessment within science and the applied energy programs.

The OTT also manages the Clean Energy Investment Center (CEIC). The CEIC's primary mission is to catalyze private, mission-oriented investment in energy technologies to address the significant gap in U.S. clean energy technology investment. The CEIC will be a single point of access to identify DOE and laboratory experts, projects and informational reports and whitepapers covering DOE's portfolio of energy research, initiatives and projects. The CEIC will lead efforts to develop a Lab "Partnering" Service to enable connections between the private sector and the National Laboratories. In FY 2017 OTT will coordinate with applied program offices on partnering-related efforts to ensure individual programs are executed in a consistent manner. Ultimately, all partnering efforts will be consolidated under OTT.

Other major OTT activities will include a Laboratory Technology Transitions Awards program focused on elevating and prioritizing the transition of technologies to the market.

The OTT mission will be accomplished and shaped through three areas of activities: Engagement, Data Collection and Analysis, and Evidenced-based Evaluations, detailed in the Activities and Explanation of Changes table.

Highlights of the FY 2017 Budget Request

The Department requests $8,400,000 for the OTT in FY 2017. For FY 2015 and FY 2016, the technology transition activities are funded through funds executed within DOE's applied energy programs. For FY 2017, the Department is seeking funding consistent with the OTT's operational requirements, to fully establish the OTT as an integral function within DOE. The resources requested for FY 2017 are required to maintain adequate staffing to fulfill Congressional and Administration direction to increase Departmental engagement for the transition of new and evolving energy technology to the U.S. markets.

Office of Technology Transitions
Funding by Congressional Control ($K)

	FY 2015 Enacted	FY 2015 Current	FY 2016 Enacted	FY 2017 Request	FY 2017 vs FY 2016 Enacted
Office of Technology Transitions					
Office of Technology Transitions	0	0[2]	0	8,400	+8,400
Total, Office of Technology Transitions	**0**	**0**	**0**	**8,400**	**+8,400**
Federal FTEs	**0**	**0**	**0**	**11**	**+11**

[2] Starting in FY 2015, and throughout FY 2016, funding to start up and operate OTT (Salaries and Benefits, Travel, Technology Transition Activities, Support Services, and Other Related Expenses) to execute its mission of technology transitions is provided via an assessment within science and the applied energy programs.

Office of Technology Transitions

Overview

The Office of Technology Transitions (OTT) staff provides strategic management and support of the Department's technology-to-market activities. This includes the duties of the statutorily-created Technology Transfer Coordinator, management of the Technology Commercialization Fund, development of the statutory Technology Transfer Execution Plan and Annual Technology Transfer Report and the development and management of the Clean Energy Investment Center (CEIC). This includes the coordination of technology transition activities across the whole Department.

OTT Coordination and Collaboration

While the terms "technology transfer" and "technology transitions" are used interchangeably in the context of the National Laboratories, both terms refer "to the process by which knowledge, intellectual property or capabilities developed at the DOE's National Laboratories, single-purpose research facilities, plants, and other facilities are transferred to other entities, including private industry, academia, state or local governments." For OTT, "technology transitions" more accurately reflects the wider scope of the efforts to which DOE is committed. The OTT is directed not to simply guide singular acts of technology transfer, but rather to foster multiple handoffs between scientists and innovators and investors that make up the dynamic process of technology transitions and nurture the nation's innovation ecosystem. To fulfill this direction, OTT works to increase the commercial impact of DOE investments through 1) the transition of DOE developed technologies to the private sector and 2) private sector utilization of national laboratory facilities and expertise.

A priority for DOE is to work across programs and with the National Laboratories to ensure an enterprise-wide emphasis on technology transitions as an outcome of the nation's investment in energy research and development. OTT works with DOE's program offices to integrate mission-appropriate technology transition goals into their strategic activities, clarify and streamline relevant policies and procedures, and coordinate and disseminate best practices across the Departmental programs' technology to markets activities.

In overseeing and coordinating technology transitions involving Departmental R&D programs, OTT works with corporate staff offices to ensure that best practices in technology transitions are identified and implemented. OTT coordinates technology transitions across other Departmental programs and facilitates exchange of information regarding innovative technology and commercialization with entities such as ARPA-E and LPO. For example, OTT has tracked and elevated the EERE Lab Impact Pilots across the Department and the Office of Nuclear Energy's launch of a Small Business Voucher pilot is an example of how these pilots are being adopted by other programs.

OTT is engaged in developing and deploying Department-wide tools to facilitate engagement with the private sector and investors which will accelerate the commercialization of technologies. For example, OTT is now responsible for the Energy Innovation Portal originally developed by EERE, and is developing the Lab Partnering Service to access technology specific information and expertise across all of DOE and its National Laboratories. A recent example of OTT's efforts is its close coordination with the Office of Nuclear Energy's (NE's) Gateway for Accelerated Innovation in Nuclear (GAIN). Through GAIN NE will more effectively engage with private sector stakeholders, speeding consideration of innovative ideas toward a less expensive, nearer term level of commercial readiness of NE-related technologies. Another example is the OTT geo-mapping data tool developed from its annual data call on National Laboratory agreements. This tool has been requested by several National Laboratories and NNSA for use in their own planning.

