Energy Efficiency and Renewable Energy
Proposed Appropriation Language

For the Department of Energy expenses including the purchase, construction, and acquisition of plant and capital equipment, and other expenses necessary for energy efficiency and renewable energy activities in carrying out the purposes of the Department of Energy Organization Act (42 U.S.C. 7101 et seq.), including the acquisition or condemnation of any real property or any facility or for plant or facility acquisition, construction, or expansion, [$1,912,104,111,] *$2,316,749,000*, to remain available until expended: *Provided*, That [$162,000,000] *$160,000,000* shall be available until September 30, [2015] *2016* for program direction: *Provided further*, That, of the amount provided under this heading, the Secretary may transfer up to [$45,000,000] *$60,000,000* to the Defense Production Act Fund for activities of the Department of Energy pursuant to the Defense Production Act of 1950 (50 U.S.C. App. 2061, et seq.): *Provided further*, That [$4,711,100 from Public Law 111–8 and $5,707,011 from Public Law 111–85 provided under this heading are hereby rescinded: *Provided further*, That no amounts may be rescinded from amounts that were designated by the Congress as an emergency requirement pursuant to a concurrent resolution on the budget or the Balanced Budget and Emergency Deficit Control Act of 1985.] *of the amount provided under this heading*, *$15,000,000 shall be available for weatherization assistance for State level demonstrations of financing methods for low-income multi-family units, including technical assistance for recipients, and shall be awarded on a competitive basis, notwithstanding the requirements of Part A of Title IV of the Energy Conservation and Production Act (42 U.S.C. 6861 et seq.). Provided further, That, of the amount provided under this heading, not to exceed $14,000,000 shall be available for a technical assistance program for local governments and community agencies to support energy planning, and program development and implementation, and may include assistance awarded on a competitive basis, notwithstanding the requirements of Part D of Title III of the Energy Policy and Conservation Act (42 U.S.C. 6321 et seq.).*

Explanation of Changes

Deleted language referencing the rescission of prior year balances included in the FY 2014 Appropriations Bill.

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

- Included language to authorize competitive funding for low-income multi-family units within the Weatherization Assistance Program.
- Included language to authorize funding for a technical assistance program for local governments and community agencies for the new Clean Energy and Economic Development Partnerships program.

Public Law Authorizations

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

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

Energy Efficiency and Renewable Energy

($K)			
FY 2013 Current[1]	FY 2014 Enacted[2]	FY 2014 Current	FY 2015 Request
1,691,757	1,900,641	1,900,641	2,316,749

Overview

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

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

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

In FY 2015, EERE will continue to inform its investments through insights from the above retrospective analyses, as well as through internal and independent economic analyses and assessments of potential technology impacts on energy usage, energy emissions, American oil imports, and U.S. manufacturing competitiveness. This approach focuses efforts on the most promising opportunities across a full spectrum of sectors and maturation timeframes to ensure a full pipeline of efficiency and renewable technologies in both the near and longer term. To design a specific program activity, EERE works with industry and creates technology-specific roadmaps — evaluating the future market potential and public benefit of technologies by incorporating in-house expertise, market awareness, and knowledge of private investment. EERE continues to develop its portfolio to ensure its investments can make a significant impact in transforming large existing global energy markets and to maximize the value it delivers to the taxpayer.

To complement and enhance its roadmap-based approach, EERE designates a small fraction of its annual funding for "incubator" programs within its programs, designed to enable potential on-ramping of innovative new "off-roadmap"

[1] Funding reflects the transfer for SBIR/STTR to the Office of Science.
[2] FY 2014 Enacted and FY 2014 Current reflect the contractor foreign travel rescission of $1,045,000.
[3] Preliminary aggregate net benefits calculation by EERE Office of Strategic Programs, combining cost-benefit impact results from formal evaluation studies conducted for the Solar Energy, Geothermal Technologies, Wind Energy, Vehicle Technologies, and Advanced Manufacturing programs.

technologies and solutions not represented in a significant way in current EERE program plans, roadmaps, or project portfolios. These incubator programs allow EERE to further develop, assess, and screen new technologies for their potential to be "on-ramped" into its future updated roadmaps and program plans. Highly successful Incubator projects should demonstrate the potential and reduce the risk of "off roadmap" new approaches and technologies such that they warrant significant consideration for inclusion into future EERE programs roadmaps at the end of the project performance period.

Highlights and Major Changes in the FY 2015 Budget Request

In FY 2015, EERE will invest $2.3 billion toward continuing its focus on growing the domestic clean energy industry, increasing energy productivity for American businesses, and expanding access to renewable power and alternative vehicles. Areas of increased emphasis include additional support for R&D in advanced manufacturing, sustainable transportation, emerging building and equipment technologies and standards, hydropower, geothermal energy; crosscutting grid integration activities and weatherization assistance, among other areas. EERE will also sustain efforts to streamline and enhance its operations, conduct rigorous evaluations of its portfolios, and achieve the greatest possible efficiency and outcomes in each of its three sectors and its key organization-wide initiatives.

Sustainable Transportation ($705.2 million)

- Vehicle Technologies: EERE will invest $359 million in FY 2015 to support RDD&D of efficient and alternative fuel vehicles. A significant component, the EV Everywhere Grand Challenge aims to aggressively reduce costs and improve performance of electric vehicles–specifically, in the areas of (1) advanced batteries; (2) electric drive systems, including electric motors with significantly reduced or no rare-earth materials and advanced power electronics that use wide bandgap devices; (3) lightweight materials technologies; and (4) other enabling technologies as well as collaborative work to better integrate plug-in vehicles with the electric grid. FY 2015 funding also supports significant R&D on more efficient combustion engine technologies as well as work to eliminate technical barriers to increased transportation use of alternative and renewable fuels, with a focus on natural gas and drop-in biofuels. In the deployment area, FY 2015 funding initiates new alternative fuel vehicle community partner projects to build strategically-placed, high-impact community-scale demonstrations of alternative fuel vehicles.

- Bioenergy Technologies: EERE will invest $253 million in FY 2015, with an emphasis on the development of innovative processes to convert cellulosic and algal-based feedstocks to bio-based gasoline, jet, and diesel fuels at a cost of $3.00 per gallon of gasoline equivalent. In collaboration with the U.S. Departments of Navy and Agriculture, commercial-scale biorefineries to produce military-specification fuels will be demonstrated. Additionally, funds will be utilized to advance innovative new technologies from R&D to pilot- and demonstration-scale. FY 2015 funding also enables development of technologies to produce high-value bio-chemicals for bio-based carbon fibers for use in applications such as lightweight vehicles, wind turbine blades, and novel insulation materials, in support of DOE's Clean Energy Manufacturing Initiative.

- Hydrogen and Fuel Cell Technologies: EERE will invest $93 million in FY 2015 to support a focused R&D effort to reduce the cost and increase the durability of fuel cell systems, with a targeted cost of $40/kW and durability of 5,000 hours, which is equivalent to 150,000 miles, by 2020. In addition, EERE will invest in R&D for technologies that can bring the cost of hydrogen from renewable resources to less than $4.00 per gallon of gasoline equivalent–dispensed and untaxed–by 2020. In FY 2015, Fuel Cell R&D will emphasize areas such as stack component R&D, systems, and balance of plant (BOP) components. Hydrogen Fuel R&D will focus on technologies and materials that will reduce hydrogen production, compression, transport, and storage costs. Funding also supports targeted early market fuel cell demonstrations and addresses codes and standards to overcome barriers to commercialization.

Renewable Power ($521.3 million)

- Solar Energy: EERE will invest $282 million in FY 2015 to support the SunShot Initiative goal to make solar power cost-competitive without subsidies by 2020. This includes the development and demonstration of innovative manufacturing technologies to increase U.S. competitiveness, in support of DOE's Clean Energy Manufacturing Initiative, and solar photovoltaic activities that enable both hardware development and a 50 percent reduction in non-hardware "soft costs". FY 2015 funding also supports development of advanced thermal storage and supercritical CO_2 power cycles so that concentrated solar power can achieve base-load grid parity.

- Wind Energy: EERE will invest $115 million in FY 2015, including funding for three advanced offshore wind demonstration projects planned to be in operation by 2017, as well as an Atmosphere to Electrons Initiative focused on optimizing whole wind farms as a system to lower the cost of land-based and offshore wind energy. FY 2015 funding also enables pursuit of new designs, materials and manufacturing processes for longer blades to capture greater wind resource and address transportation barriers, in support of DOE's Clean Energy Manufacturing Initiative.

- Water Power: EERE will invest $62.5 million in FY 2015 to support innovative technologies for generating electricity from water resources. HydroNEXT, a new EERE initiative, aims to improve the performance, flexibility, and environmental sustainability of technologies applicable to existing hydropower facilities, while also developing and demonstrating technologies that will enable new, low-impact, fish-friendly hydropower development. HydroNEXT will emphasize modular, "drop-in" systems that will minimize capital costs and environmental impact and maximize ease of manufacture. FY 2015 funding also supports marine and hydrokinetic activities to develop and validate open-source design tools and support testing of wave and tidal energy systems, to enable industry to develop robust next-generation systems.

- Geothermal Technologies: EERE will invest $61.5 million in FY 2015, including support for site characterization of the Frontier Observatory for Research in Geothermal Energy (FORGE), a critical step for readying the FORGE site to test and validate cutting-edge enhanced geothermal systems (EGS) technologies and techniques. FORGE is a dedicated site with a central focus on creating an accelerated commercial pathway to large-scale EGS power generation in the U.S. FY 2015 funding also advances validation of the program's "Play Fairway Analysis," which assesses exploration risk and the probability of finding new resources on a regional scale, resulting in maps and studies that reduce the industry's drilling and development risks. FY 2015 funding will also advance the DOE Strategic Materials effort by transitioning its most successful feasibility studies of technologies to extract strategic materials from geothermal brines to technology prototype development or field demonstration projects.

Energy Efficiency ($857.7 million)

- Advanced Manufacturing: EERE will invest $305 million in FY 2015 to enable the development and deployment of industrial efficiency and cross-cutting clean energy manufacturing technologies. The funding supports high-impact R&D focused on advanced manufacturing and materials with U.S. manufacturers to realize significant gains in energy productivity, environmental performance, and product yield. As part of a larger proposed interagency network aimed at bringing together universities, companies, and the government to improve U.S. manufacturing competitiveness, the funding includes the deployment of at least one additional Clean Energy Manufacturing Innovation Institute, along with continued support of existing institutes. FY 2015 funding will also support the deployment of energy efficient manufacturing technologies and practices, including strategic energy management and combined heat and power, across American industry through training programs, site assessments, and standards development.

- Buildings Technologies: EERE will invest $212 million in FY 2015, including support for several high-impact R&D initiatives in the Emerging Technologies (ET) area. Specifically, ET will invest in a new activity to pursue non-vapor-compression air conditioning technologies and increased investments in transactive communication and controls that will enable appliances and buildings to more efficiently interact with the grid, both of which offer significant opportunity to increase energy savings with reduce greenhouse gas emissions in buildings. FY 2015 funding also supports increased investment in the Equipment and Appliance Standards subprogram to establish minimum efficiency requirements pursuant to Federal statutes. FY 2015 funding will assist home builders to build to high efficiency levels, improve homeowner access to home improvement services, and improve the information, tools, and resources available to the commercial sector with a goal of achieving 20 percent savings by 2020. The FY 2015 request also includes $10M for a consortium for building energy innovation to reduce energy use in small- and medium-size commercial buildings and demonstrate new paths to market for real energy savings.

- Weatherization and Intergovernmental Program: EERE will invest a total $305 million in FY 2015, with $228 million to support the Weatherization Assistance Program at levels that provide access to home weatherization services for low-income households in jurisdictions across the country, including over 33,000 homes in FY 2015. Increased funding for the State Energy Program to $63 million allows for expansion of innovative initiatives through key engagements with the state energy office network to spur accelerated energy efficiency and clean energy technology deployment. New funding is provided for Clean Energy and Economic Development Partnerships to assist regions in creating economic development roadmaps in sustainable shale gas growth zones and technical assistance to incentivize and enable local

governments/communities to leverage clean energy technologies to meet their energy goals and achieve local economic growth.

- Federal Energy Management Program (FEMP): EERE will invest $36 million in FY 2015 to continue FEMP's core activities to assist and enable Federal agencies to meet energy-related and other sustainability goals and provide Federal energy leadership to the country. Additional areas of focus in FY 2015 include support for a new center of expertise focused on Federal Data Center Energy Efficiency and Optimization, increased project tracking, and expanded development and implementation of critical tools for enhancing the effective use of project financing mechanisms. FEMP, through the continuation of the Federal Energy Efficiency Fund, will also provide direct funding to leverage cost-sharing at Federal agencies for capital projects and other initiatives to increase the energy efficiency, water conservation, and renewable energy investments at agency facilities.

Key Crosscutting Initiatives

Within its programmatic activities, EERE engages in high-impact internal crosscutting initiatives that are closely coordinated across EERE's programs to break down silos and maximize the coordination and impact of taxpayer investments.

- The *Grid Integration Initiative* focuses on EERE-specific activities that that enable seamless integration of EERE technologies into the electrical grid at scale. In coordination with DOE's cross-cutting grid modernization efforts, EERE's activities target the development of next-generation technologies and solutions that will enable smarter, interactive systems for intermittent and distributed EERE technologies that better enable integration into the grid in a safe, reliable, and cost-effective manner. The flagship of EERE's Grid Integration Initiative is the Energy Systems Integration Facility (ESIF) at the National Renewable Energy Laboratory (NREL). Commissioned in September 2013, ESIF is a state-of-the-art facility designed for testing, simulation, data analysis, engineering, and evaluation techniques for integrated technologies in a risk-free environment. ESIF serves as the hub for EERE grid integration activities and is providing unique R&D opportunities for utilities, advanced clean energy technology manufacturers, and system integrators that together will help reshape the energy system of the 21st century. This exceptional national resource enables scientists and engineers from the private and public sector to conduct critical research, development, testing, and validation. The efforts at ESIF will directly benefit and inform equipment providers, utilities, public utility commissions, legislative bodies and other entities working to integrate renewable energy and advanced efficiency technologies and approaches into the Nation's electricity grid. In FY 2015, EERE will increase its core investment in ESIF to $30 million to allow the expansion of ESIF staff and equipment to support full operation of the user facility.

- The *Clean Energy Manufacturing Initiative (CEMI)* is a comprehensive DOE-wide approach to increase U.S. competitiveness in clean energy manufacturing. CEMI supports innovation in manufacturing technology that will help companies competitively manufacture clean energy technologies in the U.S., while increasing U.S. manufacturing competitiveness across the board by increasing energy productivity.

- The *Next Generation Power Electronics Initiative* seeks to maintain U.S. leadership in wide bandgap (WBG) semiconductor technology and create a U.S. manufacturing and R&D base for WBG power devices and power electronics systems, which allow these systems to be smaller, cheaper, and more efficient for clean energy applications. This class of WBG technologies enables power electronics to operate at much higher voltages, temperatures, and switching frequencies compared to silicon devices and has applications in next-generation power electronics for solar power, wind power, plug-in electric vehicles, variable drive motors, and other clean energy technologies. EERE seeks to further develop and transition these technologies into the commercial clean energy marketplace by leveraging the new Next Generation Power Electronics Manufacturing Institute, the first Clean Energy Manufacturing Innovation Institute. These Institutes are consistent with the President's vision for a larger multi-agency National Network for Manufacturing Innovation (NNMI).

- The *Carbon Fiber Composites for Clean Energy Initiative* seeks to coordinate and optimize RD&D investments across EERE to address challenges throughout the entire supply chain for carbon fiber composites, which are a platform material relevant to a number of clean energy applications. Their high strength-to-weight and stiffness-to-weight ratios, outstanding corrosion resistance and other properties enable use in lightweight vehicles, next generation blades for wind turbines, high pressure storage tanks for natural gas and hydrogen, and a wide variety of other applications.

FY 2013 Key Accomplishments

The accomplishments listed below provide both results of specific internal and independent analyses conducted on return on investment as well as noteworthy project, portfolio, or program accomplishments in FY 2013 that have been achieved through EERE partnerships with industry, research or academic institutions, cross-cutting consortia, and/or our Federal, state, and local partners.

Sustainable Transportation

Vehicle Technologies

- Through the EERE-supported SuperTruck Initiative, demonstrated a 22 percent engine efficiency improvement in the laboratory and developed a full-scale prototype class 8 heavy duty truck that demonstrated a 61 percent improvement in freight efficiency during initial on-road testing (compared to a 2009 baseline truck).
- Since 2010, reduced the cost of plug-in electric vehicle batteries by more than 50 percent to $325/kilowatt hour.
- Since 2013, increased use of advanced transportation technology through two new public-private partnerships: the National Clean Fleets Partnership, which collaborates with large vehicle fleets to significantly reduce fuel use and save money, has grown from fewer than 10 partners at its launch, to 23 partners in February 2014; and the Workplace Charging Challenge, which calls upon America's employers in all sectors of the economy to provide PEV charging access at worksites across the country, has grown from 13 partners and eight ambassador stakeholder groups to more than 50 since its launch in January 2013.

Bioenergy Technologies

- In FY 2013, the five EERE-supported high-tonnage feedstock logistics projects—which included partnerships with original equipment manufacturers—demonstrated an up to 25 percent reduction in cost (e.g., $13.00/ton cost reduction relative to conventional systems for baled corn stover) for integrated systems that utilize agricultural residues, forest resources, and/or herbaceous and short-rotation energy crops. Cost reductions claimed in all five projects have been independently validated by Oak Ridge National Laboratory researchers.
- Also in FY 2013, the Nation's first EERE-funded pioneer cellulosic ethanol plant began production and commercial sale of product. This plant has an annual cellulosic ethanol production capacity of 8 million gallons per year (mmgy). Two additional, commercial scale biorefineries are expected to complete construction and commissioning in 2014, adding a production capacity of more than 50 mmgy of domestic cellulosic ethanol.
- After a decade of pilot-scale work, technical performance data were generated in FY 2012 that validated the potential of biochemical and thermochemical process pathways to produce cellulosic ethanol in a mature commercial biorefinery for approximately $2.00/gallon.

Hydrogen and Fuel Cell Technologies

- In FY 2013, demonstrated technology capable of reducing the high-volume modeled cost of automotive fuel cell systems to $55/kW, which is a reduction of more than 30 percent since 2008 and more than 50 percent since 2006—and is well on the way to achieving the 2020 target of $40/kW.

Renewable Power

Solar Energy

- DOE investments in efficiency improvement and 'soft cost' reduction continue contributing to rapid deployment of solar energy; through FY 2013, this investment helped U.S. realizes a 32 percent year over year increase in solar energy deployment, up to 9.5 GW total installed capacity.
- As of December 2013 – 3 years into the 10 year SunShot initiative – EERE is more than 60 percent of the way to its 2020 goals. Specifically, EERE-supported efforts have enabled a reduction of the utility-scale photovoltaic (PV) system's 2010 baseline price of $3.80/Wdc to $1.85/Wdc, demonstrating that PV is on target for achieving the 2020 goal of $1.00/Wdc; and from concentrated solar power's levelized cost of electricity's 2010 baseline of $0.21/kWh, the reduction was to $0.13/kWh, continuing towards the 2020 target of $0.06/kWh.

Wind Energy

- In FY 2013, awarded funding and began development of the first U.S. offshore wind energy projects through a 5-year initiative with multiple competitively awarded projects—which have completed the preliminary engineering and project development phases. In 2014, EERE will select and fund three of seven projects to move to final design, construction, and installation. These demonstration projects are anticipated to complete construction and be operational by the end of 2017, accelerating the development and deployment of breakthrough offshore wind power

technologies, which will help diversify our Nation's energy portfolio, promote economic development, and launch a new U.S. industry.

- A program-funded project at the University of Maine recently became the first grid-connected offshore wind turbine in the U.S., and represents the first concrete-composite floating platform wind turbine to be deployed in the world.

Water Power

- In FY 2013, DOE collaborated with the International Energy Agency's Ocean Energy Systems group on the first-of-its kind Tethys database, which catalogues, shares, and maps environmental research from around the world to enable sustainable development and expansion of clean offshore wind and ocean renewable power. In addition to the database, DOE released a complementary report providing an in-depth analysis of the environmental impacts of wave, tidal and current devices, including on wildlife and overall health of the host water body. The results of the analysis show some promising information about the environmental safety of marine and hydrokinetic devices.
- In FY 2013, EERE funded fabrication of a basin-scale model of and ocean current device and completion of a series of tow tank tests at the Naval Surface Warfare Center's David Taylor Model Basin in Bethesda, MD. The tests demonstrated static and dynamic stability of the device in a variety of modes and validated numerical and modeling data, bringing the technology another step closer to commercialization.

Geothermal Technologies

- In FY 2013, EERE supported the first sustained enhanced geothermal system (EGS) demonstration success in the U. S. at The Geysers. Following a year-long stimulation along the outer edges of an operating geothermal field, this EGS demonstration project in northern California successfully accessed a new and distinct reservoir in a very low-permeability, high-temperature region, yielding a clearly demonstrated commercial-strength 5 MW resource.
- Also in FY 2013, the Desert Peak 2 project in Nevada completed an 8-month, multi-stage stimulation of an existing yet underperforming well, making it the first EGS project in America to supply commercial electricity to the grid by providing an additional 1.7 MW at the existing well-field. The National Renewable Energy Lab estimates 7-10 GW of resource from in-field and near-field EGS in the U. S.

<u>Energy Efficiency</u>

Advanced Manufacturing

- Provided Department of Energy contribution to support for the pilot National Additive Manufacturing Innovation Institute (NAMII), known as AmericaMakes, in Youngstown, OH. In its first year of operation, AmericaMakes has already enlisted 92 partners in a membership consortium.
- As part of the Better Plants Program, more than 125 Program Partners—representing close to 1,800 plants and over 8 percent of the total U.S. manufacturing energy footprint—have committed to reduce their energy intensity by 25 percent over 10 years. As of October 2013, Partners have reported about 190 trillion Btu and $1 billion cumulatively in energy savings since 2009.

Building Technologies

- In FY 2013, EERE completed 13 new Energy Star test procedures proposals or final test procedures and issued final rules for test procedures and standards for 19 products, saving American businesses and consumers billions of dollars in estimated energy costs over the lifetime of associated new products.
- In FY 2013, EERE R&D in solid-state lighting (SSL) technologies enabled an efficacy of 168 lumen per Watt in a laboratory device with quality warm white lights, exceeding the target efficacy for the year by 15 percent. Overall, SSL products on the market and installed in buildings for FY 2012 were estimated to save consumers 70 trillion Btu.

Weatherization and Intergovernmental Program

- In FY 2013 improved the energy performance and comfort in the homes of 46,871 American low-income families across the Nation, resulting in an estimated 1.4 trillion Btus of first-year energy savings and $20 million in first-year energy cost savings.

Federal Energy Management Program

- In FY 2013, EERE assisted Federal agencies in reducing the life-cycle energy consumption of Federal facilities through performance contracting and technical assistance programs by more than 27.9 trillion Btus, equal to the energy consumption of 312,000 average American homes in a single year.