OTT implements national policy priorities associated with technology transfer as enacted into law by Congress and as identified by Administration policies. OTT coordinates activities of these national priorities by working across multiple federal agencies through the Lab-to-Market Cross Agency Priority goal. This provides an opportunity for OTT to take lessons learned from other agencies and bring them to DOE. OTT develops statutory Department-wide annual reports on DOE's technology transfer activities. These reports consist of data collected from across the DOE enterprise including all of the DOE Laboratories, sites, facilities and programs. OTT uses the data collected to conduct analysis resulting in the establishment of clear goals and objectives for the National Laboratories, other partners, and the Department by facilitating the evaluation of best practices and effective metrics. The information is used to continually improve the delivery of the DOE missions over the short, medium, and long term, and this data also is used to help understand and encourage

laboratory planning, evaluation, and professional development of laboratory staff across all of the Department's laboratories.

Technology Transition Activities
The OTT mission will be accomplished through the Clean Energy Investment Center (CEIC) and shaped by three areas of key activities: Stakeholder Engagement, Data Collection and Analysis, and Evidenced-based Impact Evaluations.

The CEIC's primary mission is to catalyze private, mission-oriented investment in energy technologies to address the significant gap in U.S. clean tech investment. CEIC will create and manage a web based single point of access that makes the Department's resources more readily available to the public, including to mission-driven investors, by providing connections to points of contact and subject matter experts within relevant DOE programs and USG energy programs. The portal will allow the public and investors to access research and analysis produced by DOE and the National Laboratories on relevant developments in clean energy technology. Also, it is through the Center's web platform that DOE will aggregate and make available existing public information on entities currently engaged in partnerships with DOE.

Stakeholder engagement is central to successful technology transfer. OTT engages national labs, the business and industrial sectors and other stakeholders to gather their feedback and input on key areas of focus to maximize the impact of DOE's technology transitions activities. DOE's Technology Transfer Coordinator (who also serves as OTT's Director) engages the private sector and venture capitalists, as well as others, to transition technologies to the market. The Coordinator also oversees the statutory Technology Transfer Working Group (TTWG). The TTWG is a group of national laboratory and facility representatives which focuses on technology transfer activities, issues, and concerns at the working level. Engagement with these two groups will help set priorities for OTT and strengthen relationships focused on efficient transition of technologies to the market. The OTT, through its web site and the CEIC, increases engagement between laboratories and the private sector to facilitate communication and transparency of lab capabilities.

A significant project for the OTT, being developed by CEIC, is developing and implementing the DOE National Laboratory Partnering Service, which is a customer oriented service provided by a group representing all 17 DOE National Laboratories. The service will specialize in answering external stakeholder questions about the capabilities of the Laboratories and then directing those stakeholders to the best capabilities of the whole National Laboratories enterprise. The lab representatives will be technical experts, but they will also be able to interpret and translate stakeholder needs into laboratory capabilities. The representatives will facilitate the development of relationships between the wide ranging laboratory enterprise and the diverse needs of stakeholders. This will streamline access to exceptional capabilities that are often difficult for stakeholders to find because the capabilities are distributed across the lab enterprise and challenging for the layperson to understand. This service will help the National Laboratories directly interact with the private sector. With respect to the Lab-to-Market CAP Goal vision, this service will "significantly accelerate and improve technology transfer by streamlining administrative processes, facilitating partnerships with industry, evaluating impact, and opening federal research and development (R&D) assets as a platform for innovation and economic growth."

OTT conducts streamlined data collection and analysis activities in order to deliver the Department-wide statutorily-mandated annual technology transfer report, the annual Technology Transfer Execution Plan. Also, the data collection and analysis helps establish clear goals and objectives for the National Laboratories, other partners, and the Department by facilitating the evaluation of best practices and effective metrics. The resulting information is used to continually improve the delivery of the DOE missions over the short, medium, and long term, and it also is used to help understand and encourage laboratory planning, evaluation, and professional development of Laboratory staff. OTT's collection of data will be shared, as appropriate, with the public to enhance its understanding of DOE resources such as user facilities and licensable technologies.

Evidence-based impact evaluations and analysis are a core part of OTT's efforts. This work informs the management of Research and Development (R&D) portfolios, and the transition of technology to the market from programs across the department. Evaluation metrics, outputs and outcomes, and other information from national laboratories and DOE grantees are analyzed to understand the Department's impact on the commercial sector. Studies are conducted on the programs and activities, such as the Agreements for Commercializing Technology pilot, to inform DOE decision-making and policy-setting. Additionally, in-depth case studies are conducted on specific technology areas to be used to evaluate the impact of DOE's RDD&D portfolio. The findings from these studies will identify the correlation between pilot programs and

the impacts of those programs, which will enable effective program design, new policies, new pilot programs, or other activities to facilitate the transition of technologies to the market. In addition, these evaluations examine, develop best practices from, and communicate the broad impact of DOE funded technology through the use of peer reviewed case studies employing methodologies similar to that developed by the National Academy of Sciences (NAS), or similar, approaches to impact evaluations. These evaluations focus on DOE funded and commercialized technologies or whole sectors, and their energy, economic and environmental impacts.