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

	FY 2013 Current[a]	FY 2014 Enacted[b]	FY 2014 Adjustments	FY 2014 Current	FY 2015 Request	FY 2015 vs FY 2014 Enacted
Vehicle Technologies	303,165	289,737	—	289,737	359,000	+69,263
Bioenergy Technologies	—-	232,290	—	232,290	253,200	+20,910
Biomass & Biorefinery Systems R&D[c]	185,190	—	—	—	—	—
Hydrogen and Fuel Cell Technologies	95,844	92,928	—	92,928	92,983	+55
Solar Energy	269,050	257,058	—	257,058	282,300	+25,242
Wind Energy	86,129	88,126	—	88,126	115,000	+26,874
Water Power	54,687	58,565	—	58,565	62,500	+3,935
Geothermal Technologies	35,025	45,775	—	45,775	61,500	+15,725
Advanced Manufacturing	—	180,471	—	180,471	305,100	+124,629
Industrial Technologies[d]	114,254	—	—	—	—	—
Federal Energy Management Program	28,265	28,248	—	28,248	36,200	+7,952
Building Technologies	204,601	177,868	—	177,868	211,700	+33,832
Weatherization and Intergovernmental Program			—			
Weatherization Assistance Program						
Weatherization Assistance	128,879	170,898	—	170,898	224,600	+53,702
Training and Technical Assistance	2,826	2,998	—	2,998	3,000	+2
Total, Weatherization Assistance Program	131,705	173,896	—	173,896	227,600	+53,709
State Energy Program	47,108	49,970	—	49,970	63,100	+13,130
Clean Energy and Economic Development Partnerships	—	—	—	—	14,000	+14,000
Tribal Energy Program[e]	9,421	6,996	—	6,996	0	-6,996
Total, Weatherization and Intergovernmental Program	**188,234**	**230,862**	—	**230,862**	**304,700**	**+73,838**
Program Direction	160,455	162,000	—	162,000	160,000	-2,000
Strategic Programs	23,554	23,540	—	23,540	21,779	-1,761
Facilities and Infrastructure	24,880	45,973	—	45,973	56,000	+10,027
Subtotal, Energy Efficiency and Renewal Energy	**1,773,333**	**1,913,441**	—	**1,913,441**	**2,321,962**	**+408,521**
Use of Prior Year Balances	-81,576	-2,382	—	-2,382	-5,213	-2,831

	FY 2013 Current[a]	FY 2014 Enacted[b]	FY 2014 Adjustments	FY 2014 Current	FY 2015 Request	FY 2015 vs FY 2014 Enacted
Rescission of Prior Year Balances	—	-10,418	—	-10,418	—	+10,418
Total, Energy Efficiency and Renewal Energy	**1,691,757**	**1,900,641**	—	**1,900,641**	**2,316,749**	**+416,108**
Federal FTEs	**732**	**707**		**707**	**697**	**-10**

SBIR/STTR:

- FY 2013 Transferred[f]: SBIR $23,346; STTR: $3,027
- FY 2014 Proposed: SBIR: $23,509; STTR: $3,358
- FY 2015 Request: SBIR: $29,616; STTR: $4,085

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[a] Funding reflects the transfer of SBIR/STTR to the Science.
[b] FY 2014 Enacted and FY 2014 Current reflect the contractor foreign travel rescission of $1,045,000).
[c] Biomass & Biorefinery Systems R&D (formerly Bioenergy Technologies in FY 2014).
[d] Industrial Technologies (formerly Advanced Manufacturing in FY 2014).
[e] In the FY 2015 Budget Request, the Tribal Energy Program (TEP) is transferred within DOE's Office of Indian Energy Policy and Programs.
[f] FY 2013 transfer included $1,297,380 of prior year balances.

Vehicle Technologies

Overview

The transportation sector accounts for two-thirds of United States (U.S.) petroleum use and on-road vehicles are responsible for 80 percent of this amount. Our dependence on oil for transportation affects our national economy and individual wallets. We continue to send nearly $1 billion a day overseas for oil and Americans currently pay over $3.50 per gallon at the pump. The U.S. Department of Energy's (DOE's) first Quadrennial Technology Review states that, "dependence on petroleum creates significant economic, security, and environmental challenges."[1] To address these pressing challenges and help Americans reduce their energy costs, there are two solution pathways: (1) use conventional fuels more efficiently and (2) replace them with cost competitive, domestically-produced alternatives. Public investment in advanced transportation technologies that enable both of these pathways will improve our Nation's energy security, reduce greenhouse gas (GHG) emissions, and strengthen our economic competiveness in the global clean energy race.

Aligning with the President's Climate Action Plan and all-of-the-above approach to American energy, the Vehicle Technologies program supports a broad technology portfolio; adheres to a comprehensive and analysis-based strategy of research, development, demonstration, and deployment activities; and relies on strategic partnerships to accelerate the movement of technologies from the laboratory to the showroom and onto the road:

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

Close coordination with other Programs in EERE and across the DOE complex – National Laboratories, DOE's Office of Science, Office of Electricity Delivery and Energy Reliability (OE), and the Advanced Research Projects Agency-Energy (ARPA-E) – ensures the effective use of resources while avoiding duplication. This coordination enables program leadership of the EV Everywhere Grand Challenge; supports the vehicle-related components of EERE's Clean Energy Manufacturing Initiative, Wide Bandgap Semiconductors for Clean Energy Initiative, and Grid Integration Initiative; and facilitates the transfer of successful technologies across the research and development continuum. In FY 2015, Vehicle Technologies will place increasing emphasis on collaboration with EERE's Fuel Cell Technologies and Bioenergy Technologies programs as part of a coordinated and comprehensive strategy to achieve the EERE goal of expanding the adoption of sustainable, domestically-powered transportation alternatives.

Highlights of the FY 2015 Budget Request

The Vehicle Technologies budget request supports several key initiatives that contribute to achieving its high-level goals:

- The EV Everywhere Grand Challenge, a bold DOE-wide initiative, seeks to enable the United States to produce a wide array of plug-in electric vehicle models (PEVs, including plug-in hybrids and all-electric vehicles) that are as affordable and convenient as the gasoline powered vehicles we drive today by 2022. Developed with key stakeholder input, EV Everywhere technology performance and cost targets will guide DOE investments to reduce the combined battery and electric drive system costs of a PEV by up to 50 percent. Specific technical targets include:
  - Cutting battery costs from $325/kWh in 2013 to $125/kWh by 2022;
  - Eliminating almost 30 percent of vehicle weight through light weighting by 2022, compared to a 2002 baseline; and
  - Reducing the cost of electric drive systems from $16/kW in 2013 to $8/kW by 2022.
- The program will pursue new opportunities to dramatically improve the performance and lower the cost of power electronics through wide bandgap semiconductors (in support of the EERE Wide Bandgap Semiconductors for Clean Energy Initiative and in coordination with the Clean Energy Manufacturing Initiative), and improved motor technologies that eliminate and/or reduce the use of critical materials, such as rare earth metals.

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[1] Available at: http://energy.gov/sites/prod/files/ReportOnTheFirstQTR.pdf.

- An important activity in the Vehicle Technologies portfolio is the Workplace Charging Challenge, which aims to enable a tenfold increase in the number of U.S. employers offering workplace charging by 2018 – significantly increasing the convenience of PEVs and providing consumers with a variety of charging options.
- Working closely with OE, the program will support PEV-specific aspects of grid connectivity, with a focus on technologies needed to fully integrate PEVs into the distribution system in a safe, reliable, and cost-effective manner.
- Vehicle Technologies will continue support of existing awards in the SuperTruck Initiative as it works to achieve its 2015 goal to develop technologies that improve the freight hauling efficiency of heavy-duty class 8 long-haul vehicles by 50 percent with respect to a comparable 2009 vehicle. SuperTruck project teams are using a variety of approaches and have made significant progress in the areas of engine efficiency and emission control, advanced transmissions and hybridization, aerodynamic drag of the tractor and trailer, tire rolling resistance, light-weight materials, and Auxiliary Power Units to reduce engine idling.
- Vehicle Technologies R&D will support improvements to engine efficiency and the development of advanced transmissions and engine materials, which, along with fuel optimization, will improve the fuel economy of passenger vehicles by 35-50 percent in 2020, compared to a 2009 baseline.
  A program "Incubator" funding opportunity will invest 5 percent of Vehicle Technologies funding toward new, innovative technologies and solutions that can help meet existing goals but are not represented in a significant way in the current portfolio or technology roadmaps. Successful incubator projects will reduce the risk associated with potentially breakthrough approaches and technologies so they may be "on-ramped" to future roadmaps and the program portfolio.

Vehicle Technologies
Funding ($K)

	FY 2013 Current[2]	FY 2014 Enacted[3]	FY 2014 Current	FY 2015 Request	FY 2015 vs FY 2014 Enacted
Vehicle Technologies					
Batteries and Electric Drive Technology	111,663	108,935	108,935	135,531	+26,596
Vehicle and Systems Simulation & Testing	44,763	43,474	43,474	39,500	-3,974
Advanced Combustion Engine R&D	55,004	49,970	49,970	49,000	-970
Materials Technology	40,336	38,137	38,137	54,069	+15,932
Fuels and Lubricant Technologies	16,960	15,990	15,990	27,400	+11,410
Outreach, Deployment and Analysis	34,439	31,231	31,231	50,400	+19,169
NREL Site-Wide Facility Support	0	2,000	2,000	3,100	+1,100
Total, Vehicle Technologies	**303,165**	**289,737**	**289,737**	**359,000**	**+69,263**

SBIR/STTR:

- FY 2013 Transferred: SBIR $6,857,000; STTR: $889,000
- FY 2014 Projected: SBIR: $6,594,000; STTR: $942,000
- FY 2015 Request: SBIR: $8,287,000; STTR: $1,143,000

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

Vehicle Technologies
Explanation of Major Changes ($K)

	FY 2015 vs. FY 2014 Enacted
Batteries and Electric Drive Technology: Additional funding will support competitively awarded R&D teams to develop revolutionary electric vehicle energy storage systems that utilize robust battery monitoring and advanced safety technology. Emphasis will be on pack-level innovations that (1) reduce the weight and the cost of thermal management systems, structural and safety components, and electronics; (2) incorporate fast-charge capability into the design and build process; and (3) utilize robust safety technology, devices, and functionality including technology to render damaged batteries safe for first responders. Funding for the Advanced Processing activity will be increased and additional competitive awards will be supported. The funding increase expands efforts to develop motors without rare earth magnets and magnets without rare earth elements. The increase also supports new efforts to develop and commercialize WBG power modules to reduce system-level cost with improved performance and reliability. Specifically, funding supports competitively-awarded R&D teams (led and cost-shared by domestic industry partners) to develop WBG power modules that achieve performance and cost targets and goals.	**+26,596**
Vehicle and Systems Simulation & Testing: In order to maintain funding for ongoing higher priority activities, funding is reduced for Modeling and Simulation; Codes and Standards; Vehicle Technology Evaluation; and Vehicle Systems Efficiency Improvement. Funding will increase for Autonomous Vehicle Technologies.	**-3,974**
Advanced Combustion Engine R&D: Funding is increased for projects with industry for advanced engine technologies to improve the fuel economy of light-duty gasoline and diesel vehicles. No funding is requested for Solid State Energy Conversion in order to focus on higher priority activities.	**-970**
Materials Technology: Program activities shift in focus toward integrated computational materials engineering tools for composites made from low-cost carbon fiber and composites, developing lightweight materials and processes that are compatible with the existing manufacturing infrastructure. Funding increases support greater depth of ultra-lightweight vehicle sub-structure demonstrations and greater emphasis on overcoming specific technology gaps in carbon fiber composites and magnesium alloys. Support will continue for high temperature materials for valves and turbocharger components, while ending for thermoelectric materials and non-rare earth materials. Non-rare earth materials R&D support will continue through the Electric Drive Technology activity.	**+15,932**

	FY 2015 vs. FY 2014 Enacted
Fuels and Lubricant Technologies: Funding is increased to expand R&D work on drop-in biofuel compatibility with existing and future infrastructure, fuel, and engine systems, in cooperation with EERE's Bioenergy Technologies program. Activities will be initiated in development, testing, and validation for integrating natural gas into rail and ship transportation. R&D will be expanded to eliminate technical barriers for the increased use of alternative and renewable fuels, specifically in natural gas and drop-in biofuels. A study of the vehicle and infrastructure impacts of large-scale adoption of compressed and liquefied natural gas will be initiated.	**+11,410**
Outreach Deployment and Analysis: Funding is increased to initiate Alternative Fuel Vehicle Community Partner projects. New competitively-awarded projects will build strategically-placed, high impact networks and/or deploy alternative fuel vehicles. Legacy Fleet activities will eliminate driver feedback to focus on advanced fuel-efficient tire activity. No funding is requested for Biennial Peer Reviews, in order to focus resources on higher-priority activities.	**+19,169**
NREL Site-Wide Facility Support: Funding is increased as a result of a change in methodology used to allocate site-wide facility support contributions amongst programs. The FY 2015 value enables and directly equates to the program's estimated savings gained from the reduced labor multiplier.	**+1,100**
Total, Vehicle Technologies	**+69,263**

Vehicle Technologies
Batteries and Electric Drive Technology

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

Battery Technology ($100.0 million)
The focus of the Battery R&D activity is to develop the technologies necessary to reduce battery costs from $325/kWh in 2013 to $125/kWh by 2022, a nearly 40 percent reduction.

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

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

- Advanced Battery Materials ($32.0 million)
  The focus of this work will be on the development of new materials and electrode couples that offer a significant improvement in either energy or power over today's technologies. Specific technologies of interest include, but are not limited to, 2nd generation lithium ion batteries that contain high voltage (5V) and/or high capacity (>300mAh/g) cathode materials; 3nd generation lithium ion batteries that contain advanced metal alloy and composite anodes such as silicon carbon that offer 2-4 times the capacity of today's graphite anodes; and advanced electrolytes. Research on beyond lithium ion technologies, such as lithium metal batteries will be expanded.

- Advanced Battery Development ($38 million)
  The activity will continue to develop advanced PEV batteries in cooperation with industry through contracts that are awarded under a competitive process and are cost-shared by developers. The focus of this work will be on the development of robust prototype cells that contain new materials and electrodes and the development of advanced fabrication processes that offer a significant reduction in battery cost over existing technologies. Pack-level innovations will focus on the development of technology that will (1) reduce the weight and the cost of thermal management systems, structural and safety components, and electronics; (2) incorporate fast-charge capability into the design and build process; and (3) utilize robust safety technology, devices, and functionality including technology to render damaged batteries safe for first responders. The development of computer aided engineering battery design tools will also be supported. This work will result in batteries that meet PEV cost and performance goals.

- Advanced Processing ($30.0 million)
  The activity will accelerate the market entry of advanced batteries by supporting the scale-up, pilot production, and validation of new battery materials and processes in order to achieve significant battery cost reductions. Key materials (cathode, anode, electrolyte, and separator) account for 40-70 percent of PEV battery cost. This activity will focus on developing the scale up and manufacturing technologies necessary for market entry of the next generation of battery materials. Research will be conducted to support the development of more efficient electrode and cell designs and fabrication processes to reduce the cost for high-volume production of large format lithium-ion batteries. Emphasis will be placed on reducing the energy intensity to produce materials and the reclamation and reuse of key battery materials in order to reduce manufacturing cost. This activity accelerates the timetable for technologies to reach commercialization, and help meet economic, environmental, and energy security goals. Work will be carried out primarily through a competitive funding opportunity announcement.

Electric Drive Technology ($35.5 million)
The focus of the Electric Drive R&D activity is to develop technologies and designs to reduce cost, improve performance, and increase reliability of power electronics, electric motors, and other electric propulsion components. Activities also

include R&D of advanced thermal management technologies. The electric drive cost target for FY 2015 is $12/kW ($660/system), a 25 percent reduction from the 2012 cost of $16/kW ($880/system).

Key additional details include:

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

The Electric Drive R&D activity seeks to accomplish its technical objectives working closely with academia, National Laboratories, and industry. Efforts focus on R&D of power electronics, electric motors, and thermal management technologies utilizing advanced, low cost materials, technologies, and topologies compatible with the high-volume manufacturing of motors, inverters, chargers, and DC/DC converters for electric drive vehicles. Subcomponent R&D of high-temperature capacitors, advanced magnets, and materials and designs for high-temperature packaging continues.

To achieve its 2022 goals, Electric Drive R&D will be conducted through a combination of competitive funding opportunities and activities that leverage the core capabilities of our national laboratories. Work is focused on the following key areas:

- <u>Advanced Power Electronics ($10.6 million)</u>
  The activity focuses on research of critical devices and components including wide bandgap (WBG) devices, in advanced inverters, converters, and chargers for vehicle electric drive systems. It also includes the development of materials and packaging concepts to overcome barriers and challenges to enable a fully integrated electric traction drive system utilizing WBGs to increase efficiency, power density, specific power, and reliability while reducing cost. Passive devices, such as capacitors, are not currently capable of operating at the higher temperatures enabled by WBG devices at a cost that will enable automotive applications. R&D focuses on innovative technologies to improve performance over conventional Silicon (Si) devices to achieve the 2022 power electronics cost target of $3.3/kW, a 49 percent reduction from FY 2013.

- <u>Advanced Wide Bandgap (WBG) Power Modules ($7.0 million)</u>
  The activity will accelerate development of advanced WBG power modules to capitalize on WBG semiconductor capabilities that offer higher temperature, voltage, and frequency operation. Utilizing WBG devices in power modules for vehicle electric drive systems will enable substantial system-level cost reduction with improved performance and reliability. Efforts will accelerate use of WBG technologies to enable commercialization of advanced power modules. Through a competitive funding opportunity announcement, this activity will support R&D teams (led and cost-shared by domestic industry partners) to develop innovative WBG power modules that achieve performance and cost targets. Vehicle Technology WBG activities are closely coordinated with the overall EERE WBG initiative in order to avoid duplication and to ensure synergies among activities.

- <u>Advanced Electric Motors ($13.6 million)</u>
  The activity focuses on novel materials and advanced motor designs capable of meeting electric motor requirements without using rare earth materials. Motor designs will incorporate non-rare earth magnets, or eliminate magnets, while utilizing novel materials with improved electrical and thermal conductivity. Activities emphasize advanced motor designs and topologies to eliminate rare earth materials and magnets to achieve the 2022 electric motor cost target of $4.7/kW, a 51 percent reduction from FY 2013.

- <u>Advanced Thermal Management Technologies ($4.3 million)</u>
  The focus of this area is on development of interfaces, interconnects, and novel heat transfer strategies to accelerate the implementation of WBG devices that operate at higher temperatures. Conventional materials, technologies, and designs are not compatible with WBG operating temperatures but are required to meet electric vehicle performance and reliability requirements. Thermal management technology R&D focuses on increasing heat transfer and improving reliability.

Battery and Electric Drive Technology

Activities and Explanation of Changes

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs. FY 2014 Enacted
Battery and Electric Drive Technology		
• Continue support for the development and scale-up of high-capacity cathode materials. Increase support for 3rd generation lithium ion battery materials and cell R&D focused on advanced metal alloy or silicon composite anode technology. Complete the 2nd generation PEV battery development contracts focused on achieving the 2014 cost target of $300/kWh. Initiate new battery development contracts with industry to develop lower cost, durable, and safe batteries that have the potential of achieving the 2022 PEV targets. • Increase support for research focused on beyond lithium ion technologies such as lithium metal and beyond lithium battery technologies. Initiate new projects to improve the energy & power density and cycle life of beyond lithium Ion technologies such as lithium metal, lithium sulfur, and metal air systems. • Remove critical technical barriers to commercializing advanced electric traction drive components and systems. • Accelerate the implementation of WBG devices, reduce use of rare earth materials, and improve thermal management and reliability.	• Continue support for 3rd generation lithium ion battery materials and cell R&D focused on advanced metal alloy or silicon composite anode technology. Complete initial R&D to optimize battery cells containing high capacity cathodes and metal alloy or silicon anodes. Conduct extensive performance, cycle life, and safety testing of deliverables from battery development efforts with industry. Initiate new awards for the next development phase of Computer Aided Engineering Battery Design Tools. Continue support for materials research activity focused on beyond lithium ion technologies such as lithium metal and non-lithium battery technologies. • Initiate support to develop lower cost production processes that support the scale-up of advanced metal alloy or silicon composite anode materials, new cathode materials, innovative electrolytes, and other battery materials with the potential to significantly reduce battery material costs in support of the Clean Energy Manufacturing Initiative. • Continue support for the development of robust prototype battery cells and modules that incorporate new materials and advanced electrodes that offer a significant reduction in cost. • Support R&D to address critical technical barriers to commercializing advanced electric traction drive components and systems. • Develop non-rare earth magnets and motors with improved thermal management, performance, and reliability.	• Additional funding will support competitively awarded R&D teams to develop revolutionary EV energy storage systems that utilize robust battery monitoring and advanced safety technology. Emphasis will be on pack-level innovations that (1) reduce the weight and the cost of thermal management systems, structural and safety components, and electronics; (2) incorporate fast-charge capability into the design and build process; and (3) utilize robust safety technology, devices, and functionality including technology to render damaged batteries safe for first responders. Funding for the Advanced Processing activity will be increased and additional competitive awards will be supported. • The funding increase expands efforts to develop motors without rare earth magnets and magnets without rare earth elements. • The increase also supports new efforts to develop and commercialize WBG power modules to reduce system-level cost with improved performance and reliability. Specifically, funding supports competitively-awarded R&D teams (led and cost-shared by domestic industry partners) to develop WBG power modules that achieve performance and cost targets and goals.

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs. FY 2014 Enacted
	• Support R&D of innovative power electronics designs and packaging to reduce cost and improve performance. • Develop low-cost, high-temperature capacitors. • Initiate new efforts to develop WBG power modules to enable commercialization and reduce system-level cost with improved performance and reliability.	

Vehicle Technologies
Vehicle and Systems Simulation & Testing

Description
The Vehicle and Systems Simulation & Testing (VSST) subprogram conducts a broad portfolio of activities that support the reduction of petroleum consumption in the United States (U.S.) transportation sector. These activities include the development and use of advanced vehicle modeling tools to identify the most promising technologies for vehicle applications; component and vehicle evaluations in both laboratory and on-road environments to validate the modeling tools, prove the long-term reliability and benefits of advanced technologies, and identify critical Research and Development (R&D) needs to improve these technologies; the development of critical codes and standards to reduce the development time for and costs of plug-in electric vehicles (PEVs, including all-electric vehicles and plug-in hybrid electric vehicles) and components while ensuring real-world interoperability; and R&D of enabling technologies to improve overall vehicle efficiencies. VSST will perform this work in each of the focus areas identified below.

Modeling & Simulation ($5.5 million)
This activity will focus on projects that either develop advanced modeling tools or use these tools to perform simulations and studies of advanced vehicle technology options. In the area of tool development, work to expand the capabilities of the Autonomie modeling tool will continue with industry partners, adding new high-fidelity component models. These resources are made available to the automotive and heavy vehicle industries, where they accelerate development times and reduce the costs of bringing advanced, high-efficiency technologies to market. Simulation activities will focus on increasing vehicle efficiency through improved component interactions and conducting predictive modeling to identify optimal configurations and sizings for advanced components.

Vehicle Technology Evaluations ($9.0 million)
Work in this area includes in-depth laboratory testing of advanced vehicles and component interactions; closed track and on-road evaluation of the latest light-duty advanced technology vehicles to evaluate efficiency and high-mileage component reliability; in-fleet evaluation of medium- and heavy-duty advanced vehicle technologies with industry partners; charging equipment evaluations and research in Electric Vehicle Supply Equipment (EVSE) load management; and development and evaluation of vehicle thermal management systems. These efforts provide valuable data to the VSST modeling and simulation activity on the operation of advanced vehicles and technologies in laboratory and real-world conditions. In addition, these projects help R&D activities validate performance claims for advanced component technologies and identify potential R&D needs to address technology shortfalls. These projects also use vehicle and charging data trends to guide and facilitate R&D of technologies that can be used to reduce and potentially minimize the impact of PEVs on the electricity grid. Closed track and field evaluations of advanced technology vehicles also support the modeling and simulation, laboratory evaluation, and component R&D activities for Vehicle Technologies.

Codes & Standards ($4.3 million)
In support of the EV Everywhere Grand Challenge, this activity focuses on leading the development and adoption of U.S. standards for PEVs and working with international organizations to promote the global harmonization of PEV standards. Ensuring that codes and standards are in place for PEV technology directly supports the EV Everywhere Initiative and responds to industry requests for technical assistance in establishing reasonable standards that decrease product development costs and increase investment certainty. Specific standards developments that will be supported include Communications, Interoperability, Connectivity, Wireless Charging, Vehicle and Component Testing Protocols, Green Racing Protocols, and Cyber Security. Each of these efforts is coordinated and consistent with the Smart Grid Implementation Plan and being harmonized with European countries.

Vehicle Systems Efficiency Improvements ($13.2 million)
This activity seeks to improve overall vehicle operational efficiency by reducing parasitic energy losses. Projects focus on reducing the aerodynamic drag of heavy-duty trucks and tractor-trailer combinations; advanced HVAC R&D to improve PEV range; energy management strategies to improve vehicle efficiencies and R&D of advanced vehicle charging solutions such as wireless, smart fast-charging, low-power DC charging, and recharging from renewable sources. While each of the technologies being investigated can improve PEV efficiency, several of them, including the aerodynamic and advanced HVAC projects, are also applicable to vehicles with conventional drivetrains and potentially could be retrofitted onto legacy fleet vehicles. Support for existing SuperTruck awards will continue in FY 2015.