Office of Technology Transitions
Funding ($K)

	FY 2015 Enacted	FY 2015 Current	FY 2016 Enacted	FY 2017 Request	FY 2017 vs FY 2016 Enacted
Washington Headquarters					
Salaries and Benefits	0	0[3]	0	1,974	+1,974
Travel	0	0	0	120	+120
Technology Transition Activities	0	0	0	5,786	+5,786
Other Related Expenses	0	0	0	520	+520
Total, Washington Headquarters	**0**	**0**	**0**	**8,400**	**+8,400**
Federal FTEs	**0**	**0**	**0**	**11**	**11**

Authorizations

Public Law 109–58, "Energy Policy Act of 2005," Title V
15 U.S. Code § 3708(b & c) - Administrative arrangements – Corporation & Administrative authorization
15 U.S. Code § 3710(a) - Utilization of Federal technology
42 U.S. Code § 2121(a) - Authority of Commission
42 U.S. Code § 16391(e) - Establishes the Energy Technology Commercialization Fund
42 U.S. Code § 16391 - Improved technology transfer of energy technologies & Technology Transfer Coordinator

[3] Starting in FY 2015, and throughout FY 2016, funding to start up and operate OTT (Salaries and Benefits, Travel, Technology Transition Activities, Support Services, and Other Related Expenses) to execute its mission of technology transitions is provided via an assessment within science and the applied energy programs.

Technology Transition Activities

	FY 2015 Enacted	FY 2015 Current	FY 2016 Enacted	FY 2017 Request	FY 2017 vs FY 2016 Enacted
Technology Transition Activities					
Clean Energy Investment Center	**0**	0[4]	0	1,380	+1,380
Stakeholder Engagement	**0**	0	0	3,100	+3,100
Data Collection and Analysis	**0**	0	0	485	+485
Evidenced-based Evaluations	**0**	0	0	500	+500
Support Services - Contractor Support	**0**	0	0	289	+289
Support Services - Subscriptions & Other Office Requirements	**0**	0	0	32	+32
Total, Technology Transition Activities	**0**	**0**	**0**	5,786	+5,786
Total, Technology Transition Activities	**0**	**0**	**0**	**5,786**	**+5,786**

Activities and Explanation of Changes

FY 2016 Enacted[5]	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
Salaries and Benefits $0	**$1,974,000**	**+$1,974,000**
Funding, executed through the energy and science programs, will be used to support technology transition activities consistent with objectives within their program of work.	Funding will be used to support the FY 2017 OTT staffing level of 11 FTEs.	Funding will be used to support the FY 2017 OTT staffing level of 11 FTEs and anticipated promotions and pay increase.

[4] Starting in FY 2015, and throughout FY 2016, funding to start up and operate OTT (Salaries and Benefits, Travel, Technology Transition Activities, Support Services, and Other Related Expenses) to execute its mission of technology transitions is provided via an assessment within science and the applied energy programs.

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
Travel$0	**$120,000**	**+$120,000**
Funding, executed through the energy and science programs, supports travel requirements technology transition engagement and information gathering; and information sharing activities consistent with objectives within their program of work.	Funding supports travel requirements for the OTT engagement, and information gathering and sharing activities.	Funding supports travel requirements for the OTT engagement, and information gathering and sharing activities.
Technology Transition Activities $0	**$5,786,000**	**+$5,786,000**
Clean Energy Investment Center (CEIC): To support OTT start-up, obligations are executed through the energy and science programs while activities and tasks are managed by OTT. For FY 2016, Phase 1 of the Partnering Service involves the start of support at each of the 17 DOE National Laboratories to regularly survey and respond to the requests relevant to their respective laboratory's capabilities and the development of an outreach strategy to the investment community for each lab to enable information exchange. Phase 1 will also start outreach to other federal agencies within the Lab-to-Market CAP Goal. Outreach will include the development of a network of individuals across the government who can be accessed through the tool, but review of submissions through the tool will not take place until Phase 2.	($1,380,000) Conduct five stakeholder engagement workshops, implement enhancements to web based single point of access platform, prepare technical assistance reports to share research and analysis produced by DOE and its 17 National Laboratories on relevant developments in clean energy technology. The CEIC will continue prototyping a DOE project query database, where information on entities currently engaged in partnerships with DOE will be publically available. In addition, the CEIC will design and implement an evaluation of the CEIC single point of access tool. Phase 2 of the DOE National Laboratory Partnering Service will continue this Lab-to-Market CAP Goal with all of the National Laboratories. Employees at other federal agencies will be able to review submissions and, when applicable, connect innovators or potential investors to subject matter experts within their agency for responses.	Funds stakeholder engagement roundtables. The web platform design and development phase will be completed and transition to operation. Complete the design of the evaluation of the CEIC single point of access tool and moving into the ongoing assessment phase.

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
Stakeholder Engagement: Develop the Department's strategic vision and goals for the use of the Technology Commercialization Fund (TCF). Begin enhancements of a digital patent tool that will connect small businesses, innovators, government agencies, and the general public to the available patents and patent applications developed by the Department of Energy and its National Laboratories. This tool will allow for the sorting and searching of emerging and available energy technology patents, while allowing the government to better track and measure licensing leads. Evaluate the utility and suitability of establishing a new Lab awards program that would further signal the importance of the DOE's technology transitions mission and emphasize the significance of commercial impact, contributing to the long-term transition of technologies to the market from the National Laboratories. Begin the design and deployment of web based single point of access through the CEIC that makes the Department's resources and capabilities more readily available to the public, including to mission-driven investors, by providing connections to points of contact and subject matter experts within relevant DOE programs and USG energy programs. The software tool is being developed in collaboration with DOE program offices including the Office of Nuclear Energy, which will be using the Service for its Gateway for Accelerated Innovation in Nuclear (GAIN).	($3,100,000) Continue maintenance of the OTT web site, outreach to the National Laboratories via workshops, outreach to the public via workshops and roundtables, sponsorship of regional technology transfer events, continued development of the digital patent tool, and possibly funding a small-scale a Lab awards effort, depending on the outcomes of the FY 2016 evaluation.	Support for the digital patent tool as development continues to transition to operation, implementation of the Lab awards program, and support for the Lab capabilities research partnering service.

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
Data Collection and Analysis: Produce Department-wide statutorily-mandated annual technology transfer report. Finalize annual Technology Transfer Execution Plan. Other activities include: Data collection and visualization via geomapping, scoping the open data initiative, update the laboratories' user facility manuals.	($485,000) Continue development and maintenance of software tools for data management, mapping and visualization of technology transitions activities and resources for portfolio analysis and planning purposes. Develop and implement an open data initiative focused on making more information transparent about lab facilities, patents, scientists and other resources available to bring energy technologies to the market.	Supports the completion of the user facility manual updates, and the implementation of an open data initiative.
Evidenced-based Evaluations: Begin five rigorous, evidence-based impact evaluations and case studies that focus on DOE funded technologies or whole sectors, and their energy, economic and environmental impacts. Evaluations are of programs implemented by the OTT including the "partnering" service and the Technology Commercialization Fund.	($500,000) Conduct five (5) case studies on evolving technology funded by the federal government, capabilities research partnering impact evaluations, and continue ongoing TCF impact evaluation. For FY 2017, OTT will start the evaluation of the Lab Tech Transitions Awards Program.	Supports the completion of the Agreements for Commercializing Technology (ACT) Impact Analysis and the start of the Lab Tech Transitions Awards Program impact analysis.

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
Support Services - Contractor Support, Subscriptions & Other Office Requirements: Cover costs associated with contractor support, office operating expenses, and information subscription services such as electronic access to energy and environment information sources procured via annual subscription.	($321,000) Funding for contractor support, office operating expenses, and information subscription services such as Energy Daily, E&E Energy News, etc.	Supports office support contractors, and information source access.
Other Related Expenses $0	**$520,000**	**+$520,000**
Supports the business costs associated with the Department's Working Capital Fund (office space, phones, utilities, etc.); the Energy IT Services (IT equipment and support); E-Gov costs; as well as staff development and training to maintain and enhance work related skills and capabilities.	Continuation of FY 2016 activities.	Reflects the anticipated needs for overhead, IT equipment, network/LAN access/usage cost, and maintenance/enhancement of staff knowledge, skills and abilities.

Department Of Energy

FY 2017 Congressional Budget

Funding By Appropriation By Site

($K)

Office of Technology Transitions	FY 2015 Current	FY 2016 Enacted	FY 2017 Request
Washington Headquarters			
Office of Technology Transitions			
Office of Technology Transitions	0	0	8,400
Total, Washington Headquarters	**0**	**0**	**8,400**
Total, Office of Technology Transitions	**0**	**0**	**8,400**

Energy Information Administration

Energy Information Administration

U.S. Energy Information Administration

Proposed Appropriation Language

For necessary expenses in carrying out the activities of the U.S. Energy Information Administration, ($122,000,000) *$131,125,000*, 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. 95-620, 42 U.S.C. 8301, Powerplant and Industrial Fuel Use Act (1978)
P.L. 95-621, Natural Gas Policy 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 of 2014
P.L. 114-11, Energy Efficiency Improvement Act of 2015

Energy Information Administration
Congressional Control: National Energy Information System (NEIS)
($K)

FY 2015 Actual	FY 2016 Enacted	FY 2017 Request
117,000	122,000	131,125

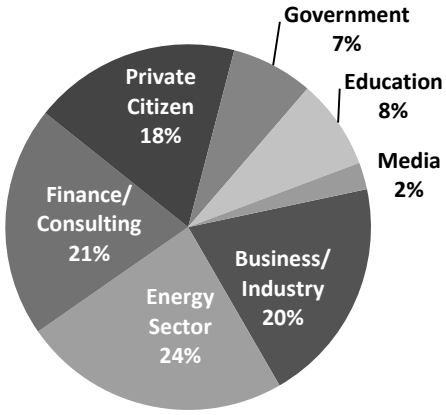
Overview

The U.S. 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 government, 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 complex and interrelated, EIA is evolving its program to provide comprehensive coverage of energy markets to an expanding customer base.

Figure 1: EIA Customers



Source: 2015 Customer Satisfaction Survey

Highlights of the FY 2017 Budget Request

The FY 2017 budget request enables EIA to continue its core data collection, analysis, and dissemination activities, while also pursuing four strategic initiatives to provide the public more detailed, timely, and accurate data and analysis in the areas of commercial building efficiency, regional petroleum markets, international trends, and vehicle transportation.

- **Revamp petroleum data and analysis to provide more regional detail (+$1.5M):** EIA's petroleum data have historically focused on the five World War II era Petroleum Administration for Defense (PAD) Districts, which is no longer sufficient to address many policymaker questions and market issues. EIA is in the process of adding more regional detail, which will require both one-time updates and a permanent increase in processing and review effort to produce more granular information. EIA also is planning to provide additional analysis of regional refining and product markets.

- **Enhance commercial building energy efficiency data** (+**$4.4M**): EIA will build upon new methodologies from its residential building data collection to realize efficiencies in its commercial building survey, such as better sampling frames, more efficient collection modes, and development of a new survey instrument for collecting commercial building energy characteristics. Additionally, in response to the Energy Efficiency Improvement Act of 2015, EIA will continue to evolve its energy consumption program by beginning to test methods for tenant-level energy data collections. EIA will pilot a study to evaluate what sampling frames and techniques, survey instruments, collection protocols, and statistical estimation methods would support a "Tenant Star" energy efficiency rating system.