EERE Grid Integration Initiative ($5 million)

Customer owned electric vehicles, distributed renewable generation, and building equipment can be integrated to optimize their overall performance and designed to interact with the utility grid and better meet grid requirements as the concentration of these technologies on the grid increases. To enable customer options that address these grid integration issues in a comprehensive manner, EERE will implement a joint $19 million funding opportunity announcement sponsored by the Vehicles Technologies program ($5 million), Solar Energy Technologies program ($7 million), and the Buildings Technologies program ($7 million) to solicit technology and tool development and demonstration activities. Specifically, the Vehicles program will focus in the following areas:

- EV electricity flow analysis tools: Improved modeling and analysis of PEVs, charging infrastructure, and associated electricity consumption and flow characteristics will better inform building energy managers, utilities, and other stakeholders and will allow them to identify and better address potential issues (e.g., compromised distribution transformer life due to geographic clustering of PEVs).
- Battery and vehicle-level communications and control: Effective coordination of PEV battery charging and storage potential with distributed renewable generation and building energy management systems, as well as with the larger distribution system, will require new advanced sensors, controls, and control algorithms for electric vehicle batteries and systems. These devices and algorithms will be designed to use the communications protocols and standards under development by the Office of Electricity and others to ensure interoperability across the distribution system.
- Owner economics: To maximize the benefit of the integrated deployment of PEVs and other energy efficiency and renewable energy technologies, a clear value proposition to consumers and stakeholders must be demonstrated not only for each individual technology, but also for the interactions enabled by the overall system. This effort will aim to explore and quantify the multiple value streams that PEVs may provide when fully integrated with distributed solar generation, building energy management systems, and other technologies on a modernized grid.

Autonomous Vehicle Technologies ($2.5 million)

Connected and autonomous driving has important implications for the core DOE mission, such as the potential impact on transportation energy use. In FY 2015, the program will fund an analytical study to assess how consumer and driver behavior would affect energy consumption, and conduct research and development of enabling technologies for breakthrough advances in fuel consumption reduction through connected driving.

Vehicle and Systems Simulation & Testing

Activities and Explanation of Changes

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs. FY 2014 Enacted
Vehicle and Systems Simulation & Testing		
• Provide an overarching vehicle systems perspective in support of R&D activities by utilizing analytical and empirical tools to model and simulate potential vehicle systems, validate component performance in a systems context, verify and benchmark emerging technologies, and validate computer models. • Continue data collection and analysis and begin issuing final repots on electric-drive vehicles and charging infrastructure through Transportation Electrification initiative. • Initiate activity to integrate electric vehicles, building energy management systems, and solar generation technologies into the grid distribution system. • Demonstrate static wireless charging of electric vehicles using fully integrated systems in real-world operating environments at 6.6kW and 90 percent efficiency.	• Continue to provide a systems-level perspective in support of R&D activities, with an expanded focus on vehicles as part of the overall energy system. Leverage modeling and laboratory testing results to identify additional areas for energy efficiency improvements, including evaluation of autonomous vehicle technologies. • Complete SuperTruck projects, demonstrating a 50 percent improvement in Class 8 line-haul truck freight efficiency over a 2009 baseline through systems-level improvements. • Initiate industry effort to develop a distributed vehicle charging system to manage load across numerous PEVs under varying grid conditions. • Initiate Efficiency Analysis of Autonomous Vehicles effort to quantify the potential efficiency and fuel consumption reduction benefits of various autonomous vehicle technologies. • Continue efforts to integrate PEVs, buildings, and distributed electricity generation.	• Reduce funds for vehicle-specific elements of the Grid Integration Initiative Collaboration. • Modeling and Simulation (-$1,700): Eliminate component hardware-in-the-loop evaluations, specifically battery and engine evaluations. In addition, eliminate funding for engine benchmarking activity to develop detailed engine data and fuel maps for integration into Autonomie. • Codes and Standards (-$600): Eliminate international efforts to harmonize U.S. PEV codes and standards with those of China and other Asian countries. • Vehicle Technology Evaluation (-$2,674): Eliminate projects to evaluate advanced batteries (developed through Battery R&D) in real-world operations and reduce the medium- and heavy-duty advanced technology vehicle evaluations. Reduce laboratory and on-road evaluations of light-duty advanced technology vehicles by 25 percent (reduce funds for Advanced Vehicle Testing and Evaluation industry award) – this will eliminate advanced vehicles planned for testing at the Advanced Powertrain Research Facility 4-wheel chassis dynamometer. • Vehicle Systems Efficiency Improvement (-1,500): Eliminate efforts in thermal management R&D to reduce cooling system size, weight, and cost and eliminate friction and wear parasitic loss R&D to reduce losses in transmissions, axles, and other non-engine moving parts. • Autonomous Vehicle Technologies (+$2,500): Conduct autonomous vehicle R&D focusing on

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs. FY 2014 Enacted
		energy benefits and fund an analytical study to assess how consumer and driver behavior would affect energy consumption.

Vehicle Technologies
Advanced Combustion Engine R&D

Description

The Advanced Combustion Engine R&D subprogram focuses on removing critical technical barriers to commercializing 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 of the Nation's vehicle fleet in the near- to mid-term. A colloquium with representatives from industry, academia, and the National Laboratories concluded that engine efficiency can be significantly increased going forward.[4] A 2013 National Academies review of the program's 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."[5]

In FY 2015, the subprogram will support research to accelerate the development of high-efficiency advanced combustion regimes while reducing emissions and develop technologies to use waste energy from engine exhaust to improve fuel economy. Targets include the following:

- In 2015, increase passenger vehicle engine efficiency to improve gasoline vehicle fuel economy by 25 percent and diesel vehicle fuel economy by 40 percent; and by 2020, improve fuel economy by 35 percent and 50 percent for gasoline and diesel vehicles, respectively, compared to 2009 gasoline vehicles; and
- In 2015, increase SuperTruck vehicle engine efficiency by 20 percent, from 42 percent (2009 baseline) to 50 percent.
- By 2020, increase heavy duty engine efficiency by 30 percent, from 42 percent to 55 percent.

<u>Combustion and Emission Control ($49.0 million)</u>

This activity will develop technologies for advanced engines with the goal of improving thermal efficiency by optimizing combustion, fuel injection, air handling, emission control, and waste heat recovery systems, along with reducing friction and pumping losses.

Thermal efficiency of passenger and commercial vehicle engines will be improved by investigating innovative combustion processes, including homogeneous charge compression ignition (HCCI) and other modes of low-temperature combustion (LTC), lean-burn gasoline, clean diesel, and multi-fuel operation while also reducing engine-out emissions of nitrogen oxides (NOx) and particulate matter (PM) to near-zero levels. Based on findings from a workshop on modeling and simulation of internal combustion engines co-sponsored by DOE's Office of Science, representatives from industry, academia, and the National Laboratories agreed that research in this area will reduce product development time for industry and significantly increase engine efficiency. These improvements in engine efficiency will increase vehicle fuel economy and contribute to meeting future CAFE standards. Prior successful DOE investments in combustion research have yielded a 70:1 return on investment in fuel savings and associated health benefits.[6]

Meeting anticipated future emission standards will be challenging for high-efficiency diesel and lean-burn gasoline engines. To address this challenge, the Combustion and Emission Control activity will conduct research of innovative emission control strategies through projects led by the National Laboratories, industry, and universities designed to reduce costs and increase the performance and durability of NOx-reduction and PM-oxidation systems. Project areas include the development of low-cost base metal catalysts (to replace expensive platinum group metals), catalysts that operate at lower exhaust temperatures, lighter and more compact multifunctional components, and new control strategies. An FY 2013 workshop conducted with industry, universities and National Laboratories pointed to the need for research of catalysts to reduce emissions at exhaust temperatures of 150°C.[7]

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[4] *<u>Combustion Engine Efficiency Colloquium 2010</u>*: "The performance, low cost, and fuel flexibility of internal combustion engines (ICEs) makes it likely that they will continue to dominate the vehicle fleet for at least the next several decades. ICE improvements can also be applied to both hybrid electric vehicles (HEVs) and vehicles that use alternative hydrocarbon fuels." *<u>QTR Report, DOE 2011, p. 39</u>*.

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

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

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

Advanced Combustion Engine R&D

Activities and Explanation of Changes

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs. FY 2014 Enacted
Advanced Combustion Engine R&D		
Combustion and Emission Control ($45,723,000) • Remove critical technical barriers to commercializing high efficiency, advanced internal combustion engines for passenger and commercial vehicles. Improve thermal efficiency by optimizing combustion, fuel injection, air handling, emission control, and waste heat recovery systems. • Achieve a 23 percent improvement in fuel economy for passenger cars and an 18 percent improvement for commercial vehicles, compared to a 2009 baseline. • Validate chemical kinetics simulation model with experimental engine data. • Initiate new projects to increase passenger vehicle fuel economy by 35 to 50 percent by 2020 compared to 2009 baseline. • Develop emission control systems to reduce NOx from lean-burn gasoline engines.	*Combustion and Emission Control ($49,000,000)* • Develop advanced engine technologies that will improve the fuel economy of passenger and commercial vehicles in the near- to mid-term. Engine efficiency will be increased by optimizing combustion, fuel injection, air handling, emission control, and waste heat recovery systems. • Improve fuel economy of passenger cars by 25 percent and commercial vehicles by 20 percent compared to a 2009 baseline. • Initiate new projects to develop energy efficient powertrain technologies that will improve commercial vehicle engine efficiency by 30 percent in 2020 compared to a 2009 baseline. • Complete characterization of particulate matter from direct injection gasoline engines. • Complete experimental validation of fuel spray models developed using high performance computers and provide to industry. • Develop atomistic-scale design and scalable synthesis of multi-functional catalyst for emissions reduction at low exhaust temperatures.	*Combustion and Emission Control (+$3,277,000)* • Increase funding for projects with industry for advanced engine technologies to improve the fuel economy of light-duty gasoline and diesel vehicles.
Solid State Energy Conversion ($4,247,000) • Demonstrate a high efficiency thermoelectric waste heat recovery device on a passenger vehicle.	*Solid State Energy Conversion ($0)* • No activities.	*Solid State Energy Conversion (-$4,247,000)* • No funding is requested for Solid State Energy Conversion in order to focus on higher priority activities.

Vehicle Technologies
Materials Technology

Description
The Materials Technology subprogram supports vehicle lightweighting and improved propulsion efficiency through the discovery, development, and utilization of materials and enabling technologies for light- and heavy-duty vehicles. The Materials Technology subprogram seeks to accomplish its technical objectives through research programs with academia, National Laboratories, and industry.

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

- 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.
- 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.
- By 2019, validate material technology enabling 35 percent weight reduction in a light-duty vehicle body versus a 2002 baseline, meeting target $4.32 per pound removed on a lifecycle basis.

Key additional subprogram details include:

- Targets for weight reduction include all major vehicle systems – the body, chassis, interior, and powertrain (enabled by higher efficiency propulsion materials);
- Cost targets for lightweighting are based on the added vehicle cost per pound of removing weight;
- Lightweight materials include carbon fiber composites, advanced high strength steels, ferrous alloys, aluminum alloys, and magnesium alloys;
- Propulsion materials activities develop high-performance materials to withstand the aggressive conditions of high efficiency combustion and the demands of improved electric vehicle drive trains; and
- The long-term subprogram goal is to enable cost-effective vehicle weight reduction for all major systems while meeting all safety and performance requirements, including recyclability.

<u>Lightweight Materials Technology ($47.0 million)</u>
This activity supports the EV Everywhere Grand Challenge and addresses technology gaps that currently prevent the further introduction of advanced lightweight materials into vehicles. Reducing the weight of a vehicle by 10 percent yields a 6-8 percent fuel economy improvement for an internal combustion engine vehicle and increases the electric range or decreases battery size of an electric vehicle. However, the integration of lightweight materials into vehicle structures is limited by cost, performance, and manufacturing barriers as well as a lack of adequate design tools. The Lightweight Materials activity addresses these barriers by developing and demonstrating advanced steels, aluminum (Al) alloys, magnesium (Mg) alloys, carbon fiber composites, and multi-material systems with performance and manufacturability that greatly exceed today's technologies. Materials and manufacturing challenges spanning from extraction to assembly are addressed with an emphasis on establishing tools and capabilities for light- and heavy-duty vehicles.

In FY 2015, the Lightweight Materials activity will emphasize the development and validation of innovative, multi-material assembly, including fastening, bonding, and joining techniques; explore computational tools to develop manufacturing approaches for improved, higher-performance aluminum sheet and extrusion components; and research nontraditional, nonpetroleum-based lower-cost precursors for low-cost carbon fiber. In addition, this activity will continue to support research of advanced techniques for lowering the cost to oxidize carbon fiber precursors prior to conversion to carbon fiber, continue validating crash models for carbon fiber composites, develop and validate integrated computational tools for carbon fiber composites, advance and integrate several technologies for Mg alloys and processes with validation in a front end structure, and validate weight reduction and crashworthiness of a multi-material vehicle. The Lightweight Materials activity will further support development and deployment of lightweight materials and manufacturing technologies through demonstration of ultra-lightweight sub-structures such as doors and hoods.

<u>Propulsion Materials Technology ($7.1 million)</u>
This activity supports developing and demonstrating materials for vehicle powertrains with greatly improved properties compared to the state-of-the-art. Advanced combustion research can yield more efficient combustion regimes, but advanced engines are limited by existing material capabilities—new materials with improved strength, toughness, and high-temperature performance are required to enable greater efficiency. In FY 2015, the Propulsion Materials activity will develop materials that enable downsized, high-efficiency engines that provide the greatest opportunity for improvements

in overall powertrain efficiency. This activity addresses new materials for components such as crankshafts, pistons, connecting rods, turbocharger wheels, engine valves, gaskets, and bearings that improve efficiency by reducing mechanical/thermal losses and enabling higher peak cylinder pressures. This activity also complements work in the Electric Drive R&D activity by developing multi-material bonding techniques for induction motor components that enable higher current capabilities and improved dimensional stability.

Materials Technology

Activities and Explanation of Changes

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs. FY 2014 Enacted
Materials Technology		
• Support vehicle efficiency improvements through vehicle lightweighting through the discovery, development, manufacturing techniques, and utilization of lightweight metals and low cost carbon fiber in light- and heavy-duty vehicles. • FY 2014 emphasis targets high-strength, low-cost aluminum alloys and computational tools for composites. Demonstrate and validate (to within 10 percent uncertainty) the modeled cost-effective reduction by 45 percent of the weight of passenger vehicle body and chassis systems with safety, performance, and recyclability comparable to 2002 vehicles (weight reduction percentage, relative to 2013 baseline). • Develop materials that enable the Advanced Combustion Engine R&D subprogram and Electric Drive R&D activity to reach their efficiency goals. Ongoing work includes cast metal for engine blocks, cast steels for rotating components, and non-rare earth magnetic materials for improved efficiency. FY 2014 emphasis targets low temperature catalysts.	• Support vehicle lightweighting through the discovery, development, and utilization of integrated computational materials engineering tools for composites made from low-cost carbon fiber; development of lightweight materials that are compatible with existing infrastructure; and validation of the Mach I design for the multi-material prototype vehicle. • Demonstrate the full performance and cost capabilities of advanced lightweight materials and manufacturing technologies through the design, construction, and testing of ultra-lightweight vehicle sub-structures. • Initiate competitively-awarded projects emphasizing improved properties, manufacturability, computational materials science, and enabling technologies for carbon fiber composites, advanced high strength steels, aluminum alloys, and magnesium alloys. • Develop enabling materials in support of Advanced Combustion Engine R&D 2020 targets of 35 percent improvement in conventional passenger car fuel economy and 30 percent improvement in heavy-duty engine efficiency. • Continue work on cast metals for engine blocks, cast steel processing for rotating components, and low temperature catalysts.	• Represents a shift in focus toward integrated computational materials engineering tools for composites made from low-cost carbon fiber and composites, developing lightweight materials and processes that are compatible with the existing manufacturing infrastructure. • Increase supports greater depth of ultra-lightweight vehicle sub-structure demonstrations and greater emphasis on overcoming specific technology gaps in carbon fiber composites and magnesium alloys. • FY 2015 will continue support for high temperature materials for valves and turbocharger components, while ending support for thermoelectric materials and non-rare earth materials. (Non-rare earth materials R&D support will continue through the Electric Drive Technology activity.)

Vehicle Technologies
Fuels and Lubricant Technologies

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

Subprogram activities focus on achieving the following targets:

- In 2015, demonstrate fuel properties that enable an increase in the operating range of advanced combustion regimes to 62 percent coverage of non-idling portions of the city (UDDS) and highway (HWFET) light-duty Federal drive cycles. Maximizing advanced combustion operation yields greater fuel economy benefits.
- In 2020, demonstrate improved natural gas refueling technology for light-duty vehicles to increase vehicle range by 10 percent, compared to a 2010 baseline with equivalent-sized 3,600 psi tanks. The increased range would make natural gas vehicle range more comparable to gasoline vehicles.
- 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 engine oil on standard ASTM tests. Achieving a 4 percent fuel economy gain would save approximately 8 billion gallons of petroleum per year.

<u>Alternative and Renewable Fuels ($21.7 million)</u>
This activity focuses on overcoming technical barriers to the implementation of petroleum-displacing fuels. Fuels such as natural gas, drop-in biofuels, and higher alcohols (e.g., butanol) frequently have technical barriers that prevent their implementation in traditional, petroleum-derived equipment and infrastructure. Work to overcome these barriers will include support for new, alternative-fuel engine offerings, test and evaluation of refueling infrastructure, and evaluation of the emissions impact of novel alternative fuels.

As part of this activity, in cooperation with EERE's Bioenergy Technologies program (BETO), Vehicles Technology will study and identify the optimal biorefinery products for use in fueling infrastructure and vehicles ($5 million). Efforts will address how the refinery product slate impacts the introduction of biofeedstocks and bioblendstocks in conventional fuel manufacturing. This analysis of candidate drop-in biofuels will form part of a larger effort to assure maximum "fungibility" of any drop-in non-petroleum component of conventional fuels (e.g., natural-gas derived liquids) and alternative fuels (e.g., dimethyl ether).

In addition, the Alternative and Renewable Fuels activity will include new emphasis on natural gas ($5.7 million). Specifically, Vehicle Technologies will initiate a major study of the vehicle and infrastructure impacts of large-scale adoption of compressed and liquefied natural gas, specifically to investigate challenges associated with maximizing the fill capacity of tanks, improving on-board storage, improving the storage and dispensing of gas at stations, and improving pressure regulation to enable additional extraction of fuel from tanks. Building on prior-year activity, the subprogram will also begin new, competitively-awarded projects to develop high-efficiency medium- and heavy-duty alternative fuel (e.g., natural gas) engines, improved enabling technologies (e.g., natural gas direct injection technology), and address infrastructure compatibility.

The Alternative and Renewable Fuels activity will also include a new Initiative to integrate natural gas into rail and ship transportation ($5 million). The initiative will include activities in development, testing, and validation for integrating natural gas into rail and ship transportation. A study will be conducted to determine the most-advantageous pathways to increase natural gas use in such off-highway modes. It is anticipated the study will identify regulatory and technical hurdles, enabling the program to determine efficient use of funds in R&D and demonstration projects. R&D opportunities include development and demonstration of retrofit hardware for legacy equipment and/or conversion of existing stationary natural gas engines to rail and ship applications.

Lubricants ($3.3 million)

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

Fuel Properties ($2.4 million)

The Fuel Properties activity focuses primarily on fuel effects in advanced combustion regimes—engines operating in these regimes are emerging and offer high-efficiency with ultra-low emissions on an engine-out basis, but because combustion is controlled through chemical kinetics, it is inherently dependent on fuel properties. The two current and conventional fuel combustibility measures – cetane and octane – do not adequately capture the critical chemical characteristics of fuels that enable these nascent combustion regimes. In close coordination with the program's Advanced Combustion Engine R&D subprogram, the Fuel Properties activity focuses on using unique fuel properties, such as octane, cetane, and volatility for ignition and combustion control, thereby extending the efficiency potential of next-generation engines.

Fuels and Lubricant Technologies

Activities and Explanation of Changes

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs. FY 2014 Enacted
Fuels and Lubricant Technologies		
• Conduct R&D to eliminate technical barriers for increased use of alternative and renewable fuels such as natural gas and biofuels. • Develop and evaluate novel materials as lubricant additives and base-oil blendstocks for reduced friction and improved engine efficiency. • Conduct R&D on the use of fuel properties to expand the operational capabilities of advanced combustion engines. • Demonstrate an increase in the operating range of advanced combustion engines due to the use of renewable fuel properties allowing 60 percent coverage of non-idling portions of the city (UDDS) and highway (HWFET) light-duty Federal drive cycles; • Complete a high-temperature, high-load full-engine test using ionic liquids as an oil additive and exceed anti-wear and friction performance of GF-5 Mobil 1 motor oil by at least 2 percent. • Complete evaluation of biofuel-dilution effects on engine oil in light-duty legacy equipment. • Initiate new projects to increase passenger vehicle fuel economy in legacy and new vehicles 2-6 percent by 2020 compared to 2010 baseline.	• In cooperation with EERE's Bioenergy program, expand R&D work on drop-in biofuel compatibility with existing and future infrastructure, fuel, and engine systems. • Initiate activities in development, testing, and validation for integrating natural gas into rail and ship transportation. • Initiate a study of the vehicle and infrastructure impacts of large-scale adoption of compressed and liquefied natural gas. • Continue R&D on the use of fuel properties to expand the operational capabilities of advanced combustion engines. • Continue R&D to develop and evaluate novel materials as lubricant additives and base-oil blendstocks for reduced friction and improved engine efficiency. • Demonstrate an increase in the operating range of advanced combustion engines due to the use of renewable fuel properties allowing 62 percent coverage of non-idling portions of the city (UDDS) and highway (HWFET) light-duty Federal drive cycles. • Demonstrate dual-zone lubrication concept combined with novel oil additives and base oils that yields at least a 2 percent fuel economy gain. • Evaluate and demonstrate the compatibility and suitability of non-ethanol biofuels in light-duty legacy equipment.	• In cooperation with EERE's Bioenergy program, expand R&D work on drop-in biofuel compatibility with existing and future infrastructure, fuel, and engine systems. • Initiate activities in development, testing, and validation for integrating natural gas into rail and ship transportation. • Expand R&D to eliminate technical barriers for the increased use of alternative and renewable fuels, specifically in natural gas and drop-in biofuels; • Initiate a study of the vehicle and infrastructure impacts of large-scale adoption of compressed and liquefied natural gas.

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 Vehicle Technologies Deployment, which enables and works with a nationwide network of local public/private partnerships (Clean Cities coalitions), bringing together key stakeholders to help accelerate the use of alternative fuel and energy-efficient vehicle technologies. This activity also supports the annual DOE/EPA Fuel Economy Guide publication and associated website, www.fueleconomy.gov, as well as the development and dissemination of related data (required by law) to the public. The Advanced Vehicle Competitions activity encourages university student engineers to participate in advanced technology development—helping to address the need for more highly-trained engineers in advanced vehicle technologies to overcome barriers in the marketplace. The Legacy Fleet Improvement activity focuses on advanced tire technology—which, given tire usage/turnover and the ability for rapid market entry, offer a tremendous opportunity for petroleum reduction across the Nation's existing fleet of passenger and commercial vehicles.[8] The Outreach, Deployment and Analysis subprogram also includes a Legislative and Rulemaking activity focused 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. FY 2015 Outreach, Deployment and Analysis activities are described below.

Vehicle Technologies Deployment ($44.0 million)

The activity, primarily through Clean Cities, will support four main focus areas: 1) helping to convene key community and business leaders to develop and implement projects and policies, leverage resources, and address local barriers; 2) developing tools and information to help consumers save money on fuel costs and help fleets understand their options for cost-effective alternatives to gasoline and diesel fuel; 3) providing technical assistance to help local leaders address permitting and safety issues, technology shortfalls, and other project implementation barriers; and 4) providing competitive awards that encourage initial private sector match and long-term investment in alternative fuel and advanced technology vehicle deployment initiatives, including Advanced Fuel Vehicle Community Projects ($20 million).