- **Expand international analysis, including Canada-Mexico collaboration and key economies in Asia (+$2.1M):** With rapid growth in U.S. oil and natural gas production there is an acute need for better understanding of domestic energy markets within the context of the world energy system, particularly export scenarios for crude oil, petroleum products, and liquefied natural gas. Additionally, EIA will continue to collaborate with counterparts in Canada and Mexico to improve the quality and transparency of North American energy data with the ultimate goal

of harmonizing product definitions and classifications. Mapping of North American infrastructure and current energy flows will also be expanded to improve market transparency.

- **Collect transportation energy consumption data (+$1.0M)**: EIA will explore options and partnerships to collect and analyze data on personal vehicle transportation related to macroeconomic, demographic, and behavioral changes, such as driver licensing rates and access to alternative transportation options, which contributed to recent trends in vehicle miles traveled. These data will help in developing projections of motor fuel demand, and will also be highly useful to policymakers who assess, plan, and fund energy infrastructure needs.

Energy Data Program

EIA's comprehensive energy data program conducts surveys of energy suppliers and consumers and then processes and integrates the data to produce a full range of publicly available 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.

The program also integrates data from its multiple collection processes to develop comprehensive national and state-level data sets. The State Energy Portal 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. The program also produces the *Monthly Energy Review* (MER) that features more than 90 integrated monthly and annual data tables.

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, survey frame management, 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. EIA is developing an evidence base of innovative methodologies for collecting valid survey samples at lower cost through different modes (e.g. telephone, mail, web, and third party validation data).

Energy Analysis Program

EIA conducts a robust energy analysis program to bring meaning and context to a rapidly-evolving energy marketplace. The program maintains and operates the National Energy Modeling System (NEMS), the nation's preeminent tool for developing long-term projections of U.S. energy production, consumption, prices, and technologies. EIA's modeling outputs underpin its flagship projections, including the *Annual Energy Outlook* (AEO), *International Energy Outlook* (IEO), and *Short-Term Energy Outlook* (STEO), as well as periodic analysis of the impacts of proposed energy policies, such as the effects of Clean Power Plan regulations.

In addition to its modeling and forecasting work, the program produces a range of recurring reports, such as *Today in Energy* and *This Week in Petroleum,* as well as ad-hoc analysis of emerging topics, such as the growth of crude oil and shale

gas production in the U.S., impacts of planned and unplanned refinery outages on regional supplies and prices, and market impacts from lifting the ban on U.S. crude oil exports. The program is staffed with experts in all areas of the energy sector, including fossil fuels, nuclear, renewables, electricity, transportation, and energy efficiency in the built environment.

EIA also is expanding the depth and breadth of its international energy coverage, including a dynamic new international energy statistics data browser, and continuously updating its body of analytical country profiles and regional reports on major energy economies, which cover production, consumption, reserves, electricity, policy, and trade, among other areas. In particular, EIA is collaborating with counterparts in Canada and Mexico to improve the quality and transparency of North American energy data by harmonizing terms, units, and energy infrastructure mapping.

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 an employee intranet. EIA is integrating state-of-the-art technologies and best practices on its website, including developing customizable data browsers; Application Programming Interfaces (APIs) that enable the development of software applications using EIA data; and dynamic layered state energy maps that provide views of energy production, distribution, generation assets, and National Oceanic and Atmospheric Administration (NOAA) storm tracks, among other areas. The design and customization of EIA's website and multimedia content features are updated based on external feedback mechanisms, including web traffic analytics and input from the annual customer satisfaction survey. The program also maintains EIA's award-winning educational products, such as Energy Kids, and executes a robust social media and state outreach strategy.

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. It also facilitates EIA's participation in cost-effective DOE shared-services programs.

Using Administrative Data for Statistical Purposes
EIA is actively engaged in an Administration initiative to better share and utilize administrative data sets for statistical purposes. Using administrative and third-party data sets is a key strategy for EIA to close energy data gaps while minimizing the costs and respondent burden of survey data collection. EIA currently uses more than 60 administrative data sets and is actively pursuing several new partnerships, including movements of commodities (crude, ethanol, coal) by rail using data from the Surface Transportation Board; and weekly petroleum export data from Customs and Border Protection. As it does with its other data, EIA maintains strict measures to safeguard the privacy and confidentiality of the businesses, individuals, and institutions providing the data.

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 2017 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
Support three DOE 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). The crosscut also enables the Cyber Sciences Laboratory (CSL) to be funded and supported by multiple programs to focus on longer-term, higher-risk, game-changing technologies targeted towards solving fundamental cybersecurity problems in the DOE mission space.

FY 2017 Crosscuts ($K)

	Cyber-security	Total
	865	865
Total, Crosscuts	**865**	**865**

FY 2015 Key Accomplishments

In FY 2015 EIA made significant progress delivering on new initiatives that were started following its FY 2014 funding increase.

- **Oil and natural gas production**: EIA began monthly survey-based collection of new crude oil and expanded natural gas production data directly from operators, including data on oil quality, improving estimates by representing more than 90% of oil and natural gas production in the United States. As oil and natural gas prices have fallen and states' production reporting is often lagged significantly and subject to frequent revisions, these surveys provide the public, industry, and government audiences more timely and accurate data, promoting sound policy-making and efficient markets.