Advanced Vehicle Competitions ($2.5 million)

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

Legacy Fleet Improvement ($2.0 million)

The activity focuses on reducing fuel consumption through improvements in tire rolling resistance for passenger cars and commercial vehicles in the existing fleet. Building on prior-year activities, FY 2015 activities will include cost-effective reductions in tire rolling resistance through materials development and new tread designs.

Legislative and Rulemaking ($1.9 million)

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

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[8] Passenger car tires are replaced every 3.75 years on average, and Class 8 tractor-trailer tires are replaced every 14 months on average. The entire fleet of about 220 million passenger cars and 8 million commercial vehicles could potentially be affected in less than four years, with a possible reduction of 0.3 MBPD, or savings of $11 billion per year. Committee for the National Tire Efficiency Study, Transportation Research Board of the National Academies, 2006.

Outreach, Deployment and Analysis

Activities and Explanation of Changes

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs. FY 2014 Enacted
Outreach, Deployment and Analysis		
• Displace petroleum use through public/private partnerships to catalyze the widespread adoption of advanced vehicle technologies, publishing the annual DOE/EPA Fuel Economy Guide publication and www.fueleconomy.gov, conducting advanced vehicle competitions, implementing statutory responsibilities placed on DOE by EPAct 2005 and other statutes and legislation, improving the legacy vehicle fleet energy use, and holding peer reviews to inform decisions about program focus. • Exceed Clean Cities' petroleum reduction goal of 850 million gallons per year. • Complete data gathering for, and analysis of, American Reinvestment and Recovery Act projects to develop relevant case studies and educational materials for local communities. • Complete three-year Clean Cities re-designation process for coalitions to improve planning, project effectiveness, and commitment to key strategic directions. • Develop tools to reduce key regulatory, permitting, and technical certification barriers to electric vehicle deployment. • Establish relationships with major Internet Information providers to increase distribution of web-accessible content and data, as per the Digital Government Strategy. • Plan and execute Year 3 of the EcoCAR 2 competition, focusing on the refinement of student-built vehicles. • Complete a vehicle demonstration of an automatic tire inflation system. • Complete a vehicle demonstration of a new tire	• Displace petroleum use through public/private partnerships to catalyze the widespread adoption of advanced vehicle technologies, publishing annual DOE/EPA Fuel Economy Guide publication and www.fueleconomy.gov, conducting advanced vehicle competitions, implementing statutory responsibilities placed on DOE by EPAct 2005 and other statutes and legislation, and improving the legacy vehicle fleet energy use. • Exceed Clean Cities' petroleum reduction goal of 950 million gallons per year. • Expand work with the Natural Gas Vehicle Technologies Forum to identify near-term barriers to vehicle deployment. • Expand participation in the National Clean Fleets Partnership and support member fleets' implementation of petroleum reduction strategies. • Complete data gathering from earlier AFV community planning projects, analyze data, and hold public forum to present findings. • Plan and begin Year 1 of a four-year collegiate engineering competition, EcoCAR 3. • Demonstrate finite element analysis capable of predicting effects of tire tread design parameters on tire rolling resistance. • Demonstrate feasibility of replacing tire inner-layer liner with a barrier film to enable improved efficiency. • Review and process petitions to designate new alternative fuels under EPAct. Implement legislative changes to the EPAct fleet activities, as needed.	• Initiate Alternative Fuel Vehicle Community Partner projects. New competitively-awarded projects would build strategically-placed, high impact community infrastructure networks and/or deploy alternative fuel vehicles. • Incorporate increased emphasis on workforce development and technology innovation within student competitions. • Eliminate driver feedback activity to focus on advanced fuel-efficient tire activity. • No funding for Biennial Peer Reviews, in order to focus resources on higher-priority activities.

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs. FY 2014 Enacted
design and materials leading to 2 percent reduction in fuel use. • Demonstrate, through a limited field trial, a driver feedback system capable of reducing over-the-road fuel use by 2 percent. • Review and process petitions to designate new alternative fuels under EPAct. Implement legislative changes to the EPAct fleet activities, as needed. • Analyze the impact of other regulatory and pending legislative activities and implement legislative changes to the EPAct fleet activities, as needed. • Initiate an independent critical review of the 21st Century Truck Partnership activity.		

Vehicle Technologies
NREL Site-Wide Facility Support

Description
In FY 2015, EERE will continue to 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. This practice is consistent with other National Laboratories. EERE began this practice in FY 2014 to reduce NREL's labor rate multiplier, thereby reducing the cost barrier to accessing unique NREL capabilities (such as facilities and staff expertise) by industry and academia. This practice also makes site operating costs more transparent in order to facilitate cost control and planning. In FY 2014, this practice resulted in a reduction in the Lab-wide direct labor multiplier of approximately 15 percent compared to FY 2013. The proposed FY 2015 budget continues this approach. The site-wide facility support funds cover maintenance and engineering support; fire, emergency, and custodial services; general utilities; network infrastructure and licenses; environment, safety, and health support; and sustainability. By moving these costs from laboratory overhead to direct funding, EERE accelerates technology transfer and mission impact by making it easier for companies and external researchers to access NREL capabilities and expertise.

This funding supports research programs by providing basic site services, functions, and infrastructure for Site Operations, which includes: Management, Building Operations, Building & Grounds Maintenance, Fire & Emergency Response, Engineering & Construction support, Minor Construction projects, Electrical Safety Program, Utilities, and Facilities Planning Support; and activities within the Sustainability and Environmental Health and Safety (EHS) portfolios. These activities and their costs are relatively fixed and only vary significantly based upon variations in commodities, construction activity, emergencies, weather patterns, etc. They are considered to be the core functions for site operations, safety, environmental compliance, and sustainability at NREL. In FY 2015, this funding will support more than 60 full time equivalents that manage and provide support for these core functions. It will also fund site-wide subcontracts such as janitorial services, refuse and recycling, and subcontracts for minor construction. Additionally, this funding will support site-wide costs associated with maintaining NREL's leadership position, such as: maintaining International Organization for Standardization (ISO), American Association for Laboratory Accreditation (A2LA), and other lab-wide accreditations, managing facilities to enable mission goals, improving sustainability, pollution prevention, waste minimization, improving energy efficiency, reducing water use, and maintaining an effective emergency management system.

The FY 2015 contribution from each program differs from the FY 2014 allocation, because EERE has developed a more precise, equitable, and economically neutral method that ensures a net-zero impact on programs' funding. For each program, the contribution to direct funding for site-wide facility support is equivalent to the estimated contribution the program otherwise would have made through overhead charges. This method is based upon each program's level of funding to NREL, adjusted to account for anomalies from capital expenditures and major subcontracts.

NREL Site-Wide Facility Support

Activities and Explanation of Changes

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs. FY 2014 Enacted
NREL Site-Wide Facility Support		
• Directly fund NREL Site-Wide Facility support costs that are not included in the Facilities and Infrastructure budget rather than continue to fund these costs in the laboratory overhead rate.	• Directly fund NREL Site-Wide Facility support costs that are not included in the Facilities and Infrastructure budget rather than continue to fund these costs in the laboratory overhead rate.	• The delta is the result in a change in methodology used to allocate site-wide facility support contributions amongst programs. The FY15 value enables and directly equates to the program's estimated savings gained from the reduced labor multiplier.

Vehicle Technologies
Performance Measures

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

	FY 2013	FY 2014	FY 2015
Performance Goal (Measure)	**Batteries - Reduce the modeled cost of energy storage for Electric Vehicles (EVs). ($/kWh)** 2013 – 2014: Measure for modeled production cost of a high power battery for a Plug-In Hybrid Electric Vehicle Battery capable of a 40 mile all electric range.		
Target	400 $/kWh	300 $/kWh	275 $/kWh
Result	Exceeded – 325	N/A	N/A
Endpoint Target	$125/kWh by 2022		

Bioenergy Technologies

Overview

The Bioenergy Technologies program's mission is to catalyze the development of a domestic capability to produce cost-competitive renewable fuels from non-food biomass resources. Biofuels are a major component of a multipronged strategy that addresses energy security, transportation-related greenhouse gas (GHG) emissions, and U.S. job growth. The potential exists to sustainably produce at least 1 billion dry tons of non-food biomass resources by 2030[1]: this is a sufficient quantity to displace approximately 30 percent of the country's present petroleum consumption without impacting food or feed needs, and to have a positive impact on the environment by significantly reducing GHG emissions. To deliver on the broad benefits of advanced biofuels and bioenergy technologies, the program works to understand the critical linkages along the supply chain including research, development, demonstration, and deployment (RDD&D) on sustainable feedstock supply, and logistics, cost competitive conversion process including cost-shared scale up and construction of integrated biorefineries that will reduce the risk of this "First of a Kind" technology encouraging further private investment. The program enables the development of technologies that transform the robust, renewable biomass resources of the U.S. into commercially viable, high-performance biofuels, bioproducts, and biopower through targeted RDD&D supported by public-private partnerships. Research is targeted primarily on fuels that have the potential to enter the market and compete directly with petroleum, both in terms of cost and performance. Cellulosic ethanol was the program's initial focus because it could easily be blended into the gasoline fuel pool, in order to address the need for increased octane content. DOE has made significant progress in the RD&D of cellulosic ethanol in order to enable appreciable market penetration for the foreseeable future. While cellulosic ethanol has the potential to displace up to 38 percent[2] of crude oil that is used to produce light-duty gasoline, it cannot be blended with diesel or jet fuel or be integrated within the existing refinery system. Building on the foundation and success of cellulosic ethanol R&D, the program has now shifted toward RDD&D activities focused on drop-in hydrocarbon biofuels, including renewable gasoline, diesel, and jet fuel — as well as chemicals and products. Science and technology have evolved to make drop-in hydrocarbons a highly promising future opportunity that supports the domestic demonstration and deployment of commercial renewable fuels supply. These bio-based hydrocarbon fuels are more compatible with today's engines and fuel delivery infrastructure. Cellulosic ethanol has enjoyed over 10 years of RDD&D which is leading to demonstration of first of a kind cellulosic ethanol producing biorefineries at commercial scale. To address the next wave of technologies to drop-in hydrocarbon fuels, the program is pursuing multiple pathways, including thermochemical-, catalytic-, biochemical- and hybrid-conversion routes of lignocellulosic and algal feedstocks with the goal of achieving $3/Gasoline gallon equivalent (gge) by 2022 with at least 50 percent GHG reduction on a lifecycle basis with several down-selected technologies in order to provide optimal solutions across the nation.

Several key challenges must be addressed for the bioenergy sector to significantly contribute further to our national goals of reducing oil dependency and decreasing GHG emissions:

- Scalability — significant quantities of biomass exist today as agricultural and forestry residues and urban wastes. However, it is difficult to economically collect and haul these materials to a central processing facility because they have intrinsically lower bulk and energy densities than crude oil, coal, or corn grain. In addition, first-of-a-kind facilities carry large risks in scaling technologies from bench to commercial scale.
- Cost reduction — the significant external advantages to the U.S. economy of domestically produced biofuels and bioproducts are not captured in the market price, so domestic production must be able to compete in the market in order to develop a meaningful industry. A recent survey[3] indicated that the cost of biofuels has dropped significantly since 2008. The survey found that the largest cost elements for producers in 2012 were project capital expenditure, feedstock, and enzymes. The operating costs of the process have dropped significantly since 2008 due to leaps forward in the technology. For example between 2008 and 2012, the program's 10 year investment of over $65 million contributed to a 72 percent reduction in the enzyme cost necessary to produce a liter of cellulosic ethanol. Continued investments to achieve these types of cost reductions will be necessary to maintain this same reduction trajectory for the whole value chain.
- Private-sector investments — In order to support the emerging advanced biofuels industry through its early development and commercialization, the industry needs to demonstrate the technology thus reducing risk in order to attract future private sector investment in subsequent commercial facilities. For example, continued government

[1] http://www1.eere.energy.gov/bioenergy/pdfs/billion_ton_update.pdf.
[2] EIA, Annual Energy Review 2012, 85 percent of gasoline stream in total petroleum products.
[3] Bloomberg New Energy Finance, "Cellulosic Ethanol Costs: Surveying an Industry" (March 2013).

support, in partnership with the private sector, to build specialized, first-of-a-kind facilities will help validate performance and economics at a scale necessary to enable confidence from the financial markets for commercializing a robust biofuels industry.

- Infrastructure — there is a need to ensure that the transportation supply chain and delivery infrastructure are able to deploy and utilize advanced biofuels as they are produced in significant volumes. Vehicle compatibility will need to be validated for drop-in replacement fuels as well. This work represents a significant opportunity for collaboration between Bioenergy Technologies and Vehicle Technologies, and ensures widespread adoption within the transportation sector.

Within the program's mission, the following activities are directed at overcoming these fundamental challenges:

- Conduct research and development (R&D) directed at reducing the cost of producing biofuels, bioproducts, and biopower by improving the efficiencies of feedstock production and delivery, as well as through developing more effective, cost-competitive processes to convert biomass into finished products.
- Develop technologies to convert non-food sources of biomass to intermediates — such as low-cost sugars, chemicals, and crude bio-oils — to meet the need for fuels and bioproducts, thus enhancing project economics and environmental sustainability.
- Evaluate infrastructure readiness through analysis and testing of advanced biofuels to enable use of existing infrastructure for deployment and utilization, thus reducing the need for capital investments in new infrastructure.
- Enable demonstration activities for the manufacturing of biofuels and bioproducts that are critical to proof of performance and lay the groundwork for future commercial deployment.

To measure performance and support these objectives, the program has set a technical goal to reduce the cost for converting cellulosic biomass feedstocks to hydrocarbon biofuels via biological, catalytic, thermochemical, biochemical, or hybrid pathways to $3/gge ($2011) between 2017 and 2022 at increasing scales and with a selection of technologies to enable optimal deployment of bioenergy solutions across the large diversity within the U.S. This equates to a cost equivalent of approximately $100 barrel of oil—a target that will allow these renewable fuels to successfully enter the market and manage profitably notwithstanding the price volatility of transportation fuels due to the regionality and diverse nature of biomass resources utilized; a number of technology pathways may ultimately be required in order to achieve large-scale production of biofuels. For this reason, the program is currently pursuing a variety of feedstock-conversion method pathways. (See one example in Figure 1)

The subprograms are organized to undertake RDD&D activities across the entire supply chain necessary to meet the cost targets, technical goals, and associated milestones outlined in the program's Multi-Year Program Plan (MYPP). In addition, the program seeks to support emerging technology approaches via its Incubator activity. This initiative is an annual funding mechanism to support the investigation of innovative solutions and potentially breakthrough "off-road-map" approaches that can help accelerate meeting the program's overall goals. For FY 2015, Incubator funding represents 5 percent of the program's total budget.

Highlights of the FY 2015 Budget Request

The program's budget request supports several focus areas in FY 2015:

- Feedstock production and logistics efforts will focus on integrating environmental sustainability and quality criteria into biomass supply assessment for crop residues, energy crops, and forest resources, as well as on down-selecting feedstock blend formulation for the thermochemical oils pathway based on ash and moisture content, carbon levels, and other characteristics. The program will pursue new research in advanced biology and carbon dioxide (CO_2) utilization to leverage capabilities at the algae testbed facilities and lay a foundation for breakthroughs needed to meet FY 2022 algae productivity targets.
- Conversion pathways (at least two) will be selected for validation at integrated bench and pilot scale in FY 2017, and modifications to facilities will begin as needed. The program will issue funding opportunity announcements (FOAs) for consortia to further the integration of bio-oils into petroleum refineries, development of biological and chemical catalysts and clean sugar production, resolution of gasification and gas to liquids (GTL) issues identified in FY 2014 workshops, and continued incubator and carbon fiber activities.
- Demonstration and Deployment subprogram efforts will focus on drop-in hydrocarbon production and scale up. Support of commercial demonstration of military-specification jet fuel in collaboration with the U.S. Department of Defense (DOD) and the U.S. Department of Agriculture (USDA) through the Defense Production Act (DPA) will continue. In addition, new investments will enable new technologies to validate scale up, accelerating momentum for advanced

biofuel production in the wake of pioneer large-scale cellulosic ethanol successes. Additional challenges and high-leverage opportunities for drop-in fuel, including reducing the balance of plant costs, will be identified in a FY 2014 biorefinery deployment workshop. Investment in biofuels compatibility will increase through collaborative efforts with the Office of Energy Efficiency and Renewable Energy's (EERE's) Vehicle Technologies program.

- Strategic Analysis and Cross-Cutting Sustainability subprogram efforts will focus on coordinating with logistics and conversion R&D areas on the goal to set targets for minimizing GHG emissions, air pollutants, and consumptive water use for at least three renewable hydrocarbon pathways by FY 2016.

Collectively, program activities focus on achieving the following high-level goals:

- Through RDD&D, make drop-in hydrocarbon fuels competitive with petroleum-based fuels at a modeled cost of mature technology of $3/gge ($2011), based on EIA projected gasoline wholesale prices in 2017.
- The 2017 performance goal of the IBR Technology Area is to validate a mature technology plant model cost of ethanol production, based on actual IBR project plant performance data and compared to the target of $2.15/gallon ethanol ($2007).

These goals reflect the strategy of making advanced biofuels—renewable gasoline, diesel, and jet—commercially viable, as the most effective path for meeting EISA 2007 goals.

The program's goal to accelerate the development and deployment of advanced biofuel technologies directly supports the President's Climate Action Plan,[4] which was issued in June 2013.

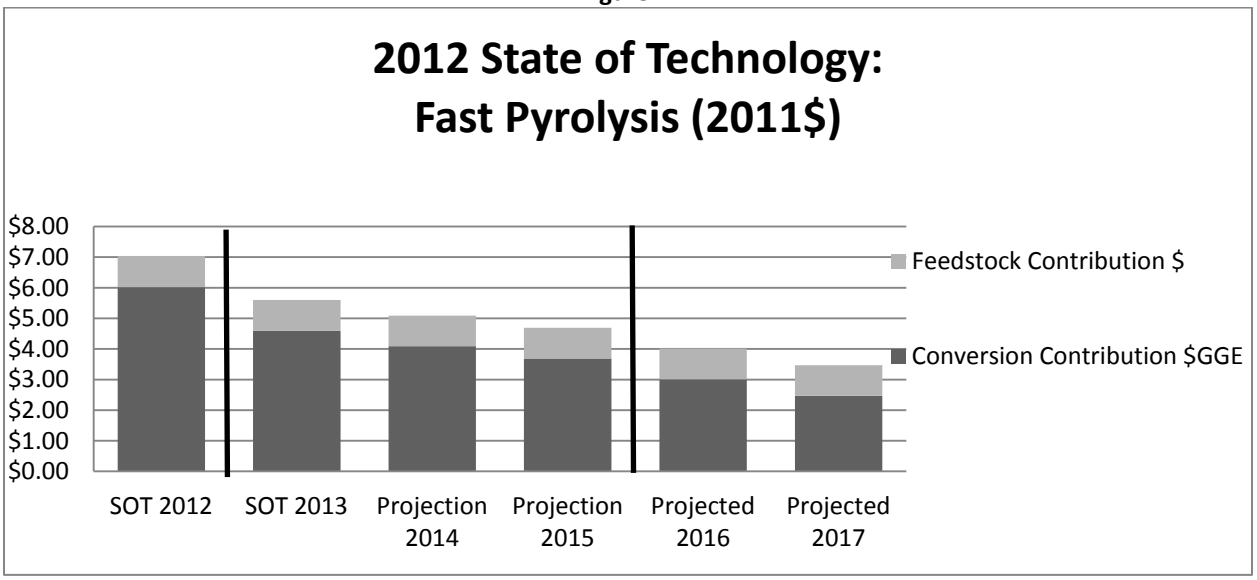
The program's efforts to accelerate the deployment of a domestic bioenergy industry directly support the directive issued by the President in March 2011 as part of his Blueprint for a Secure Energy Future,[5] which challenges DOE, USDA, and the Navy to collaborate and speed the development of military-specification biofuels, including jet fuel.

In addition, the program's development and maintenance of the Bioenergy Knowledge Discovery Framework (KDF) directly supports the Administration's goals for sharing federally funded R&D data. In February 2013, the White House issued a policy memorandum to expand public access to the results of federally funded research.

The program utilizes design cases to understand the current state of conversion technologies and to determine where improvements need to take place in the future. Figure 1 illustrates the cost projections and state of technology for biomass conversion to gas and diesel via fast pyrolysis. The program incorporates data from research into the model annual to update progress to the programmatic goal of $3.00/gge.

[4] http://www.whitehouse.gov/sites/default/files/image/president27sclimateactionplan.pdf.
[5] http://www.whitehouse.gov/sites/default/files/blueprint_secure_energy_future.pdf.

Figure 1[6]



	SOT 2012	SOT 2013	Projection 2014	Projection 2015	Projection 2016	Projection 2017
Conversion Contribution $GGE	6.0	4.6	4.1	3.7	3.0	2.5
Feedstock Contribution $	1.0	1.0	1.0	1.0	1.0	1.0
Minimum Fuel Selling Price $GGE	7.0	5.6	5.1	4.7	4.0	3.4

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

Bioenergy Technologies
Funding ($K)

	FY 2013 Current[7]	FY 2014 Enacted[8]	FY 2014 Current	FY 2015 Request	FY 2015 vs. FY 2014 Enacted
Bioenergy Technologies					
Feedstocks	47,359	46,972	46,972	30,500	-16,472
Conversion Technologies	75,140	101,384	101,384	100,500	-884
Demonstration and Deployment (formerly Integrated Biorefineries)	43,630	64,790	64,790	105,000	+40,210
Strategic Analysis and Cross-Cutting Sustainability	14,939	12,146	12,146	11,000	-1,146
Biopower	4,122	1,998	1,998	0	-1,998
NREL Site-Wide Facility Support	0	5,000	5,000	6,200	+1,200
Total, Bioenergy Technologies	**185,190**	**232,290**	**232,290**	**253,200**	**+20,910**

SBIR/STTR:

- FY 2013 Transferred: SBIR: $2,867,000; STTR: $371,000
- FY 2014 Projected: SBIR: $4,343,000: STTR: $620,000
- FY 2015 Request: SBIR: $3,683,000; STTR: $508,000

[7] Funding reflects the transfer of SBIR/STTR to the Office of Science.
[8] FY 2014 Enacted funding reflects the contractor foreign travel rescission of $139,000.

Bioenergy Technologies
Explanation of Major Changes ($K)

	FY 2015 vs. FY 2014 Enacted
Feedstocks: The decrease is due to greater reliance on feedstock production research activities at USDA and due to fully funding feedstock logistics FOA selectees in FY 2013 and FY 2014. The decrease is also due to fully funding the Algae Biomass Yield FOA selectees in FY 2013 and FY 2014.	**-16,472**
Conversion Technologies: The decrease is minor and results from fully funding awards in FY 2013.	**-884**
Demonstration and Deployment (formerly Integrated Biorefineries): Increased funds to initiate new pilot- and demonstration scale projects.	**+40,210**
Strategic Analysis and Cross-Cutting Sustainability: The decrease is minor and results from fully funding analysis projects in FY 2013 and FY 2014.	**-1,146**
Biopower: Not funded in FY 2015.	**-1,998**
NREL Site-Wide Facility Support: Increased funds are the result of a change in methodology used to allocate site-wide facility support contributions amongst programs. The FY 2015 value enables and directly equates to the program's estimated savings gained from the reduced labor multiplier.	**+1,200**
Total, Bioenergy Technologies	**+20,910**

Bioenergy Technologies
Feedstocks

Description

The Feedstocks subprogram includes feedstock production and logistics, as well as the Algae and Advanced Feedstocks subprogram. This subprogram has the goal of developing strategies, technologies, and systems that can provide feedstock to the throat of the conversion reactor for a total cost of no more than $80/dry ton by FY 2017, while meeting conversion process specifications. Past accomplishments for this subprogram have included the publication of the Billion-Ton Update,[9] as well as disseminating resource assessments and other information from the Regional Feedstock Partnership seven-year field trials—including yield density maps—and making this data publicly available for researchers and biorefinery developers in the KDF. The KDF provides online access to a wide variety of information resources, including biomass production data and decision-support tools. In FY 2013 and FY 2014, the five high-tonnage feedstock logistics projects—which included partnerships with original equipment manufacturers—demonstrated significant reduction of costs (e.g., $13/ton for corn stover, relative to conventional systems) for integrated systems that utilize agricultural residues, forest resources, and/or herbaceous and short-rotation energy crops. In addition, the Idaho National Laboratory (INL) process development unit completed designation as the Biomass Feedstock National User Facility (NUF). The NUF, with its associated Biomass R&D Resources Library (currently with more than 50,000 archived samples), houses commercial-scale equipment and is fully integrated with the conversion capabilities at Lawrence Berkeley National Laboratory (LBNL), the Pacific Northwest National Laboratory (PNNL), and the National Renewable Energy Laboratory (NREL).

Feedstock production ($4 million)

Feedstock production research is critical to meeting the program's objectives. Activities are focused on producing sufficient, sustainable, affordable biomass feedstocks to support the development of the biomass conversion industry. Results obtained from ongoing feedstock trials will be incorporated into core resource assessment efforts and will be used to evaluate progress toward meeting the Billion-Ton "vision," to set technical targets, and to identify research needs. The feedstock quality information available in the INL Biomass R&D Resources Library will be expanded and results shared publicly via the KDF. The NUF will be used to obtain and test feedstocks produced by the USDA Concentrated Agriculture projects, program-funded (and other) integrated biorefineries, and other users in a variety of preprocessing configurations.

Feedstock logistics ($12.5 million)

Recognized as a major element in the *National Biofuels Action Plan*, the program MYPP, and other analyses, feedstock logistics challenges need to be overcome to build a sustainable, national bioenergy and bioproducts industry. Core integrated research for FY 2015 includes harvesting, collection, in-field handling and drying, storage, preprocessing (including drying, grinding, and densification), and transport of biomass feedstocks. Through its biomass depot concept, the program is exploring blending and formulation strategies for utilizing a combination of feedstocks capable of providing large quantities of biomass that meet or exceed quality specifications for a variety of biorefinery conversion processes at a cost not to exceed $80/dry ton at the throat of the conversion reactor. These strategies could be regional in nature and vary among different conversion pathways. Parameters included in the testing are ash and moisture content, dry matter loss, particle size and shape, carbohydrate and lignin content, and others. The INL NUF will be given base funding with additional funds provided on a cost-share basis with various users, including the private sector, universities, and federal and state agencies.

In FY 2013, the program's five high-tonnage feedstock logistics projects—which included partnerships with original equipment manufacturers—demonstrated significant reduction of costs (e.g., $13/ton cost reduction relative to conventional systems for baled corn stover) for integrated systems that utilize agricultural residues, forest resources, and/or herbaceous and short-rotation energy crops. Cost reductions reported in all five projects have been independently validated by Oak Ridge National Laboratory researchers.

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

Algae & Advanced Feedstocks ($14 million)

The Algae and Advanced Feedstocks subprogram goal is to develop cost-effective algal biofuels production and logistics systems. The challenges and opportunities to commercializing algal biofuels production systems are broad and complex, requiring the close integration and collaboration of many scientific and engineering disciplines to bring about innovations.

The Algae subprogram is focused on supporting the growth of the emerging domestic algae industry and its interest in commercialization for fuels and products. Support includes the development of validated models for techno-economic, sustainability, and engineering analyses.

The primary advantages of algal biomass, which include its ability to grow quickly, use waste resources, and accumulate ideal fuel precursors (e.g., lipids), are broadly recognized. In recent years, the program has achieved technological advancements that promise to bring about transformational changes, including the ability to predict, breed, and select the best-performing strains; the ability to monitor and control system inputs in a dynamic and integrated fashion; the ability to harvest algae at ever higher throughputs; and the ability to extract and convert more algal biomass components into fuels.

However, based on the results of a peer review held in May 2013 and from earlier R&D efforts, the strategic direction and priorities of Algae and Advanced Feedstocks are being reevaluated. Initially addressing a broad array of technical barriers identified in the comprehensive National Algal Biofuels Technology Roadmap,[10] research primarily focused on strain screening, natural selection, and strain development. These efforts have provided important data and understanding of the potential use of algae for commodity fuels production. Recently completed techno-economic models indicate a more than five-fold increase is needed in combined productivity and yield, with a reduction in capital cost, to meet the $3/gge fuel cost goal identified in the program's MYPP. This will include investigating complex algal communities' potential for utilization of waste water to reduce production costs. Thus, Algae and Advanced Feedstocks will increase efforts in quantitative analysis to mitigate risk of technology options and will develop a more targeted approach to overcome barrier areas identified through techno-economic analysis and stage-gate reviews. Funding will support the development of a portfolio of technologies focused on demonstrating a mature plant and an economically competitive hydrocarbon fuel pathway.

The costs associated with producing, handling, and converting these primarily aquatic feedstocks are still too high to produce cost-competitive biofuels. In FY 2015, work selected and funded through the FY 2013 Algal Biomass Yield solicitation to address yield, productivity, and integration of downstream logistics at the pre-pilot scale will continue. This will support a programmatic path aligned with the MYPP goal of validating the potential for algae supply and logistics systems to produce 5,200 gallons of oil (or equivalent biofuel intermediate) per acre of cultivation per year. This will also achieve a modeled nth plant minimum selling price of $3.27/gge ($2011) of raw biofuel intermediate by FY 2022 that will enable the final fuel production price of $3.00/gge.

The Algae Testbed Public-Private Partnership—based at Arizona State University with additional facilities in Hawaii, California, Ohio, and Georgia—will continue to support best practices for algae cultivation in different geographic locations. In addition, resource assessments, life-cycle GHG emissions, and techno-economic modeling will continue.

The Algae subprogram plans to meet program goals through the consideration of additional selections from prior year FOAs and/or planning for new FOAs.

In FY 2015, Algae and Advanced Feedstocks will evaluate and expand how the R&D efforts are proceeding to produce mixed cultures and species in a single pond or bioreactor. The main objective is to test the idea that certain naturally diverse groups of algae have complementary traits that enhance the efficiency and stability of biofuel yield beyond what any single species can do alone. The subprogram will use the results from several workshops held in FY 2014 to determine if the Algae Roadmap should be updated or revised to address the technology advances that have occurred since it was published in FY 2010. This effort will advise the subprogram on a FOA on advanced biology and CO_2 utilization to leverage capabilities at the algae testbed facilities and implement a strategy to overcome the critical barriers needed to meet FY 2022 algae productivity targets.

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[10] U.S. Department of Energy, Bioenergy Technologies Program. *National Algal Biofuels Technology Roadmap: A Technology Roadmap Resulting from the National Algal Biofuels Workshop*. By Daniel Fishman, Rajita Majumdar, Joanne Morello, Ron Pate, and Joyce Yang. Washington, D.C. May 2010.

The Feedstock subprogram will also be involved in the program's incubator activities. The intent of the incubator is to identify new off-road map innovative technologies that can help meet the program goals. For the program's incubator activity specifically, technologies from across all aspects of the biofuel supply chain — feedstock production and logistics (both terrestrial and algae), biochemical conversion, thermochemical conversion, and sustainability—will be considered for funding. Selected incubator projects demonstrating technologies toward feedstock production, feedstock logistics, or algae will be managed within the Feedstock portfolio.

Feedstocks

Activities and Explanation of Changes

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs. FY 2014 Enacted
Feedstocks		
• New results obtained from ongoing feedstock trials sponsored by DOE at USDA, land grant universities, and the private sector will be incorporated into the resource assessment efforts via the KDF. • Quality analysis available in the INL Biomass R&D Resources Library will be expanded and shared with feedstock logistics and conversion researchers. • Biomass NUF will be used to obtain and test feedstocks produced by the USDA concentrated agriculture projects, DOE-funded and other integrated biorefineries, and other users in a variety of preprocessing configurations. • Research activities will focus on three critical constraints currently confronting the emerging industry: delivered feedstock cost; delivered feedstock quality and maintenance of quality characteristics during storage; and accessible feedstock volume. • Deployment of the Process Demonstration Unit at INL to assess performance and cost data at a biorefinery. • The Algae activity will evaluate the major process performance and capital cost assumptions utilized in the techno-economic analysis for the design cases. Based on technical expertise of external reviewers will identify assumptions used that are in question, identify realistic targets for assumed values, and identify alternatives for process improvements. • Perform techno-economic sensitivity analysis on major process parameters based on the results of technical evaluation with an external reviewer	• Biomass supply assessments for crop residues, energy crops, and forest resources will include environmental and quality criteria to meet feedstock quality demands of conversion facilities. • Quality analysis work will continue at the Biomass NUF. • Continued public-private partnerships to develop systems at industrial scale to reduce cost and energy associated with biomass drying and densification, such that the feedstocks are compatible with existing high-capacity handling and transport infrastructure. • Continued research focused toward demonstrating biomass stabilization technologies (e.g., high-moisture pelleting) that preserve feedstock quality during transport and storage, thereby reducing degradation potential and cost. • Increase the longer-term core research targeted at more fundamental understanding of algae ecology, physiology, biochemistry, and genetics; and use new techno-economic models to screen projects and direct more of the longer-term research.	• The decrease is due to greater reliance on feedstock production research activities at USDA and to fully fund feedstock logistics FOA selectees in FY 2013 and FY 2014. • The decrease is also due to fully funding the Algae Biomass Yield FOA selectees in FY 2013 and FY 2014.

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs. FY 2014 Enacted
and new results from mixed culture analysis and the best strains from the algal test-bed facilities.		

Bioenergy Technologies
Conversion Technologies

Description

The goal of the Conversion Technologies subprogram is to develop technologies for converting biomass feedstocks into commercially viable liquid transportation fuels, as well as bioproducts and biopower. After a decade of pilot-scale work, technical performance data were generated in FY 2012 that validated the potential of biochemical and thermochemical process pathways to produce cellulosic ethanol in a mature commercial biorefinery for approximately $2/gallon. The program is focused on hydrocarbon fuel production to increase compatibility with existing infrastructure and to displace a larger percentage of petroleum use. This R&D priority also reflects the recent successful commercial deployment of early cellulosic ethanol technologies. Many of the technology breakthroughs responsible for achieving the $2/gallon ethanol goal can and will be leveraged for the production of hydrocarbon fuels going forward. The program has set an ultimate target of $3/gge for hydrocarbon fuels in order to be competitive with petroleum fuels at $80/barrel oil.

Conversion R&D includes biological, catalytic, thermochemical, and hybrid routes to convert biomass into suitable intermediates, including—but not limited to—sugars, bio-oils, and gases. These intermediates are then upgraded into renewable gasoline, diesel, jet fuels, chemicals, and heat and power. Renewable diesel can also be used in place of home heating oil.

In the past, the Conversion subprogram was divided into two technology pathway areas—Biochemical and Thermochemical (including pyrolysis and gasification), as depicted in Figures 2, 3, and 4.

Figure 2

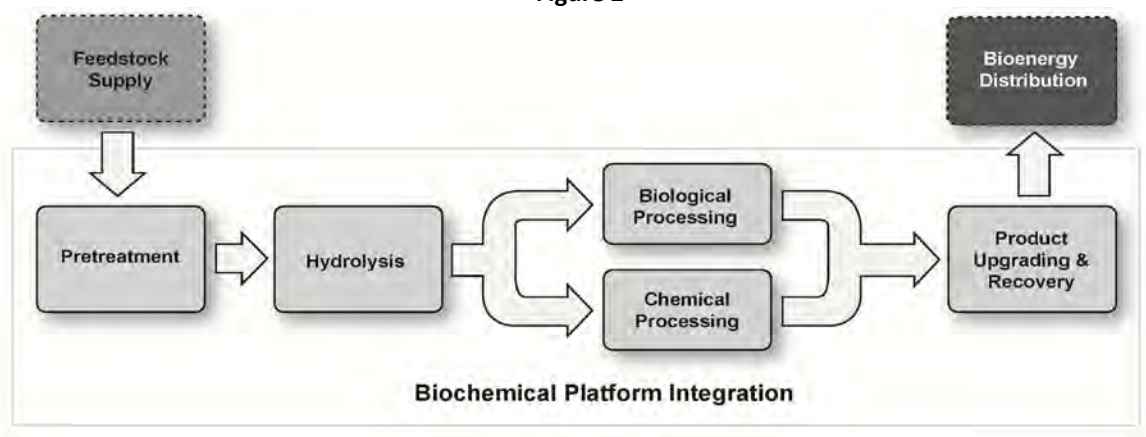


Figure 3

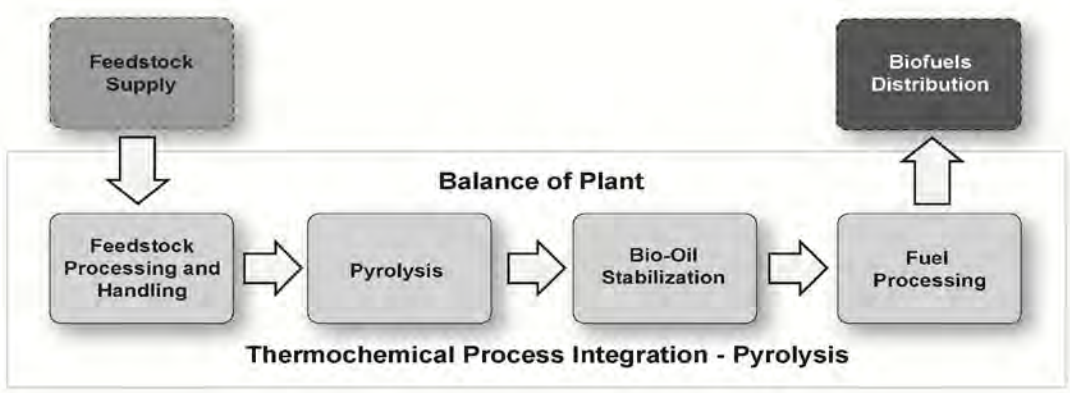
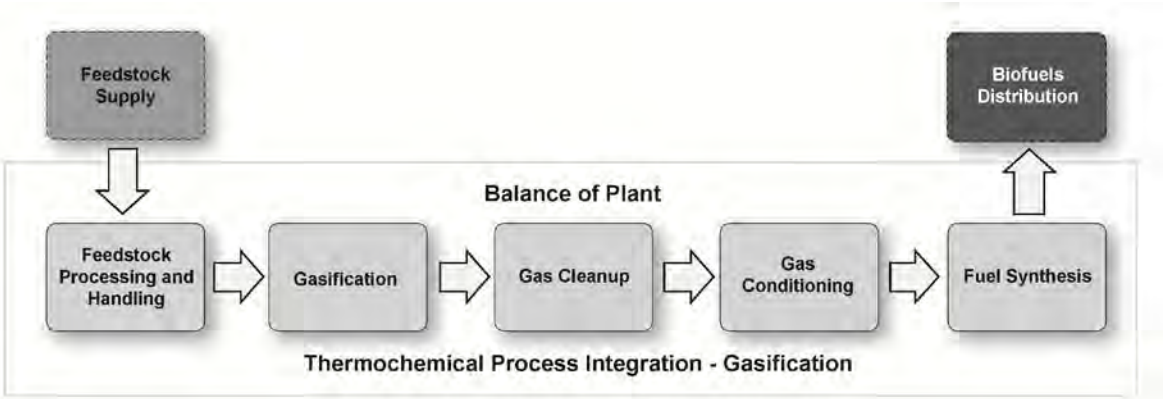
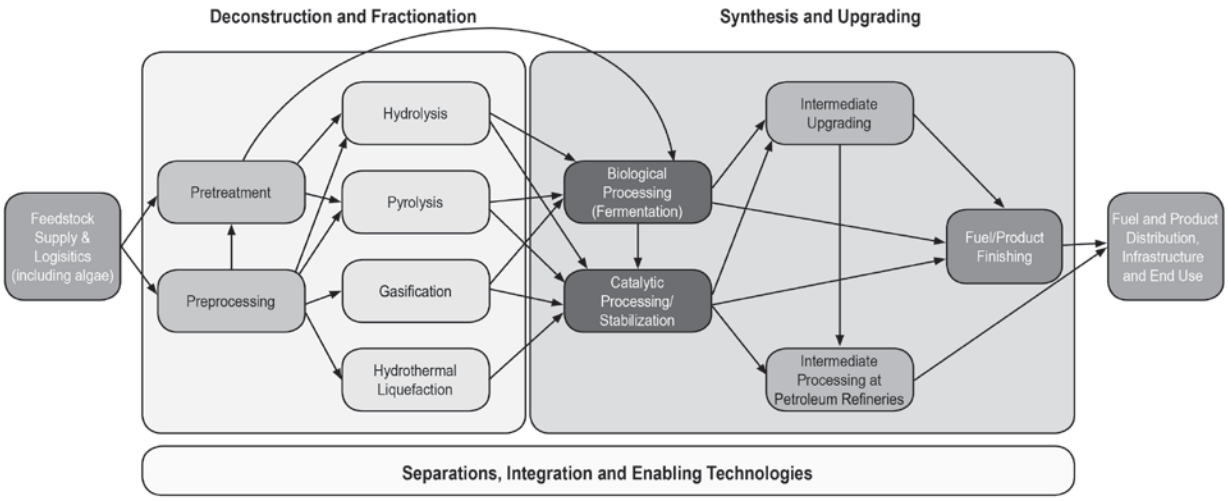


Figure 4



However, an increasing number of technologies are emerging that do not fit this simple taxonomy. Hybrid processes are being developed and show promise. For example, the combination of gasification (thermochemical) and fermentation (biochemical) to produce ethanol and the conversion of historically biochemical-derived intermediates (i.e., sugars, acetic acid, lignin, etc.) via direct chemical conversion to hydrocarbon molecules. Figure 5 illustrates the possible combinations and permutations of these conversion steps.

Figure 5



Each pathway in Figure 5 represents a viable route that is showing initial promise in the subprogram's techno-economic screening process. To reflect this, the Conversion subprogram has been reorganized into more fundamental processing steps such as deconstruction (comprising such techniques as pretreatment/hydrolysis, gasification, pyrolysis, etc.), fractionation, synthesis and upgrading, and integration and process intensification.

The diversity of biomass resources across the nation necessitates the development of multiple conversion technologies that can efficiently deal with a broad range of feedstock materials, as well as their physical and chemical characteristics. The subprogram will seek to develop multiple candidate technologies that can potentially meet the cost goal of $3/gge using a wide array of feedstocks in both the FY 2017 and FY 2022 time frames.

As recommended by the FY 2013 program Peer Review, techno-economic assessments were completed in 2013 and 2014 to establish the technical targets necessary to meet the cost goals for the processing elements of several candidate hydrocarbon fuel production pathways. These include processes using organisms and chemical catalysts to produce fuels and products from hydrolysis intermediates (including sugars), catalytic and non-catalytic pyrolysis with upgrading, gasification, and hydrothermal liquefaction.

Deconstruction and Fractionation ($26 million)

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

Synthesis and Upgrading ($26.25 million)

Based on technical targets established by these FY 2014 techno-economic analyses, as well as the barriers documented in the Conversion Technologies for Advanced Biofuels Workshop report (scheduled to be published in FY 2014), significant effort will be devoted to R&D to continue development of biological organisms and chemical catalysts for the conversion of hydrolysis intermediates to fuels and products.

Specifically, a FOA for improved catalyst performance for the upgrading of hydrolysis intermediates to final fuels will be issued. Efforts will also continue to convert lignin to fuels and products (rather than combusting it for heat and power), as this will be critical to the economics of fuel production within a biorefinery. Facility identification and, where necessary, modification will also begin in FY 2015 for generation of data to validate mature-plant modeled fuel production for an intermediate target of $5/gallon (including feedstock cost) via hydrolysis-based pathways in FY 2017, which will inform out-year research needs to meet a FY 2022 goal of $3/gallon for the relevant pathways.

A second FOA will be issued to initiate one or more consortia that will include researchers and experienced refiners to ensure seamless deployment of the resulting technology into the existing fuel production and distribution infrastructure. The focus of this work will build on previous competitively funded work that evaluated the integration points in the refinery for renewable oils, and it will result in refinery trials. This also addresses a recommendation from the 2011 program Peer Review that parties with refinery expertise be increasingly involved in defining R&D and integration activities. As noted in the *Initial Assessment of U.S. Refineries and the Potential for Bio-Based Oil Insertions* report,[11] an important target for the industry would be to fulfill the potential for processing bio-oil intermediates in the 106 refineries that could accept them. The Renewable Fuel Standard (RFS) target of 36 billion gallons per year represents approximately 12 percent of the capacity of these 106 petroleum refineries.

Validation of Technical Progress ($10 million)

In FY 2015, based on the results from these analyses and R&D results from competitive and national laboratory activities, a subset of pathways will be identified for validation similar to those conducted for cellulosic ethanol production in FY 2012.

In FY 2017, at least two pathways will be validated for the projected commercial production of hydrocarbon fuels (gasoline, diesel, and jet). Data generated from the FY 2017 validation will be used in models (i.e., ASPEN or ChemCad) to confirm the projected $1.73/gge mature biorefinery production conversion cost ($3.00, including feedstock) for at least one subset of high-impact feedstocks. Facility identification and/or modification for the FY 2017 pilot-scale operations for validation of the program cost target will also begin by the end of FY 2015.

At least one additional pathway will be validated in FY 2022. This will be accomplished by incorporating advanced deconstruction methods and new metabolic pathways for hydrocarbon production into organisms; further developing catalysts—both for conversion of sugars and other hydrolysis intermediates, as well as pyrolysis and gaseous intermediates, into fuels and chemicals; and improving separation and upgrading technologies.

[11] Freeman, CJ, SB Jones, et al. PNNL (2013). *Initial Assessment of U.S. Refineries and the Potential for Bio-Based Oil Insertions.* PNNL 22432. 43 pp. (manuscript in progress).

Separations, Integration and Enabling Technologies ($25.25 million)
Other novel areas of interest to the subprogram include process intensification, such as combining or eliminating reaction steps and increasing the overall efficiency of deconstruction processes. Separation technologies necessary to remove impurities from hydrolysis, oils and gaseous intermediates, and product mixtures also remain a critical R&D focus in FY 2015.

Bioproducts and Clean Energy Manufacturing ($7 million)
Bioproducts, co-products, and value-added uses for lignin and the aqueous phase resulting from some pyrolysis pathways are also receiving increased emphasis. In FY 2015, as part of EERE's Clean Energy Manufacturing Initiative, and in partnership with the Advanced Manufacturing and Vehicles Technology, the program will continue funding R&D to enable the efficient manufacturing of low-cost (less than $5/lb.) carbon fibers. An important element of this initiative is to investigate the utilization of cellulosic sugars and lignin in the manufacturing process. Equally important to establish are analyses that address the process economic and life cycle material differences between existing carbon fiber manufacturing processes and emerging biobased routes. Competitive manufacturing of high-value carbon fiber is important because it's a versatile material that can be used across a number of different clean energy and energy efficiency manufacturing platforms, including—but not limited to—light-weight vehicles, pressurized gas storage vessels, advanced wind turbine blades and components, and novel insulation materials for energy-efficient buildings and appliances.

Waste-to-Energy ($6 million)
In FY 2014, the program initiated research and analyses to improve two aspects of methane production/utilization in one waste-to-energy (WTE) pathway and completed analysis of a RFI to identify priority areas and barriers to define a FOA to be issued in FY 2015. Priority areas identified at this point include the need to manage variable feedstocks, such as municipal solid waste; assess spatially resolved biogas resources; improve microbial consortia for processing biosolids and other waste streams; determine opportunities to improve biosolids treatment; and improve separation processes for feedstocks and products. Analyzed and prioritized in FY 2014, the RFI response data will be used to identify core R&D activities and FOA topics. In FY 2015, core R&D will also continue in advanced WTE technologies, including enabling process improvements in methane-to-lactic acid and methane production from anaerobic digestion. Techno-economic analyses will continue to inform the subprogram on key areas for R&D and potential demonstration of WTE processes.

Conversion Incubator
The Conversion subprogram will also continue investment in an incubator activity at approximately 5 percent of the total Program budget, within the distribution of the Conversion and Feedstock Programs. This is to identify and develop promising technologies that are innovative and not currently funded within multi-year strategies, but hold the potential to leapfrog existing technology developments. The EERE incubator activities are intended to be open to all technologies that help the program achieve its goals. For the program's incubator activity specifically, technologies from across all aspects of the biofuel supply chain—feedstock production and logistics (both terrestrial and algae), biochemical conversion, thermochemical conversion, and sustainability—will be considered for funding.