- **Energy by rail:** EIA launched monthly reporting on shipments of crude oil by rail to provide key insights into oil-by-rail movements, including shipments to and from Canada. With nearly one out of every seven barrels of onshore oil produced in the U.S. Lower 48 states being shipped by rail, the data allows the public, government, and industry audiences to track where oil is being produced and where it is being shipped by rail and the volumes thereof. In FY 2016, EIA is developing reporting on movements of ethanol and propane by rail.

- **Hourly electricity data:** This year EIA is launching real-time electricity data from the EIA-930, the world's first hourly energy data collection, processing, and dissemination by a government statistical agency. EIA will provide updates every 60 minutes on power demand at the 65 balancing authorities (BAs) that manage the grid for the Lower 48 states. The new data is now being collected and shared with respondents and experts for validation, and will be publically posted in 2016. The data will be a significant improvement over current grid status information, which is scraped on an as-available basis from an incomplete set of publicly available sources. Should a disaster strike the power grid, the new EIA data will allow policymakers to immediately see where load has dropped off and how badly.

- **Distributed solar generation:** EIA initiated monthly state-level estimates of small-scale distributed solar photovoltaic (PV), including rooftop generation, and incorporated these estimates into EIA's monthly electricity data publications and browsers. The new estimates are based on a blend of survey, administrative and third-party data sources. Generation from roof-top PV systems has become an increasingly important part of total solar generation in the United States. The new monthly estimates provide the public, government, and industry with the ability to tracking where and by how much small-scale distributed PV generation contributes to the nation's electricity supply.

- **North American cooperation on energy information:** The United States began collaboration with its Canadian and Mexican counterparts to create North American energy maps, to reconcile energy trade flows data between the three countries, and to develop common terminologies and outlook comparisons across national energy data reports and analyses. As trilateral energy trade continues to grow, the reconciliation and harmonization of energy statistics, maps, and analysis allows policy makers and industry to make more informed decisions and to undertake deeper and broader initiatives regarding North American energy cooperation.

- **Energy policy analysis and modeling:** EIA completed four important, independent and impartial policy analysis reports in response to requests from Congress and key stakeholders.
    - Reports and analyses of issues surrounding implications of removing current restrictions on U.S. crude oil exports, including a modeling report that assesses impacts on prices, production, and trade in crude and petroleum products under alternative assumptions.

- Analysis of the June 2014 Clean Power Plan proposal that addresses impacts on the generation mix, electricity prices, domestic production of coal and other fuels, and energy efficiency among other key indicators.
- A report detailing direct federal financial interventions and subsidies in energy markets in FY 2013 compared with FY 2010.
- A study that examines supply, demand, and distribution of petroleum-based transportation fuels in the Western U.S., part of a series of regional reports.

- **Energy accessibility tools**: EIA opened a new international energy data portal to improve access to international energy data and trends in global energy markets and link to EIA's international forecasts and projections. EIA also released an add-in for Microsoft Excel, allowing the public to find and download directly into a spreadsheet EIA energy time series data alongside economic data series from the Federal Reserve Bank of St. Louis. Finally, a new widget allows Internet users to display interactive visualizations of current energy data from EIA on their own websites. These products make EIA's data more accessible and useful to internal and external users.

EIA 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 2015	FY 2016	FY 2017
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	90%	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	95%	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)

Program Direction	FY 2015 Enacted	FY 2015 Current	FY 2016 Enacted	FY 2017 Request	FY 2017 vs. FY 2016 Enacted
Salaries and Benefits	55,598	48,521	56,389	58,588	2,199
Travel	278	273	278	288	10
Support Services	42,996	49,078	44,870	51,590	6,720
Other Related Expenses	18,128	19,128	20,463	20,659	196
Total, Program Direction	**117,000**	**117,000**	**122,000**	**131,125**	**9,125**
Federal FTEs	**370**	**329**	**375**	**375**	0
Support Services					
Technical Support					
Administrative Support Services	9	13	9	9	0
Human Resources Support Services	4	281	4	4	0
E-Government Support Services	1	1	1	1	0
Scientific/Technical and IT Training	40	0	40	40	0
Data Center (Application Hosting/Housing)	21	4,675	180	184	4
IT Management Services	5,400	5,300	5,508	5,618	110
Other Advisory and Assistance Services	36,221	37,508	37,698	44,304	6,606
Total, Technical Support	**41,696**	**47,778**	**43,440**	**50,160**	**6,720**
Management Support					
Program Management	1,300	1,300	1,430	1,430	0
Total, Management Support	1,300	1,300	1,430	1,430	0
Total, Support Services	**42,996**	**49,078**	**44,870**	**51,590**	**6,720**
Other Related Expenses					
Communications, utilities, and misc. charges	4,228	4,143	4,257	4,279	22
Training	390	546	466	466	0
Other goods and services from Federal sources	300	249	310	310	0
Working Capital Fund	9,706	9,453	9,694	9,868	174
O&M of IT systems or equipment	1,000	1,500	1,144	1,144	0
Printing, supplies and materials	854	1,500	1,300	1,300	0
Equipment	1,325	1,222	2,967	2,967	0
Grants, subsidies, and contributions	325	515	325	325	0
Total, Other Related Expenses	**18,128**	**19,128**	**20,463**	**20,659**	**196**