Conversion Technologies

Activities and Explanation of Changes

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs. FY 2014 Enacted
Conversion Technologies		
• Biological, chemical catalysis, pyrolysis, and gasification-based hydrocarbon fuel production. Continue activities to improve separations of intermediates and final products and higher-value uses for lignin and aqueous fractions of pyrolysis oil. Continue biological and chemical catalyst development for production of intermediates and final products. • Continue competitive and core R&D projects focused on addressing the key technical barriers to converting biomass (including algae) to bio-oil through various pyrolysis and hydrothermal liquefaction processes, followed by catalytic upgrading to produce finished fuels or a petroleum refinery feedstock. Based on the current design case (Jones et al., 2009); R&D investments are projected to achieve the FY 2014 state of technology conversion contribution cost of $2.70/gge for a combined fuel. • Increase R&D efforts for upgrading syngas intermediate from biomass through gasification to produce gasoline, distillate, and jet-range hydrocarbons in support of the program goal of less than or equal to $3/gge by FY 2022.	• Finalize selection of conversion pathways for validation in FY 2017 and begin facility modifications as needed. Issue FOAs for consortia to further the integration of bio-oils into petroleum refineries; biological and chemical catalyst development and clean sugar production; and resolution of gasification and gas-to-liquids issues identified in FY 2014 workshops. Continue incubator activities. Issue second FOA for carbon fiber or other topic supporting Clean Energy Manufacturing Initiative.	• The decrease is minor and results from fully funding awards in FY 2013.

Bioenergy Technologies
Demonstration and Deployment
(formerly Integrated Biorefineries)

Description

The Demonstration and Deployment (D&D) subprogram goal is to de-risk bioenergy production technologies through validated proof of performance at the pilot, demonstration, and pioneer scales. This assistance is critical to enable private sector confidence to invest in facility construction and replication at the commercial scale. D&D selects technologies for cost-shared validation that have shown strong performance through techno-economic evaluation and research-scale development.

Pilot-scale facilities verify the integrated technical performance of the given suite of technologies and provide the initial detailed financial data for scaling confidence. Integrated pilot-scale validation is essential for identifying flaws that must be corrected for a successful commercial launch. Demonstration-scale facilities validate performance at a scale sufficient to provide the data and equipment specifications required to design a pioneer or "first-of-a-kind"-scale facility. Pioneer-scale deployment is critical to prove efficient integrated technical operation and economical production at commercial volumes on a continuous basis. Once a pioneer facility achieves design specifications and positive cash flow, the technology application can be replicated through equity investor, traditional debt, or project financing.

To this end, the subprogram manages a diverse portfolio of integrated biorefinery projects focused on the scale up of biofuels production. The current portfolio of 25 projects includes 4 at commercial scale, 5 at demonstration scale, 12 at pilot scale, and 4 additional projects selected under at the Innovative Pilot FOA to support aviation and military fuel applications. The conversion pathways addressed include 13 biochemical technologies, 7 thermochemical technologies, and 5 algal technologies. The active portfolio includes 13 projects that focus on cellulosic ethanol and 12 projects that focus on renewable hydrocarbons, and one project focused on a renewable intermediate bioproduct chemical.

In 2013, the U.S. first pioneer, cellulosic ethanol plant began production and commercial sale of product with assistance from the D&D subprogram. This plant will have an annual production capacity of 8 mmgy of cellulosic ethanol derived from municipal solid waste and green waste.

In FY 2013 and FY 2014, the program continued cost-reduction efforts for thermochemical conversion of biomass to a diesel gasoline blendstock and achieved state of technology modeled cost of $4.6/gge to $4.1/gge conversion only cost respectively (equivalent to a modeled Minimum Fuel Selling Price of $5.6/gge and $5.1/gge, respectively) toward the program goal of $3/gge, including final production costs.

In FY 2014, two more commercial plants are scheduled for commissioning with assistance from the U.S. Department of Energy (DOE). The two plants will build up to full production capacity of 50-million-gallon-a-year (mmgy) of domestic cellulosic ethanol derived from agricultural residues. In FY 2015, two additional demonstration-scale facilities may come online, bringing the total program-supported production capacity to more than 80 mmgy of cellulosic ethanol.

Numerous barriers must be successfully addressed in the D&D subprogram in order to advance biofuels into high-volume production, including developing secure and cost-effective feedstock supply chains, ensuring efficient operation of integrated end-to-end systems, reducing capital and operating costs, testing product qualifications, enabling off-take agreements, and encouraging commercial financing. However, financial barriers are the most challenging hurdle for technology deployment.

The May 2013 program Peer Review Panel — made up of experts from the refining, chemical, and financial industries— reviewed the D&D subprogram portfolio and concluded that "the use of grants has been necessary to attract private investment, reduce capital investment, provide project credibility, and provide a path for demonstrating technology proof of concept." Given the lack of experience in scaling these advanced energy technologies, the significant capital required to build large-scale integrated biorefineries, and the market risk associated with volatile transportation fuel prices, investment solely by private industry would not occur without government assistance. All of the current, successful, commercial cellulosic ethanol biorefinery developers confirm that they would not have made the investment without the DOE partnership to aid in de-risking the technology and processes.

The Renewable Fuel Standard mandates the production of 36 billion gallons of advanced biofuels by FY 2022. Recent studies[12] indicate that this will require more than 500 biorefineries.[13] Of the more than 200 U.S. companies currently working to develop advanced biofuels, only a small fraction have progressed beyond laboratory or small-scale pilot testing. Through the D&D subprogram DOE is currently the only program government-wide that is designed to fund integrated pilot and demonstration projects to assist these 200+ companies to reach their full potential and kick-start a robust biofuels industry.

Defense Production Act (DPA) ($60 million)

In FY 2015, the subprogram will continue to support the intent of the memorandum of understanding signed by DOE, USDA, and DOD (June 2011) and DOE is requesting $60 million in order to enable the objective of producing advanced biofuels meeting military-specification at a price competitive with petroleum. Funds will be administered through the DPA authority to fund commercial demonstrations of technologies able to produce military-specification fuels that are cost competitive with their petroleum counterparts.

Integrated Biorefineries ($35 million)

In FY 2015, the D&D subprogram will be nearing completion of 21 out of the 25 pilot-, demonstration-, and pioneer-scale projects and this will be last year for funds to be requested to meet the outstanding mortgages from these investments. Beyond these successful cellulosic ethanol demonstrations and early hydrocarbon fuel pilots, there is a need to expand the program's focus on drop-in fuels that are fully compatible with today's engines, delivery infrastructure, and refueling station equipment, and that hold great potential for market impact. However, these newly developed conversion processes of biomass-to-hydrocarbon molecules are less developed than cellulosic ethanol pathways, so they must be fully tested and demonstrated at the pilot and demonstration scales first to enable full commercialization. Therefore, in FY 2015 a new competitive FOA will be offered to de-risk the wide range of technologies in biomass-to-hydrocarbon fuels. This FOA will serve to help develop and validate these technologies and their production costs at the pilot and demonstration scales, including through process improvements, operational efficiencies, and significant cost reductions. Under this FOA, biorefineries that integrate other high-potential sustainable feedstock resources, associated conversion pathways, and potential co-products will also be eligible. Potential opportunities will include municipal solid waste, advanced anaerobic digestion and other waste-to-energy (WTE) technologies, as well as advancements for improving the financial viability of biorefineries through the addition of high-value co-products. Project awards will be cost-shared with industry and other partners and will include extensive process capability data collection, validation, and analysis to inform technology development as well as assessment of commercial viability.

The D&D subprogram has extensive stage gates and comprehensive project reviews in order to actively manage all projects and enable decisions on optimal project progress while stewarding government funding.

Biofuels Compatibility ($10 million)

To evaluate and enable usage of advanced biofuels at higher volumes in light duty vehicles, in cooperation with Vehicle Technologies, the D&D subprogram will study and identify both optimization of "Renewable Super Premium" (RSP) 20–40 vol percent ethanol fuels and the optimal "drop-in" biofuels for use in fueling infrastructure and current and future vehicles. Recently published data from DOE laboratories and original equipment manufacturers, as well as discussions from the U.S. Environmental Protection Agency, suggest that a new RSP fuel with 20–40 vol percent ethanol could be used to reach RFS and GHG goals. This mid-level ethanol content fuel, with a research octane number of near 100, appears to enable efficiency improvement for a properly calibrated and designed engine/vehicle system to more than offset the lower energy density, thus negating the tank mileage loss typically seen with ethanol blends in gasoline and gasoline-tolerant vehicles. The prospects of such a fuel are even more attractive because it can be used legally in 14 million flex-fuel vehicles (FFV) on the road today. Thus, the current FFV fleet can serve as a bridge by providing a market for the new fuel today so that future vehicles can have improved efficiency through optimization of the new fuel. In this respect, RSP can simultaneously enable compliance with future GHG standards and the RFS by creating a growing market for ethanol. There is also growing interest from biofuel producers in ethanol-butanol and/or mixed alcohol blends. Both research thrusts could be used to reduce our dependence on imported oil and reach GHG-reduction goals. Renewed efforts to bring biofuels across the full length of the supply chain would enable much needed market engagement by original equipment

[12] http://www.usda.gov/documents/USDA_Biofuels_Report_6232010.pdf.

[13] *A USDA Regional Roadmap to Meeting the Biofuels Goals of the Renewable Fuels Standard by 2022*. June 23, 2010. U.S. Department of Agriculture, available at: http://www.usda.gov/documents/USDA_Biofuels_Report_6232010.pdf.

manufacturers, energy companies, and the public at large. This much needed analysis of candidate drop-in biofuels and RSP fuels will form part of a larger effort to assure maximum "fungibility" of any drop-in, non-petroleum component of fuels.

In addition, to further advanced biofuels usage and vehicle integration, a research program will build on the preliminary work started in FY2014 that includes: research to quantify the efficiency and GHG benefits of vehicles optimized for both biomass-derived "drop-in" fuels and RSP fuels; a complete well-to-wheels analysis to understand the tradeoffs between improvements in tailpipe CO_2 emissions versus GHGs generated in petroleum fuel and biofuels processing and distribution (and other criteria pollutants); fuels will be characterized and tested to develop a knowledge base of fuel-property impacts on infrastructure, engines, emissions, and refinery configurations for biorefineries to target; understanding the state of the legacy refueling infrastructure; development of an appropriate specification for "drop-in" fuels and RSP; and development of appropriate marketing strategies to encourage use of RSP and "drop-in" fuels. The full effort will include the following: infrastructure analysis, market analysis, economic analysis, well-to-wheel analysis, effect on both RSP and "drop-in" fuels on legacy FFVs, and efficiency gains of RSP and "drop-in" fuels and fuel blends on engines optimized to fully exploit the beneficial properties of advanced biofuel blend vehicles.

Demonstration and Deployment
(formerly Integrated Biorefineries)

Activities and Explanation of Changes

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs. FY 2014 Enacted
Demonstration and Deployment		
• Provide funding to support commercial biofuel production facility development under the DPA interagency effort with DOE, USDA, and DOD.	• Select up to 3 integrated pilot- and/or demonstration-scale biorefinery projects under a FOA focused on emerging, advanced biofuel, high-volume, potential pathways. • Down-select and fund commercial biofuel production facilities under the DPA interagency effort with DOE, USDA, and DOD. • In cooperation with Vehicle Technologies, expand R&D on super-renewable premium fuels and drop-in fuels to evaluate compatibility with existing and future infrastructure, fuel, and engine systems.	• Increased funds to initiate new pilot- and demonstration-scale projects. • Meet the commitment of DOE, USDA, and DOD memorandum of understanding through the DPA activity to fund commercial-scale biorefineries that produce military specification jet fuel. • Increased funds to initiate collaboration with Vehicle Technologies on biofuels compatibility issues.

Bioenergy Technologies
Strategic Analysis and Cross-Cutting Sustainability

Description
Strategic Analysis and Cross-Cutting Sustainability activities play a vital role in supporting decision making, demonstrating progress toward established goals, and directing research activities; the activities are instrumental in setting the entire biofuel value chain on an environmentally, socially, and economically viable course. Relationships with experts at the national laboratories, universities, and numerous external stakeholders are leveraged to obtain the best qualitative information and quantitative data possible. The program also works with EERE's Office of Strategic Programs to ensure coordination of analyses within the transportation sector, Vehicle Technologies Program, and Fuel Cell Technologies Program.

Through quantification, Strategic Analysis activities provide context and justification for decisions regarding the future direction and scope of the program's research, development, and demonstration (RD&D) work. This information is critical to the sound management of the program's RD&D portfolio and the establishment, adaptation, and fulfillment of its vision in a dynamic context of rapid technological progress and great economic and environmental uncertainty.

<u>Strategic Analysis activities ($5.5 million)</u>
Strategic Analysis activities include techno-economic, resource, market, and impact assessments that provide the analytical basis for planning and assessment of progress. High-level techno-economic and life-cycle GHG analyses on emerging biofuel pathways provide an understanding of the GHG and cost implications relative to conventional fuel pathways and identify areas where process improvements could lead to significant breakthroughs. System-level analyses identify key drivers and hurdles for industry growth and advance our understanding of bioenergy and its related impacts. Maintenance of decision support, data management, and analytical tools allow the program to better articulate its vision, identify and validate performance goals, measure progress toward these goals, and plan for the successful fulfillment of its mission in support of national policies and priorities. Along with updated techno-economic assessment reports in FY 2015, the program will publish a market assessment detailing the state of the industry.
Strategic Analysis supports each individual subprogram and the program as a whole through the provision of critical quantitative measures of progress and future projections. Critical to strategic decisions at both the program and activity levels, programmatic analysis activities are focused on clearly identifying synergies and addressing potential barriers, while progress is concurrently monitored and accomplishments are validated in each of the subprograms.

<u>Cross-Cutting Sustainability activities ($5.5 million)</u>
Focus on evaluating environmental impacts and developing more sustainable practices with regard to life-cycle GHG emissions, air quality, land use, water quality, water consumption, soil quality, and biodiversity, as well as developing relevant social aspects of sustainability. The subprogram works with research partners to conduct field trials, applied research, capacity building, and analyses to inform best practices that are integrated across the RD&D portfolio. Sustainability activities also enable the program to engage in critical international dialogues on bioenergy, such as the Global Bioenergy Partnership.

Accomplishments to date include creation of transparent methodologies for evaluating and comparing technologies, practices, and inputs in terms of environmental sustainability. Activities have also developed innovative tools and concepts for increasing biomass and bioenergy production while maintaining or improving environmental performance, such as deploying a geographic information system-based mobile application that helps feedstock producers determine a sustainable rate of agricultural residue removal while quantifying the impact on soil organic carbon, GHG emissions, and nitrate leaching. FY 2015 activities will continue demonstrating innovative concepts developed in previous years and applying those methodologies to evaluate bioenergy systems using the most current data, as well as to investigate and identify practices that maintain or improve environmental performance; these can then be promoted within RD&D projects and to external stakeholders. For example, a comprehensive case study will be completed that assesses the environmental and socio-economic sustainability of a first-of-a-kind cellulosic biorefinery using best available data. This case study will evaluate changes in sustainability indicators including soil quality, productivity, and profits so that best practices and lessons learned can be applied to other systems. In addition, updated water footprint and air emissions estimates for advanced biofuels technologies will be conducted across the bioenergy supply chain to understand potential impacts and proactively develop needed RD&D solutions. These critical efforts result in publications and data made available through the Bioenergy KDF to better inform researchers, policy makers, and private-sector stakeholders.

Strategic Analysis and Cross-Cutting Sustainability

Activities and Explanation of Changes

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs. FY 2014 Enacted
Strategic Analysis and Cross-Cutting Sustainability		
• Conduct key analyses to guide planning and portfolio management and provide an analytical basis for R&D prioritization, target development, and assessment of progress toward goals; advance scientific methods to measure and understand the land use, GHG, water, and other environmental effects of bioenergy production; and promote positive social, economic, and environmental effects and reduce negative effects of bioenergy production with a focus on innovative concepts that increase biomass production while maintaining or improving environmental performance.	• Continue key techno-economic, market, resource, and impact analyses to guide R&D prioritization, target development, and assessment of progress toward goals; advance scientific methods to measure and understand the land use, GHG, water, and other environmental effects of bioenergy production; and promote positive social, economic, and environmental effects and reduce negative effects of bioenergy production with a focus on developing practices that increase biomass and bioenergy production while minimizing GHG and air emissions, water use, and water quality impacts.	• The reduction of funding is minor and results from fully funding analysis projects in FY 2013 and FY 2014.

Bioenergy Technologies
NREL Site-Wide Facility Support

Description

In FY 2015, EERE will continue to 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. This practice is consistent with other National Laboratories. EERE began this practice in FY 2014 to reduce NREL's labor rate multiplier, thereby reducing the cost barrier to accessing unique NREL capabilities (such as facilities and staff expertise) by industry and academia. This practice also makes site operating costs more transparent in order to facilitate cost control and planning. In FY 2014, this practice resulted in a reduction in the Lab-wide direct labor multiplier of approximately 15 percent compared to FY 2013. The proposed FY 2015 budget continues this approach. The site-wide facility support funds cover maintenance and engineering support; fire, emergency, and custodial services; general utilities; network infrastructure and licenses; environment, safety, and health support; and sustainability. By moving these costs from laboratory overhead to direct funding, EERE accelerates technology transfer and mission impact by making it easier for companies and external researchers to access NREL capabilities and expertise.

This funding supports research programs by providing basic site services, functions, and infrastructure for Site Operations, which includes: management, building operations, building and grounds maintenance, fire and emergency response, engineering and construction support, minor construction projects, Electrical Safety Program, utilities, and facilities planning support; and activities within the Sustainability and Environmental Health and Safety (EHS) portfolios. These activities and their costs are relatively fixed and only vary significantly based upon variations in commodities, construction activity, emergencies, weather patterns, etc. They are considered to be the core functions for site operations, safety, environmental compliance, and sustainability at NREL. In FY 2015, this funding will support more than 60 full time equivalents that manage and provide support for these core functions. It will also fund site-wide subcontracts such as janitorial services, refuse and recycling, and subcontracts for minor construction. Additionally, this funding will support site-wide costs associated with maintaining NREL's leadership position, such as: maintaining International Organization for Standardization (ISO), American Association for Laboratory Accreditation (A2LA), and other lab-wide accreditations, managing facilities to enable mission goals, improving sustainability, pollution prevention, waste minimization, improving energy efficiency, reducing water use, and maintaining an effective emergency management system.

The FY 2015 contribution from each program differs from the FY 2014 allocation, because EERE has developed a more precise, equitable, and economically neutral method that ensures a net-zero impact on programs' funding. For each program, the contribution to direct funding site-wide facility is equivalent to the estimated contribution the programs would have made through overhead charges. This method is based upon each program's level of funding to NREL, adjusted to account for anomalies from capital expenditures and major subcontracts.

NREL Site-Wide Facility Support

Activities and Explanation of Changes

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs. FY 2014 Enacted
NREL Site-Wide Facility Support		
• EERE will begin to 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. This practice is consistent with other national laboratories.	• EERE will continue to 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. This practice is consistent with other national laboratories.	• The delta is the result in a change in methodology used to allocate site-wide facility support contributions amongst programs. The FY 2015 value enables and directly equates to the program's estimated savings gained from the reduced labor multiplier.

Bioenergy 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. For more information, refer to the Department's FY 2013 Annual Performance Report.

	FY 2013	FY 2014	FY 2015
Performance Goal (Measure)	**Thermochemical Conversion - Reduce modeled thermochemical conversion cost of a combined gasoline and diesel production ($/gallons of gasoline equivalent)**		
	2014: Reduce modeled conversion cost for feedstock to gasoline/diesel by way of liquefaction		
	2013: Reduce modeled conversion cost for feedstock to gasoline/diesel fuel via a bio-oil pathway		
Target	$3.18/gge	$2.70/gge	$3.70/gge[14]
Result	Met – $3.13/gge	N/A	N/A
Endpoint Target	$2.5/gge by 2017[14]		

[14,15] FY 2015 target and endpoint target reflect an updated design case and state of technology.

Hydrogen and Fuel Cell Technologies

Overview

Hydrogen and fuel cells have the potential to improve energy security and reduce emissions of greenhouse gases, criteria pollutants, and net oil imports by improving energy efficiency, enabling alternative fuel sources, and spurring domestic production of clean energy technologies. Widespread use of hydrogen and fuel cells can have a major impact toward achieving EERE's goals of expanding the adoption of sustainable, domestically powered transportation alternatives; improving the efficiency of energy use; stimulating the growth of domestic clean energy manufacturing; and enabling the integration of clean energy into a reliable, resilient, and more efficient electricity grid. Fuel cells also enable highly efficient use of energy and they can provide power from diverse domestic fuels, including hydrogen and other renewable fuels—such as bio-methanol or biogas—as well as natural gas. Analysis by Brookhaven National Laboratory indicates that by 2050, the market penetration of fuel cell electric vehicles (FCEVs) could reach 40–45% of light-duty vehicle stocks (not just sales) if program targets are met, and the resulting benefits of the Hydrogen and Fuel Cell Technologies program's efforts could therefore include reductions in national oil consumption of 2-3 million barrels per day and reductions in greenhouse gas (GHG) emissions of 350-400 million metric tons per year.[1]

While the program's focus is on transportation, stationary fuel cells are a strong first market that will help enable fuel cells for high impact transportation applications by achieving reductions in cost through increased volumes. Early stationary markets (i.e., backup power or small residential polymer electrolyte membrane (PEM)), as well as other early markets such as forklifts and airport/delivery trucks, would help drive down cost, develop a supply base and be a strategic pathway to high volumes and establishing an industry in transportation applications. Other examples aligned with EERE's mission include fuel cells that co-produce power, heat, and hydrogen; and reversible fuel cells that can produce hydrogen in electrolysis mode or power/heat in fuel cell mode. These are aligned with the program's hydrogen production activities, regardless of fuel cell technology, fuel, or temperature, and are focused on low life cycle emissions. The scope is technology neutral and fuel flexible with emphasis on low and medium temperature fuel cells applicable to future transportation applications, renewable pathways, and areas of synergy (e.g., biogas, tri-generation, and contaminant clean up).

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

[1] Internal analysis conducted for DOE using the MARKAL model.

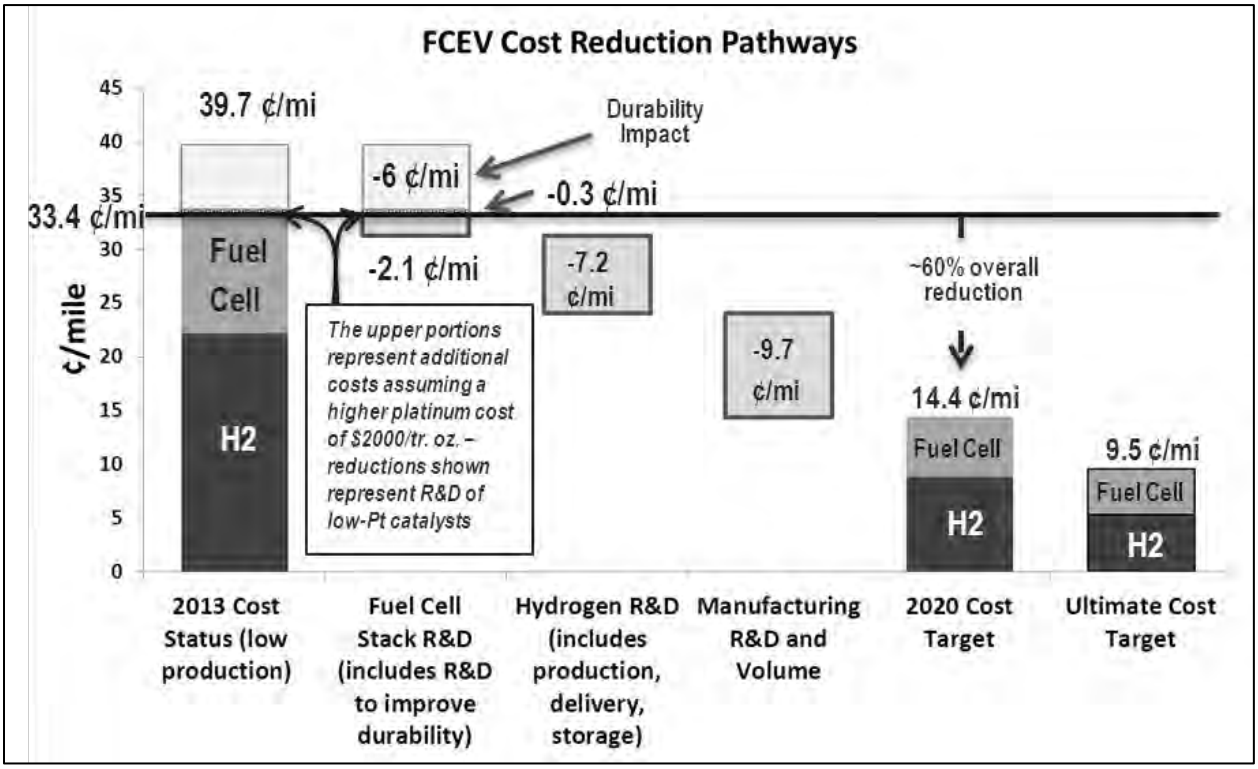


Figure 1. The program's goals for reducing FCEV cost are driven by an overarching goal to reduce the hydrogen and fuel cell portion of the life-cycle cost of the vehicle to 14.4¢/mile by 2020, with an ultimate goal of 9.5¢/mile.