Program Direction

Activities and Explanation of Changes

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
Salaries and Benefits $56,389,000	**$58,588,000**	**+$2,199,000**
Provide salaries and benefits for 375 FTEs supporting: • Administrator's office (8 FTEs) • Energy data program (160 FTEs) • Energy analysis (126 FTEs) • Communications (32 FTEs) • Resource and technology management (49 FTEs)	Provide salaries and benefits for 375 FTEs supporting: • Administrator's office (8 FTEs) • Energy data program (160 FTEs) • Energy analysis (126 FTEs) • Communications (32 FTEs) • Resource and technology management (49 FTEs)	Increase reflects inflation.
Travel $278,000	**$288,000**	**+$10,000**
Provide essential travel for EIA stakeholder engagement—both for representing EIA in public forums and engaging with industry experts.	Provide essential travel for EIA stakeholder engagement—both for representing EIA in public forums and engaging with industry experts.	Reflects increased cost of travel from inflation after holding travel reduction for four years.
Support Services $44,870,000	**$51,590,000**	**+$6,720,000**
Energy Supply Surveys $18,165,000 Operate core supply data collection program. • Produce more timely data on petroleum product exports, including gasoline, diesel fuel, and propane. • Set the framework for more granular petroleum supply surveys • Continue partnership with the Ground Water Protection Council (GWPC) to host well-level data. • Complete study of drilling costs to bring visibility to breakeven oil prices in key regions.	*Energy Supply Surveys $21,077,000* Operate core supply data collection program. • Provide more granular petroleum data, including classifications of gasoline, and expansion of renewable fuels categories, and regional data below the PAD District level. • Continue efforts to modernize legacy data collection and processing systems • Explore methodologies for collecting better data on dry gas production, and natural gas liquids production and storage, including export terminals.	*Energy Supply Surveys +$2,912,000* Increase for revamp of petroleum supply surveys and data collection modernization.
Energy Consumption and Efficiency Surveys $9,321,000 Conduct commercial, residential, and manufacturing surveys. • CBECS 2017 planning, funding, and collection preparation. • RECS 2015 fieldwork for household and suppliers surveys. • Complete and publish RECS cities pilot. • MECS 2014 post-collection processing and publication.	*Energy Consumption and Efficiency Surveys $12,213,000* Conduct commercial, residential, and manufacturing surveys. • Publication of 2015 RECS; planning 2019 RECS • Publication of 2014 MECS data. • CBECS 2017 fieldwork begins. • Explore option and partnerships for personal vehicle transportation data collection. • Conduct targeted "Tenant Star" commercial building pilot.	*Energy Consumption and Efficiency Surveys +$2,892,000* Increase for CBECS fieldwork, Tenant STAR pilot, and transportation data partnership

FY 2016 Enacted	FY 2017 Request	Explanation of Changes FY 2017 vs FY 2016
Energy Modeling and Analysis $9,326,000 Continue core forecasting and analysis work leading to the AEO, IEO, STEO and other reports and international capabilities. • Produce full AEO with multiple analytic scenarios and Issues in Focus papers; online update to IEO tables. • Three to five year STEO world supply and demand forecasts. • Continue to work with counterparts in Canada and Mexico to harmonize data, methodologies, and mapping. • Expand rail data methodology to include ethanol, and propane movements.	*Energy Modeling and Analysis $9,682,000* Achieve efficiencies in core forecasting and analysis activities and enhance mid-term analysis. • Produce full IEO and AEO with updated reference cases. • Expand international analysis, including Canada-Mexico collaboration and key economies in Asia • Maintain the flexibility and expertise base to respond to ad-hoc policy analysis needs.	*Energy Modeling and Analysis +356,000* Increase funding for international analysis
Communications $1,662,000 Maintain communication activities and invest in flexible web platforms to enhance data delivery. • Continue digital government strategy to provide open data sources, expanded use of Application Programming Interface (API) keys, and integration of other administrative statistical data. • Conduct website maintenance and conversion to PHP platform; update API servers.	*Communications $1,926,000* Maintain communication activities and invest in flexible web platforms to enhance data delivery. • Expand scope of energy mapping system, and continue to integrate mapping with relevant EIA time-series data sets. • Develop a collaborative North American energy website/portal to consolidate energy information for the U.S., Canada and Mexico.	*Communications +264,000* Maintain scope of communications program.
Resource and Technology Management $6,396,000 Provide overall business management, IT and network services, and administrative support to EIA offices and staff.	*Resource and Technology Management $6,692,000* Continue providing business management, IT and network services, and administrative support to EIA's offices and staff.	*Resource and Technology Management +$296,000* Maintain scope of mission support activities.
Other Related Expenses $20,463,000	**$20,659,000**	**+$196,000**
Support the mission by paying for rent and shared services through the DOE Working Capital Fund, IT equipment and licenses, subscriptions, and employee training among other areas.	Support the mission by paying for rent and shared services through the DOE Working Capital Fund, IT equipment and licenses, subscriptions, and employee training among other areas.	Provide for increased WCF cost and IT licenses.

Department Of Energy

FY 2017 Congressional Budget

Funding By Appropriation By Site

($K)

Energy Information Administration	FY 2015 Current	FY 2016 Enacted	FY 2017 Request
Washington Headquarters			
Energy Information Administration			
National Energy Information System	117,000	122,000	131,125
Total, Washington Headquarters	**117,000**	**122,000**	**131,125**
Total, Energy Information Administration	**117,000**	**122,000**	**131,125**

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 both Houses of Congress 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 both Houses of Congress 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 both Houses of Congress 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**]** *accompanying this* 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 both Houses of Congress at least 30 days prior to the use of any proposed reprogramming that 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 both Houses of Congress 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. 3094) during fiscal year **[**2016**]** *2017* until the enactment of the Intelligence Authorization Act for fiscal year **[**2016**]** *2017*.

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. Notwithstanding section 301(c) of this Act, none of the funds made available under the heading "Department of Energy—Energy Programs—Science" in this or any subsequent Energy and Water Development and Related Agencies appropriations Act for any fiscal year 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. 307. (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 both Houses of Congress, in classified form if necessary, a report on the justification for the waiver.**]**

SEC. **[**308**]** *307*. (a) NEW REGIONAL RESERVES.—The Secretary of Energy may not establish any new regional petroleum product reserve 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.

(b)The budget request or notification shall include—

(1) the justification for the new reserve;

(2) a cost estimate for the establishment, operation, and maintenance of the reserve, including funding sources;

(3) a detailed plan for operation of the reserve, including the conditions upon which the products may be released;

(4) the location of the reserve; and

(5) the estimate of the total inventory of the reserve.

[SEC. 309. Of the amounts made available by this Act for "National Nuclear Security Administration—Weapons Activities", up to $50,000,000 may be reprogrammed within such account for Domestic Uranium Enrichment, subject to the notice requirement in section 301(e).**]**

[SEC. 310. (a) Unobligated balances available from 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", $1,355,149.00 from Public Law 110–161; $627,299.24 from Public Law 111–8; and $1,824,051.94 from Public Law 111–85.

(2) "Energy Programs—Science", $3,200,000.00.

(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. 311. Notwithstanding any other provision of law, the provisions of 40 U.S.C. 11319 shall not apply to funds appropriated in this title to Federally Funded Research and Development Centers sponsored by the Department of Energy.**]**

[SEC. 312. 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. 313. (a) Of the funds appropriated in prior Acts under the headings "Fossil Energy Research and Development" and "Clean Coal Technology" for prior solicitations under the Clean Coal Power Initiative and FutureGen, not less than $160,000,000 from projects selected under such solicitations that have not reached financial close and have not secured funding sufficient to construct the project prior to 30 days after the date of enactment of this Act shall be deobligated, if necessary, shall be utilized for previously selected demonstration projects under such solicitations that have reached financial close or have otherwise secured funding sufficient to construct the project prior to 30 days after the date of enactment of this Act, and shall be allocated among such projects in proportion to the total financial contribution by the recipients to those projects stipulated in their respective cooperative agreements.

(b) Funds utilized pursuant to subsection (a) shall be administered in accordance with the provisions in the Act in which the funds for those demonstration projects were originally appropriated, except that financial assistance for costs in excess of those estimated as of the date of award of the original financial assistance may be provided in excess of the proportion of costs borne by the Government in the original agreement and shall not be limited to 25 percent of the original financial assistance.

(c) No amounts may be repurposed pursuant to 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.

(d) This section shall be fully implemented not later than 60 days after the date of enactment of this Act.**]**

SEC. 308. Amounts made available by this title may be transferred to the Technology Commercialization Fund in amounts not to exceed 0.9% of the amounts appropriated for applied energy research and development. Amounts so transferred shall be available for a broad spectrum of energy technology or combination of technologies, consistent with section 1001 of the Energy Policy Act of 2005 (42 U.S. Code paragraph 16391(e)), and shall remain available until expended.

SEC. 309. Not to exceed 5 percent of any appropriation made available for Department of Energy activities funded in this Act or subsequent Energy and Water Development and Related Agencies Appropriations Acts may be transferred between such appropriations, but no such appropriation, except as otherwise provided, shall be increased or decreased by more than 5 percent by any such transfers, and notification of any such transfers shall be submitted promptly to the Committees on Appropriations of the House of Representatives and the Senate.

SEC. 310. Consolidated Emergency Operations Center. Amounts available for the Department of Energy under this title in this and prior appropriations Acts shall be available for the design of a consolidated Emergency Operations Center: Provided, That no amounts may be repurposed from amounts that were designated by the Congress as an emergency requirement pursuant to the Concurrent Resolution on the Budget or the Balanced Budget and Emergency Deficit Control Act of 1985, as amended.

SEC. 311. TREATMENT OF LOBBYING AND POLITICAL ACTIVITY COSTS AS ALLOWABLE COSTS UNDER DEPARTMENT OF ENERGY CONTRACTS.

(a) Allowable Costs.—

(1) Section 4801(b) of the Atomic Energy Defense Act (50 U.S.C. 2781(b)) is amended—

(A) by striking "(1)" and all that follows through "the Secretary" and inserting "The Secretary"; and

(B) by striking paragraph (2).

(2) Section 305 of the Energy and Water Development Appropriation Act, 1988, as contained in section 101(d) of Public Law 100–202 (101 Stat. 1329–125), is repealed.

(b) Regulations Revised.—The Secretary of Energy shall revise existing regulations consistent with the repeal of 50 U.S.C. 2781(b)(2) and section 305 of Public Law 100–202 and shall issue regulations to implement 50 U.S.C. 2781(b), as amended by subsection (a), no later than 150 days after the date of the enactment of this Act. Such regulations shall be consistent with the Federal Acquisition Regulation 48 C.F.R. 31.205–22.

(Energy and Water Development and Related Agencies Appropriations Act, 2016.)

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 both Houses of Congress 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 Action to Address Environmental Justice in Minority Populations and Low-Income Populations). *(Energy and Water Development and Related Agencies Appropriations Act, 2016.)*