Highlights of the FY 2015 Budget Request

The Fuel Cell R&D subprogram will impact both transportation as well as stationary and early market applications, focusing on R&D of fuel cell stacks and systems. Emphasis will be on stack component R&D (including catalysts, membranes, and membrane electrode assembly (MEA) integration), stack and component operation and performance (including durability, impurities, and mass transport), systems and system integration, balance of plant (BOP) components, testing, technical analysis, and high-throughput combinatorial approaches. Consistent with rigorous peer review processes, competitive selection of projects in topic areas will be determined based on the relative merit, applicability, and potential for R&D progress of the projects through planned funding opportunity announcements (FOAs). Funding is anticipated to focus on cross-cutting areas that can impact multiple applications and transportation-specific areas of activity (such as 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. In FY 2015, these efforts will continue to balance near-term and longer-term approaches, to enable near-term commercialization while maintaining a critical leadership role in driving advances in longer-term technologies and leveraging investments by DOE's percent of Science, the National Science Foundation, and other Federal research programs. The subprogram's hydrogen production and delivery efforts will focus on a two pronged approach: (1) enable near term options by lowering the cost of hydrogen delivered and dispensed at the station; and (2) focusing on longer term renewable options such as direct solar water splitting, including high throughput/combinatorial approaches to enable rapid identification of promising materials as appropriate. Further efforts include developing and testing the innovative materials, components, and systems needed to establish the technical and cost feasibility for hydrogen delivery. The emphasis will be on forecourt station technologies such as reliable, cost-effective and energy efficient hydrogen compressors; durable, high pressure dynamic and static seals; and low-cost station storage.

To ensure that R&D efforts lead to successful commercialization, the program pursues a market-acceleration strategy that integrates technology demonstration and validation, codes and standards development, and early market deployments. Demonstration and validation ensure that pre-commercial technologies are ready for the deployment phase and provide critical feedback to R&D efforts, revealing issues that come to light when technologies are operated in complete systems under real-world conditions. Efforts in safety, codes and standards enable development of codes and standards that are necessary for commercial deployments and help reduce permitting times. Early market deployment activities focus on key markets for

commercial-ready technologies, where a modest number of new orders will have a significant impact on long-term commercialization by reducing costs through economies of scale and catalyzing growth of domestic manufacturing.

The fuel cell industry is poised for significant near-term expansion—investing heavily in product development and leading the clean-energy sector in patents, with nearly 1,000 patents issued in 2012.[2] The United States has been the world leader in fuel cell patents, with 44% of all patents issued from 2002 to 2012, compared to 33% issued by Japan during the same time frame, although recently and for the first time, the annual number of patents issued to Japan surpassed those for the U.S. Major government-industry partnerships in several countries abroad have been announced to support hydrogen infrastructure development for FCEVs. Continued support by major industrial players and governments of other countries underscores the global market potential for these technologies and the need for continued Federal investment for domestic industry to remain competitive.

[2] Source: http://cepgi.typepad.com/files/cepgi-4th-quarter-2012.pdf.

Hydrogen and Fuel Cell Technologies
Funding ($K)

	FY 2013 Current[3]	FY 2014 Enacted[4]	FY 2014 Current	FY 2015 Request	FY 2015 vs. FY 2014 Enacted
Hydrogen and Fuel Cell Technologies					
Fuel Cell R&D	41,266	33,383	33,383	33,000	-383
Hydrogen Fuel R&D	31,681	36,545	36,545	36,283	-262
Manufacturing R&D	1,899	3,000	3,000	3,000	0
Systems Analysis	2,838	3,000	3,000	3,000	0
Technology Validation	8,514	6,000	6,000	6,000	0
Safety, Codes and Standards	6,808	7,000	7,000	7,000	0
Market Transformation	2,838	3,000	3,000	3,000	0
NREL Site Wide Facility Support	0	1,000	1,000	1,700	+700
Total, Hydrogen and Fuel Cell Technologies	**95,844**	**92,928**	**92,928**	**92,983**	**+55**

SBIR/STTR:

- FY 2013 Transferred: SBIR $1,893,000; STTR: $246,000
- FY 2014 Projected: SBIR: $1,970,000; STTR: $281,000
- FY 2015 Request: SBIR: $2,023,000; STTR: $279,000

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

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

	FY 2015 vs. FY 2014 Enacted
Fuel Cell R&D: The funding decrease is due to an increase in the support provided to NREL Site Wide Facilities Support to account for a more precise and equitable method that ensures a net-zero impact on the overall program funding.	**-383**
Hydrogen Fuel R&D: The funding decrease is due to an increase in the support provided to NREL Site Wide Facilities Support to account for a more precise and equitable method that ensures a net-zero impact on the overall program funding.	**-262**
Manufacturing R&D: No change.	**0**
Systems Analysis: No change.	**0**
Technology Validation: No change.	**0**
Safety, Codes and Standards: No change.	**0**
Market Transformation: No change.	**0**
NREL Site-Wide Facility Support: The increase in funding is the result of a change in methodology used to allocate site-wide facility support contributions amongst programs. The FY 2015 value enables and directly equates to the program's estimated savings gained from the reduced labor multiplier.	**+700**
Total, Hydrogen and Fuel Cell Technologies	**+55**

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. The efforts in the Fuel Cell R&D subprogram seek to advance fuel cell technologies that can be used in diverse applications. Key goals include reducing the cost of automotive fuel cells to $40/kW (equivalent to the cost of a gasoline internal combustion engine) 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 gasoline engines. This cost target is compared to today's modeled automotive fuel cell cost of approximately $55/kW using state-of-the-art fuel cell technology projected to high manufacturing volumes (500,000 units/year), which represents a more than 30% reduction since 2008 and more than 50% reduction since 2006.

Since automotive fuel cells are not yet commercially available or produced at volume, actual cost based on early market applications is estimated at roughly $1,000/kW, significantly higher than the projected $55/kW as a result of high volume manufacturing processes and economies of scale. To this end, the program plans to continue R&D to address challenges facing fuel cells for near- and longer-term applications. Near-term applications—which will help drive volume—include distributed power (primary and backup), APUs, material handling equipment, and specialty vehicles. 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 systems such as APUs that could be applicable for truck, marine, or aircraft applications, and would also provide substantial environmental and energy-security benefits. Advances in fuel cell technologies can provide a range of benefits for these multiple applications. The portfolio is "technology neutral" in the sense that it covers a range of fuel cell technologies, including PEM fuel cells, alkaline fuel cells, direct methanol fuel cells, and medium-temperature fuel cells such as phosphoric acid fuel cells.

The Fuel Cell R&D subprogram ($33 million) will continue R&D for fuel cells and fuel cell systems, with emphasis on stack and system BOP components. This funding includes at least $20 million focused on fuel cell stack and component R&D, up to $10 million focused on fuel cell systems and system balance-of-plant components, and $3 million on testing and analysis. Key areas of emphasis include cell stack component R&D (including catalysts, membranes, and MEA integration), stack and component operation and performance (including durability, impurities, and mass transport), and work on systems and system integration, balance of plant components, testing, technical analysis, and high throughput combinatorial approaches. Consistent with rigorous peer review processes, competitive selection of projects in topic areas will be determined based on the relative merit, applicability, and potential for R&D progress of the projects through planned funding opportunity announcements.

The program has improved the catalyst specific power of fuel cells to 5.8 kW per gram (g) of platinum group metal (PGM) in 2012, which is more than double the 2008 baseline of 2.8 kW/g and approaching the 2020 target of 8.0 kW/g, reflecting a more than 80% reduction in total platinum content in fuel cells since 2005. This has been achieved through breakthrough developments such as nanostructured thin film catalysts and core-shell catalysts (in which platinum coats the outside of a non-platinum-containing core). In FY 2015, the program will increase the catalyst power density to 6.5 kW per gram of PGM, to help reduce the levelized cost per mile from the current cost of $0.39 per mile, toward the 2020 goal of $0.14 per mile. These efforts target cost reduction and an increase in fuel cell stack and system durability. As recommended in the 2008 NRC report,[5] the program has reallocated funding over the past several years to prioritize and emphasize R&D that addresses the most critical barriers, such as catalysts (low- and non-platinum-group-metal catalysts), electrodes, membranes, MEAs, and modes of operation addressing stack and component durability and performance. There are different technology needs for different types of fuel cells. The program implements a portfolio approach to ensure specific R&D needs are addressed based on the status of the technology compared to application-driven targets, such as fuel cleanup for fuel flexible fuel cells.

[5] Transitions to Alternative Transportation Technologies—A Focus on Hydrogen, National Research Council of the National Academies, 2008, www.nap.edu/catalog.php?record_id=12222.

In FY 2015, the program will continue to emphasize R&D at the materials and component level, as well as component integration into MEAs and stacks. The program will continue system BOP component R&D (e.g., for air management) that can lead to lower cost and lower parasitic losses, as well as on component integration in systems for non-automotive applications. The program will also pursue the development of longer-term technologies (e.g., anion-exchange [alkaline] membrane fuel cells), which will provide high-performance and durable, PGM-free technology. Targeted R&D of medium-temperature fuel cell technologies (e.g., phosphoric acid and phosphoric-acid based, molten carbonate fuel cells) will accelerate our ability to take advantage of diverse fuels, with a focus on renewables, for highly efficient production of power and heat. In addition, fuel processors integrated with the fuel cell will enable the conversion of fuels—including biomass-derived liquids and waste gas—into hydrogen for fuel cell applications.

Fuel cell system modeling will serve to guide component R&D, help to benchmark complete systems before they are built, and explore alternate system components and configurations. The modeling activity will include cost analysis for multiple applications and evaluation of operation strategies—with the aim of enhancing performance and reducing degradation. Optimizing system controls will improve performance and durability, while lowering cost. Analytical tools and partnerships continue to expand research capabilities. In addition, R&D efforts will leverage outside activities, through coordination with efforts such as those in the percent of Science's Basic Energy Sciences Program, ARPA-E, and the National Science Foundation (NSF). Fuel Cell R&D plans to continue to invest in the creation of an Incubator program in FY 2015 to bring "off-roadmap" impactful new technologies into the EERE portfolio.

Fuel Cell R&D

Activities and Explanation of Changes

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs. FY 2014 Enacted
Fuel Cell R&D		
• To lower cost and increase durability for transportation fuel cell systems and for near-term applications such as distributed power (primary and backup), APUs, and material handling equipment. • Further develop catalysts and membranes and integrate state-of-the-art components in advanced MEAs to achieve 6.3 kW/g PGM catalysts. • Validate performance, cost, and durability improvements of advanced, optimized MEAs containing previously developed catalysts and membranes. • Develop high-temperature fuel cell stack components, as well as BOP system and subsystem components.	• For continued R&D that focuses on fuel cells and fuel cell systems, with emphasis on stack and system BOP components. The program plans to allocate its funds to fuel cell stack component R&D (including catalysts, membranes, and MEA integration), stack and component operation and performance (including durability, impurities, and mass transport), and work on systems and system integration, balance of plant components, testing, technical analysis, and high throughput combinatorial approaches. • Further develop catalysts and electrodes and integrate state-of-the-art components in advanced MEAs to achieve 6.5 kW/g PGM. • Develop membranes for transportation that operate under hot and dry conditions, meeting area specific resistance of 0.02 Ohm cm^2 at 120^oC and 40kPa water partial pressure more than a 10% improvement with respect to the 2011 baseline (0.023 Ohm cm^2). • Develop and demonstrate innovative non-PGM catalysts that achieve 150 milliamps/cm^3 at 0.8 V, more than a two-fold improvement compared to the 2011 baseline value of 60 mA/cm^3. • Develop medium-temperature fuel cell stack components, as well as system and subsystem components to extend fuel cell operational life to 50,000 hours.	• No significant changes.

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 the production of low-cost hydrogen with emphasis on renewable pathways and address key challenges to hydrogen delivery and storage.

The overarching goal is to enable several different 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, in 2020. This cost represents the threshold at which hydrogen for FCEVs will be competitive on a cent-per-mile basis with conventional vehicles. To enable the use of hydrogen produced from highly efficient centralized facilities, technologies will have to be developed to lower the cost of delivery to the station. There are also costs associated with compression, storage, and dispensing (CSD) at the station that will affect the final cost of hydrogen produced at both central and distributed sites. The program is pursuing advances in existing technologies for hydrogen delivery and station CSD and developing new technologies to reduce costs, with the ultimate goal of reducing the delivery portion of the total hydrogen cost to less than $2/gge by 2020.

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

The Hydrogen Fuel R&D ($36.3 million) subprogram will continue to pursue reductions in the cost of hydrogen from renewable resources, including advances in electrolysis. While the program has dramatically reduced the capital cost of electrolyzers – more than 80% for the electrolyzer stack since 2002 – the cost of electricity remains a major cost barrier. However, significant opportunities exist for near-term utilization of electrolyzers, including: regions with low-cost electricity; larger-scale energy storage; and situations where electrolysis can play a role in additional value streams—e.g., use with stationary fuel cells to provide grid stability; and use of electricity that would otherwise be curtailed, to produce hydrogen for FCEVs or other higher-value applications. In addition, further cost-reduction opportunities exist for electrolyzers through R&D of balance of plant components, systems integration, and alternate membranes (e.g., anion-exchange membranes). In addition to the subprogram's efforts, work on electrolysis is also being done through SBIR and incubator projects. The subprogram will provide funding to develop technologies and materials to reduce electrolyzer and balance of plant costs and to reduce hydrogen compression and storage costs, which support the hydrogen goal of less than $4/gge by 2020.

The hydrogen production component ($10 million) of this subprogram will address materials and process development to enable hydrogen production, with emphasis on renewable pathways. In FY 2015, these efforts will continue to balance near-term and longer-term approaches, to enable near-term commercialization while maintaining a critical leadership role in driving advances in longer-term technologies and leveraging investments by DOE's percent of Science, the National Science Foundation, and other Federal research programs. The subprogram's hydrogen production efforts will focus on improving electrolyzer stack efficiency; and advances in hydrogen production through biological approaches, direct solar water splitting, and other innovative approaches with emphasis on renewable pathways, including high throughput/combinatorial approaches to enable rapid identification of promising materials as appropriate. The subprogram's hydrogen delivery component ($10 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 subprogram's hydrogen delivery component will focus on developing and testing the innovative materials, components, and systems

needed to establish the technical and cost feasibility for hydrogen delivery. The emphasis will be on forecourt station technologies such as reliable, cost-effective, and energy efficient hydrogen compressors; durable, high pressure dynamic and static seals; and low-cost station storage.

The hydrogen storage component ($16 million) of this 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 to meet the full set of onboard system targets and that can enable the widespread commercialization of hydrogen fuel cell systems for diverse applications across a number of sectors. The near-term focus exploring low-cost carbon fiber composites for high-pressure storage will not only benefit hydrogen fuel cell vehicles but will also be applicable to compressed natural gas vehicles. The program will also conduct R&D to develop advanced conformable and cryogenic-capable tank technologies and low-pressure, materials-based technologies as well as innovative approaches to increase storage potential and broaden the range of commercial applications.

Hydrogen Fuel R&D

Activities and Explanation of Changes

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs. FY 2014 Enacted
Hydrogen Fuel R&D		
• Develop materials and methods to enable the production of low-cost, low-carbon hydrogen from diverse renewable pathways and address key challenges to hydrogen delivery and storage. • Relative to the 2011 baseline of $8.00/gge, reduce hydrogen cost (dispensed and untaxed) to $7.20/gge. • Incorporate new organisms and nanostructure materials in photolytic hydrogen production. • Reduce cycle time and increase solar to hydrogen efficiency for solar-thermochemical hydrogen production. • Further reduce carbon fiber composite costs. • Develop hydrogen storage materials guided by system engineering analysis. • Initiate validation of hydrogen storage system models through prototype testing.	• Continue to develop technologies and materials to lower the cost and improve the efficiency of hydrogen production and delivery technologies to achieve the 2020 goal of less than $4/gge and to lower the cost of near-term physical storage options and to develop longer-term advanced hydrogen storage technologies to meet the full set of onboard system targets. • Relative to the 2011 baseline of $8.00/gge, reduce hydrogen cost (dispensed and untaxed) to $6.80/gge. • Demonstrate a semiconductor-based photoelectrochemical device with a stabilized solar-to-hydrogen conversion efficiency of >15% compared to a 2011 baseline of 12%. • Demonstrate electrolyzer stack efficiency of 76% (LHV) and determine the potential to meet a modeled high volume cost of $4/gge for hydrogen production. • Develop technologies to enable a 15% cost reduction of 700 bar compressed hydrogen storage systems from the 2013 baseline projection of $17/kWh, on track towards meeting the target of $12/kWh by 2017. • Develop and evaluate a sub-scale hydrogen adsorbent system and compare projected full-scale performance against DOE targets of 40 grams per liter and 5.5 weight percent.	• No significant changes.

Hydrogen and Fuel Cell Technologies
Manufacturing R&D

Description

The Manufacturing R&D subprogram supports the program's mission through the development of advanced fabrication technologies and processes to meet the cost targets of critical hydrogen and fuel cell technologies. These activities will help reduce fuel cell and hydrogen system costs to be competitive with those of current technologies. Growing the domestic supplier base will provide jobs in the U.S.

The program will identify specific manufacturing R&D projects as technology roadmaps are updated to reflect the needs of near- to medium-term applications. The subprogram coordinates extensively with other organizations within the Advanced Manufacturing Partnership, a national effort the Administration launched in 2011 to support the domestic advanced manufacturing sector, create high-quality jobs, and encourage companies to invest in the U.S., in addition to EERE's crosscutting Clean Energy Manufacturing Initiative.

The Manufacturing R&D ($3 million) subprogram will continue its development of fabrication processes that lead to low-cost, high-volume manufacturing and help to develop a domestic supply base. In FY 2015, the subprogram will demonstrate methods to inspect full MEAs and cells prior to assembly into stacks, which will help achieve the fuel cell portion of the FCEV levelized cost per mile target of $0.14 per mile by 2020. The subprogram will pursue methodologies to identify defects generated during the manufacture of fuel cells, and determine what effect the defects have on fuel cell performance, which will be of great value to manufacturers that lack these capabilities. The subprogram will analyze various approaches to develop and enhance the domestic supply chain for hydrogen and fuel cell components and systems. The subprogram will also carry out analysis to identify the differences between the cost to manufacture key components of hydrogen and fuel cell systems in the U.S. vs. the cost to manufacture in other countries; the manufacturing competitiveness analysis will inform the program of which future Manufacturing R&D efforts will have the greatest impact in reducing cost.

The subprogram is also pursuing reductions in the costs of manufacturing fuel cells and hydrogen technologies by eliminating intermediate backing materials and reducing process steps. Near-term activities include new and ongoing R&D of technologies critical to accelerated introduction of high-volume commercialized products such as catalyst-coated membranes and gas diffusion electrodes for fuel cells and vessels for hydrogen storage. The subprogram will coordinate with DOE's Clean Energy Manufacturing Initiative percentand Advanced Manufacturing percentprogram, the Department of Defense (DOD), and the Department of Commerce (National Institute of Standards and Technology) to leverage other activities. In particular, the Manufacturing subprogram will coordinate analysis activities with the Clean Energy Manufacturing Initiative to enhance U.S. manufacturing competitiveness.

Manufacturing R&D

Activities and Explanation of Changes

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs. FY 2014 Enacted
Manufacturing R&D		
• Development of fabrication processes that lead to low-cost, high-volume manufacturing and help to develop a domestic supply base. • Develop processes for highly uniform continuous lamination of MEA components.	• Continue developing fuel cell fabrication processes and to demonstrate methods to inspect full MEAs and cells prior to assembly into stacks, which will help achieve the FCEV life-cycle cost of $0.42 per mile by 2020. • Demonstrate continuous in-line measurement at 100 ft/min for MEA and MEA component fabrication (3X increase from 2013). • Develop cell manufacturing processes that increase throughput and efficiency and decrease complexity and waste.	• No change.

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. These efforts assess R&D gaps, planning, and budgeting, as well as synergies and interactions with other energy sectors. The subprogram assesses the requirements of potential end-users to determine metrics for multiple components, subsystems, and systems. Results also support annual updates to key planning documents that provide the current direction and planned milestones for the program. Systems Analysis also supports key collaborations, particularly through partnerships such as U.S. DRIVE and H2USA—a public-private partnership developed in FY 2013 to address the barrier of infrastructure.

The Systems Analysis subprogram ($3 million) will continue to develop, refine, and utilize analytical models and tools. In FY 2015, the subprogram will:

- Assess hydrogen infrastructure needs for transportation applications such as those in support of H2USA.
- Identify research and technology gaps in order to guide investments and enable targeted R&D that will help achieve the fuel cell portion of levelized cost per mile of $0.14 per mile by 2020; and these gaps will also be assessed for other applications, including material handling and stationary power, including CHP systems.
- Assess life-cycle GHG emissions and cost for on-board storage options, resource and technology limitations, opportunities for stationary power production from fuel cells, renewable fuel supply evolution, infrastructure issues and limitations, and the potential environmental impacts of widespread commercialization.
- Assess the use of hydrogen produced from renewable resources (such as wind and solar) for energy storage (and as an energy carrier) to understand technology opportunities to alleviate electrical grid congestion and enable the distribution of energy from the point of generation to end users through multiple transport modes such as electrical transmission.
- Assess the use of various fuels for stationary fuel cells—including stranded natural gas, landfill gas, other biogases (e.g., from dairy farms), and unused sources of gaseous hydrogen—to determine their potential environmental benefits.
- Use the Macro System Model (which provides overarching analysis for the program) to analyze near- and mid-term impacts and benefits of integrating stationary fuel cells with other renewable technologies, as well as the life-cycle cost of on-board storage options.

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

- Underlying technical analysis for technology-related go/no-go decisions.
- Assessments of market penetration, commercial market stimulus, job creation, and opportunities for fuel cell applications in the near term (e.g., material handling, backup power, and residential CHP markets).
- Updates and maintenance of the Analysis Portfolio, prioritized analysis list, and Analysis Resource Center database—to ensure analysis consistency and transparency.
- Modeling and analysis of synergies between hydrogen and fuel cells with other emerging technologies, fuels, and energy systems to identify and understand potential opportunities/system trade-offs, assess the benefits of achieving economies of scale, and identify ways to reduce infrastructure cost; and the Systems Analysis subprogram will also work with other subprograms to update other models as needed.

In addition to analyses of the environmental benefits of fuel cells mentioned above, the subprogram will also estimate the return on investment by determining the number of commercial technologies developed through the program's funding. For example as of 2013:

- A sample of the program's projects were tracked and found to have resulted in revenues of >6x the amount of DOE funding; and funds invested in projects were found to result in >9x additional investment by industry.
- The program's funding has also led to 40 commercial technologies, more than 60 emerging technologies (expected to be commercial within three years) and more than 450 patents.

Systems Analysis

Activities and Explanation of Changes

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs. FY 2014 Enacted
Systems Analysis		
• Provide the analytical and technical basis for informed decision making for the program's R&D direction and prioritization. • Calculate return on investment by determining the number of commercial technologies that were developed using the program's funding. • Develop life cycle model for water use of hydrogen production pathways. Complete analysis for 1 pathway. • Complete analysis of job creation from infrastructure development for fuel cell applications for material handling equipment. • Assess optimum refueling pressure for compressed onboard storage for at least 3 pressure levels. • Using the Macro System Model, assess hydrogen cost and GHG emission for 5 future hydrogen production pathways.	• Continue the use of analytical models and tools and also to support the H2USA partnership that has been developed to address the hydrogen infrastructure barrier. • Complete analysis of the program's performance, the cost status of key technologies, and the potential use of fuel cells for a portfolio of commercial applications. • Complete analysis of impacts such as job creation from infrastructure development for early market fuel cell applications. • Using the Macro System Model, analyze the life-cycle GHG emissions and cost of on-board storage options including cold, chemical, and adsorbent systems. • Complete life cycle analysis for water use of at least 2 hydrogen production pathways, with emphasis on renewables. • Assess and compare the potential economic, environmental, and GHG emissions reduction benefits of utilizing fuel cells for power generation from various fuel sources.	• No change.

Hydrogen and Fuel Cell Technologies
Technology Validation

Description

The Technology Validation subprogram provides accurate assessments of the state of hydrogen and fuel cell technologies—providing valuable feedback to R&D efforts, and validating the performance of pre-commercial technologies to enable informed decisions for public and private investment in continued R&D or commercial deployment. These efforts form a crucial part of an integrated strategy to move technologies from the laboratory to commercialization. The validation of pre-commercial technologies ensures the technologies are ready for the deployment phase. To enable the automotive, energy, and utility industries to determine whether technology readiness has been achieved, vehicles and hydrogen infrastructure components are validated under real-world operating conditions against their technical targets. This subprogram has supported the program's mission by providing critical data to predict whether FCEVs can meet the 2020 targets of 60% peak efficiency, 5,000-hour fuel cell durability, a range greater than 300 miles, 5-minute fill time, and hydrogen fuel costs of less than $4 per gge. Specifically, the subprogram will validate the performance and vehicle interfaces of FCEVs to demonstrate an increase in durability from 2,521 hours in 2012 to 5,000 hours by 2020 (5,000 hours is equal to approximately 150,000 vehicle miles). Technology Validation also provides information in support of codes and standards development, as well as for the development of best practices regarding safety.

The Technology Validation ($6 million) subprogram will continue to fund cost-shared demonstrations of pre-commercial technologies in fully integrated systems and collect and analyze real-world operational data. In addition to equipment and operational costs, Technology Validation projects may include activities such as siting, installation, commissioning and system design and integration to bridge gaps between the R&D program portfolio and real-world operations necessary for validation. Technology Validation may also augment and leverage existing or externally funded deployments with data collection activities that provide the data for validation.

In FY 2015, the subprogram will assess current technology and provide feedback to hydrogen and fuel cell R&D activities to help achieve an FCEV life-cycle cost of $0.42 per mile by 2020. The subprogram will collect data from advanced light-duty FCEVs, hydrogen refueling stations, and other vehicles such as fuel cell–powered transit buses (in collaboration with the U.S. Department of Transportation [DOT]). Technology Validation 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.

Data collection efforts will also include hydrogen refueling systems and fuel cells for early fuel cell markets, such as material handling equipment and backup power (e.g., for telecommunication towers. 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 to capture the performance, reliability, maintenance, and repairs over the life cycle of a technology and as the technology advances. These efforts identify needs and provide direct feedback to R&D efforts.

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

The subprogram will increase its emphasis on grid-integration; integrating electrolyzers or fuel cells with the grid to test and validate dispatch capability and technical potential to provide high-value services such as demand response. The subprogram will coordinate these efforts with DOE's Grid Integration Initiative to avoid duplication.

Technology Validation

Activities and Explanation of Changes

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs. FY 2014 Enacted
Technology Validation		
• Track light duty fuel cell hybrid vehicles, fuel cell hybrid buses, stationary fuel cell power system, refueling stations, refueling components, fuel cell powered material handling equipment, fuel cell backup power, and hydrogen recycling technology. • Collect data from light-duty FC vehicles to determine their range, fuel economy, and operating hours. • Measure refueling time, maintenance, and hydrogen dispensed or produced from hydrogen refueling stations and renewable hydrogen production. • Collect and analyze data from fuel cells used in transit buses and light-duty vehicles. • Analyze real-world data from fuel cell backup power deployments to characterize their performance and value proposition. • Identify R&D gaps relating to hydrogen compressor reliability from fuel cell material handling equipment operations.	• Validate advanced stationaryfuel cell systems, such as tri-generation systems capable of producing hydrogen, heat, and power. • Demonstrate a zero-emission medium-duty fuel cell hybrid electric truck with a range that is projected to be greater than 100 miles (meeting parcel delivery route requirements). • Demonstrate an electrolyzer capable of producing hydrogen for a refueling station with an output pressure of greater than 50 bars. • Demonstrate the potential for doubling hydrogen capacity at refueling stations.	• No change.

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. The subprogram also develops information resources and best practices for the safe use of hydrogen. The subprogram utilizes extensive external stakeholder input from, for example, automobile manufacturers and the energy, insurance, and aerospace sectors, as well as the fire protection community and academia, to enhance and create safety knowledge tools for emergency responders and authorities having jurisdiction. Continual availability of safety knowledge tools, distributed via an array of media outlets to reach the largest number of safety personnel possible, is a subprogram priority. The subprogram also supports the development and implementation of best practices and procedures to ensure safety in the operation, handling, and use of hydrogen and fuel cell technologies in program-funded projects.

The Safety, Codes and Standards subprogram ($7 million) will continue conducting research to identify the impacts of fuel quality and to develop metering technologies, and in FY 2015, will continue to quantify the impact of fast fueling (e.g., SAE standard J2601). Metering technologies and fuel dispensing requirements will be developed to allow accurate measurement of hydrogen and the impact of fuel contaminants on fuel cell system performance will be quantified to help achieve the FCEV life-cycle cost of $0.42 per mile by 2020. The subprogram will collaborate with DOT, the Environmental Protection Agency (EPA), NIST, and other government agencies, as well as the International Partnership for the Hydrogen and Fuel Cells in the Economy and the International Energy Agency to ensure that fuel, fuel storage, and dispensing standards development proceeds in agreement with existing regulatory authorities. The cooperating agencies will maximize available resources and expertise in areas such as hydrogen dispensing and measurement (NIST), vehicle safety (DOT National Highway Traffic Safety Administration), and the development of a Global Technical Regulation (DOT, EPA). The subprogram will also conduct comprehensive R&D to characterize the behavior of materials such as polymers in hydrogen environments and provide data to optimize the design engineering of components and systems.

In the area of safety research, the subprogram will continue analysis of creditable accident scenarios to identify potential system weaknesses, with complementary R&D efforts focusing on mitigating the identified weaknesses to improve system safety. FY 2015 funding will also support risk assessment activities, which will provide information to guide the codes and standards development process. Risk assessment activities will include: supporting the development of numerical experiments and models, such as computational fluid dynamics, and characterizing the release of gas and liquid hydrogen to help determine technical requirements for the hydrogen infrastructure, such as separation distances.

In addition to R&D activities, the subprogram will continue to develop and enhance safety information tools and monitor the safety of DOE hydrogen projects through the Safety Panel. The panel will conduct site visits, interviews, and safety plan reviews of program-funded hydrogen projects. To facilitate the approval and implementation of fuel cell projects using hydrogen, the subprogram will also conduct training for firefighters and fire department training coordinators, law enforcement personnel, and emergency medical technicians, as well as code officials, fire marshals, city planners, state government representatives, and other fuel cell users. Building on prior-year efforts, the subprogram will also expand the implementation and deployment of an introductory course designed specifically for code officials.

Safety, Codes and Standards

Activities and Explanation of Changes

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs. FY 2014 Enacted
Safety, Codes and Standards		
• Provide critical data required for the development of technically sound codes and standards. • Publish results from hydrogen cycle tests and materials studies conducted in a high pressure hydrogen environment. • Conduct a quantitative risk assessment study to address indoor refueling requirements to be adopted by code development organizations. • Validate the impact of fuel impurity in PEM stacks and other fuel cell system components. • Support the development and validation of metering technologies and fuel dispensing requirements, such as SAE J2601.	• Continue efforts in fuel quality and metering to quantify the impact of fast fueling (SAE standard J2601). • Publish hydrogen quality testing protocols (e.g., PEM stacks). • Complete hydrogen fueling station template including the codes necessary for widespread commercialization of infrastructure. • Implement a standardized training mechanism and information related to the model codes and train at least 250 first responders and code officials. • Develop a predictive engineering model for hydrogen dispersion and ignition.	• No change.

Hydrogen and Fuel Cell Technologies
Market Transformation

Description

Market Transformation activities make up a key final phase in the program's comprehensive strategic timeline for moving technologies from the laboratory to self-sustaining commercialization in the marketplace. This market-acceleration strategy integrates technology demonstration and validation (conducted by the Technology Validation subprogram), codes and standards development (conducted by the Safety, Codes and Standards subprogram), and early market deployments (conducted by the Market Transformation subprogram). The primary goal of the Market Transformation subprogram is to increase penetration of commercial-ready hydrogen and fuel cell technologies in key early markets where a modest number of new orders will have a significant impact on reducing costs through economies of scale. Enabling economies of scale will reduce total life-cycle costs (not just the costs of hardware components) and will help fuel cell technologies achieve life-cycle cost parity with incumbent technologies. The program's approach is aligned with National Laboratory and market research studies that outline necessary deployment measures to reach the program's goals.

Early market sales will also stimulate further market activity by supporting the growth of the domestic fuel cell manufacturing industry, overcoming some of the logistical and other deployment challenges associated with adoption of new technologies, and establishing key elements of the infrastructure that will be essential for later market growth. For example, the program successfully stimulated early markets for fuel cells and catalyzed industry investment with cost-shared deployments of approximately 1,600 fuel cell powered lift trucks and backup power systems that led to nearly 9,000 additional orders by industry with *no additional DOE investment*. In addition to their direct positive impact on the market, these deployments will also provide valuable data on the performance of the technologies and lessons learned from early adopters, which will help the private sector build business cases and encourage further adoption.

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

The Market Transformation ($3 million) subprogram will continue to fund cost-shared deployments and provide technical support to deployment efforts, which will help address deployment costs and market barriers that industry does not currently address. The program will build on the successful deployments of backup power fuel cell systems and fuel cell powered lift trucks and catalyze sales of additional applications that it has identified as strategically valuable and commercially viable. In FY 2015, the program will complete assessment of early market fuel cell systems and provide feedback to R&D areas to help achieve the hydrogen and fuel cell portion of the levelized cost per mile of $0.14 per mile in 2020. Focus areas include:

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

In FY 2015, the subprogram will conduct and coordinate the development of inter-governmental deployment tools that support cost-effective siting of fuel cells for specialty vehicles and APUs or other early market applications. It will also support activities to reduce costs associated with the installation process, and it will coordinate the development of strategies for projects using hydrogen for utility-scale renewable energy storage. In FY 2015, to facilitate Federal early adoption, the subprogram will develop an on-line portal which will assist in estimating cost to replace incumbent stationary and motive power systems.

Market Transformation

Activities and Explanation of Changes

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs. FY 2014 Enacted
Market Transformation		
• Increase penetration of hydrogen and fuel cell technologies in key early markets where a modest number of new orders will have a significant impact on reducing costs through economies of scale. • Develop fuel infrastructure location strategies with key stakeholders in Federal, State and city government agencies to reduce fuel station costs such as real property access, permitting, insuring and operating. • Provide technical and financial assistance for technology in critical early market niches such as auxiliary power applications.	• Complete assessment of early market fuel cell systems and provide feedback to R&D areas to help achieve the hydrogen and fuel cell portion of the FCEV levelized cost per mile of $0.14 per mile by 2020 focusing on specialty vehicles and hybrid power. • In collaboration with FAA, FTA, GSA, DOD and other Federal agencies, deploy fuel cell powered GSEs at 1 major airports and hybrid trucks/buses at 1 Federal site. • Develop an on-line planning tool that calculates installed cost and air emission reductions (i.e., criteria pollutants and GHGs) to accelerate demonstrations and deployments by reaching 400 CHP projects. • Support strategic deployments of early market fuel cells to spur commercial adoption and seek to enable a five-fold increase in the number of installed fuel cells relative to the FY 2012 baseline achieving further cost reductions across the industry through economies of scale, improvements in the supply chain, and increased investment in manufacturing.	• No change.

Hydrogen and Fuel Cell Technologies
NREL Site-Wide Facility Support

Description
In FY 2015, EERE will continue to 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. This practice is consistent with other National Laboratories. EERE began this practice in FY 2014 to reduce NREL's labor rate multiplier, thereby reducing the cost barrier to accessing unique NREL capabilities (such as facilities and staff expertise) by industry and academia. This practice also makes site operating costs more transparent in order to facilitate cost control and planning. In FY 2014, this practice resulted in a reduction in the Lab-wide direct labor multiplier of approximately 15% compared to FY 2013. The proposed FY 2015 budget continues this approach. The site-wide facility support funds cover maintenance and engineering support; fire, emergency, and custodial services; general utilities; network infrastructure and licenses; environment, safety, and health support; and sustainability. By moving these costs from laboratory overhead to direct funding, EERE accelerates technology transfer and mission impact by making it easier for companies and external researchers to access NREL capabilities and expertise.

This funding supports research programs by providing basic site services, functions, and infrastructure for Site Operations, which includes: Management, Building Operations, Building & Grounds Maintenance, Fire & Emergency Response, Engineering & Construction support, Minor Construction projects, Electrical Safety Program, Utilities, and Facilities Planning Support; and activities within the Sustainability and Environmental Health and Safety (EHS) portfolios. These activities and their costs are relatively fixed and only vary significantly based upon variations in commodities, construction activity, emergencies, weather patterns, etc. They are considered to be the core functions for site operations, safety, environmental compliance, and sustainability at NREL. In FY 2015, this funding will support more than 60 full time equivalents that manage and provide support for these core functions. It will also fund site-wide subcontracts such as janitorial services, refuse and recycling, and subcontracts for minor construction. Additionally, this funding will support site-wide costs associated with maintaining NREL's leadership position, such as: maintaining International Organization for Standardization (ISO), American Association for Laboratory Accreditation (A2LA), and other lab-wide accreditations, managing facilities to enable mission goals, improving sustainability, pollution prevention, waste minimization, improving energy efficiency, reducing water use, and maintaining an effective emergency management system.

The FY 2015 contribution from each program differs from the FY 2014 allocation, because EERE has developed a more precise, equitable, and economically neutral method that ensures a net-zero impact on programs' funding. For each program, the contribution to direct funding for site-wide facility support is equivalent to the estimated contribution the program otherwise would have made through overhead charges. This method is based upon each program's level of funding to NREL, adjusted to account for anomalies from capital expenditures and major subcontracts.

NREL Site-Wide Facility Support

Activities and Explanation of Changes

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs. FY 2014 Enacted
NREL Site-Wide Facility Support		
• Directly fund NREL site-wide facility support costs that are not included in the Facilities and Infrastructure budget rather than continue to fund these costs in the laboratory overhead rate.	• Directly fund NREL site-wide facility support costs that are not included in the Facilities and Infrastructure budget rather than continue to fund these costs in the laboratory overhead rate.	• The delta is the result in a change in methodology used to allocate site-wide facility support contributions amongst programs. The FY 2015 value enables and directly equates to the program's estimated savings gained from the reduced labor multiplier.

Hydrogen and Fuel Cell Technologies
Performance Measures

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

	FY 2013	FY 2014	FY 2015
Performance Goal (Measure)	**Fuel Cell Power - Improve the catalyst specific power of fuel cells, as measured in kW per gram of platinum group metal**		
Target	5.9 kW per gram of platinum group metal	6.3 kW per gram of platinum group metal	6.5 kW per gram of platinum group metal
Result	Met – 6.0	N/A	N/A
Endpoint Target	8 kW/g by 2020; $40/kW fuel cell system cost target in 2020 and $30/kW ultimate fuel cell system cost target		

Solar Energy

Overview

The 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. SunShot will enable widespread, large-scale adoption of solar across America by making solar energy systems cost-competitive with other forms of energy by the end of the decade. These objectives serve the broader purpose of creating reliable domestic energy options manufactured in the U.S. that reduce carbon pollution and strengthen U.S. competitiveness. In FY 2015, the Concentrating Solar Power (CSP) subprogram will collaborate through the Advanced Solar Power Cycles R&D activity with Fossil Energy, Nuclear Energy, and EERE's Geothermal Technologies program on a crosscutting initiative on supercritical carbon dioxide electricity production technology.

The Solar Energy program supports the DOE SunShot Initiative's mission to make solar energy technologies, including both solar photovoltaic (PV) and CSP technologies, cost-competitive with traditional sources of electricity, without subsidies, by 2020. This will require cost reductions of 75 percent relative to 2010 baseline levels. Reducing the total installed cost for utility-scale solar electricity to roughly $0.06/kWh (corresponding to approximately $1.00/W for system prices) without subsidies will help enable rapid, large-scale adoption of solar electricity across the U.S. The program has similar aggressive targets for residential and commercial market segments as well. By the end of 2013, reductions of 51 percent, 52 percent, and 54 percent have been achieved for PV system costs at the utility, commercial, and residential scale respectively, well on target to achieve the 75 percent cost reduction goal by 2020.

Deployment of PV across the U.S. has been growing at a rapid rate, with a record 4.3 GW (estimate) deployed in 2013, almost a 10 fold increase from 2009 of 0.44GW.[1] This has resulted in significant job growth. By the end of 2013, there were approximately 143,000 people in the U.S. employed in the solar sector according to the National Solar Jobs Census, representing a 19.9 percent job growth rate over the prior year.[2] This rapid market and job growth has been made possible by rapid declines in systems costs.

Solar Energy investments will help re-establish American technological and market leadership in solar energy, diversify the Nation's electricity supply, reduce environmental impacts of electricity generation, strengthen U.S. manufacturing competitiveness, and catalyze domestic economic growth. Through the SunShot Initiative, the program closely coordinates its activities with those in the Office of Science and ARPA-E to prevent duplication of efforts while maximizing the department-wide impact on solar energy. At the fundamental level, the program embraces two complementary approaches, namely converting solar photons to electricity through direct conversion in a semiconductor (PV) and through conversion of intermediate thermal energy to electricity (CSP).

The program will continue to focus on innovative technology and manufacturing process concepts as applied to PV and CSP and will help stimulate and spur the domestic PV and CSP manufacturing base and supply chain. The program also supports systems integration by developing radically new approaches to reduce the cost and improve the reliability and functionality of power electronics associated with solar energy systems by supporting industry development through test and evaluation standards and by developing technologies and tools for meeting grid requirements. Increased emphasis will also be placed on reducing balance of systems (BOS) soft costs, including streamlined permitting, inspection, and interconnection, as well as performing key analyses of policy options and their potential impact on the deployment of solar technologies. Continuing with the success with the Incubator program, the Solar Energy program is devoting 5 percent of its proposed FY 2015 funding to its tenth round of early-stage assistance to help small businesses commercialize innovative solar technologies.

Highlights of the FY 2015 Budget Request

The Solar Energy program will launch significant new efforts in three major areas in FY 2015:

- Leveraging promising early research supported by the DOE in FY 2013 and FY 2014, the Advanced Solar Power Cycles R&D activity will support research on advanced supercritical CO_2 (sCO_2) Brayton cycle power systems offering higher efficiency and lower cooling water needs compared with conventional steam-Rankine power cycles. This technology

[1] "U.S. Solar Market Insight Report: 2012 Year in Review," GTM Research and SEIA, March 2013. Includes solar energy firms working in installation, manufacturing, sales and distribution, project development, R&D, etc.
[2] "National Solar Jobs Census 2013,"The Solar Foundation, Jan. 2014.

pathway has the opportunity to not only enable Concentrating Solar Power to achieve the SunShot objectives, but also to revolutionize the entire power generation industry. This program-specific element of the broader supercritical carbon dioxide electricity production technology crosscutting collaboration within DOE will focus on sCO_2 Brayton cycle energy R&D relevant specifically to CSP, including the development of sCO_2 solar receivers and the study of the degradation mechanisms of sCO_2 containment materials. It will also help to define the operating parameters and conditions that are necessary considerations for the collaborative Supercritical Transformational Electric Power Generation (STEP) initiative led by the Office of Nuclear Energy.

- R&D and technology development to enable higher levels of integration of solar power generation with the grid. This includes integration with the built environment (offices and homes) as well as electric vehicles and other renewable energy technologies.
- Solar Manufacturing Technologies III will be the third round of a successful program that has helped U.S. industry develop manufacturing technologies and advanced materials used to manufacture solar products.
- Non hardware "soft costs" remain one of the largest challenges in achieving the 2020 SunShot targets. These soft costs now account for 64 percent of the total cost of residential systems. Increased focus on engagement with state and local governments and small businesses as well as community colleges will help reduce the "soft costs" as well as enable a trained and efficient solar workforce that now numbers over 142,000 jobs in America.

Solar Energy
Funding ($K)

	FY 2013 Current[3]	FY 2014 Enacted[4]	FY 2014 Current	FY 2015 Request	FY 2015 vs FY 2014 Enacted
Solar Energy					
Concentrating Solar Power	43,080	48,571	48,571	61,400	+12,829
Photovoltaic R&D	150,580	56,641	56,641	42,000	-14,641
Systems Integration	45,773	52,816	52,816	56,900	+4,084
Balance of Systems Soft Cost Reduction	29,617	42,558	42,558	45,100	+2,542
Innovations in Manufacturing Competitiveness	0	44,472	44,472	67,700	+23,228
NREL Site Wide Facility Support	0	12,000	12,000	9,200	-2,800
Total, Solar Energy	**269,050**	**257,058**	**257,058**	**282,300**	**+25,242**

SBIR/STTR:

- FY 2013 Transferred: SBIR $3,518; STTR: $456
- FY 2014 Projected: SBIR: $1,776; STTR: $254
- FY 2015 Request: SBIR: $1,933; STTR: $267

[3] Funding reflects the transfer of SBIR/STTR to the Office of Science.
[4] FY 2014 Enacted funding reflects the contractor foreign travel rescission of $153,166.

Solar Energy
Explanation of Major Changes ($K)

	FY 2015 vs FY 2014 Enacted
Concentrating Solar Power (CSP): Funding reflects a shift in mission critical needs as the technical and economic landscapes for concentrating solar power evolve. Promising results have emerged from FY 2013 efforts utilizing supercritical CO_2 Brayton cycle power systems for thermal efficiency gains that could increase the performance of CSP systems. The cost of the solar field is now a dominant factor in overall CSP systems costs; this cost is targeted by focusing on lowering the cost and raising the efficiency of the collectors.	**+12,829**
Photovoltaic (PV) R&D: Reduction in funding reflects the fact that the photovoltaic module is no longer the highest barrier to the SunShot initiative reaching $1/W_{DC}$ utility scale, $1.25/W_{DC}$ commercial scale and $1.50/W_{DC}$ residential scale by 2020. With continued innovation, module costs are currently on target to achieve $0.50/W_{DC}$ by 2020; however, gaps remain in module efficiencies that can reduce balance of systems costs. Accordingly we are shifting funds from PV R&D to other areas which represent proportionately larger cost barriers and cost reduction opportunities. The decrease in funding is also reflective of the transfer of the SunShot Incubator to the Innovations in Manufacturing Competitiveness subprogram so that it better reflects the cross-program focus of the Incubator program on addressing barriers and opportunities in not just PV, but also CSP, Systems Integration, and Balance of Systems. The focus of R&D in the Solar program also begins to shift towards systems integration technologies to enable higher levels of solar on the grid as well as towards CSP.	**-14,641**
Systems Integration: The funding reflects continued emphasis on addressing system integration issues as the concentration of PV on the grid increases, and the need to store solar energy for times when solar energy is not being generated.	**+4,084**
Balance of Systems Soft Cost Reduction: The funding request reflects a shift from utility scale engagement towards a program more focused on building partnerships with state and local governments as well as other stakeholders. The program expects to leverage experience from previous rounds of the Rooftop Solar Challenge in the work with state and local governments. This funding level also supports developing the training framework to ensure a highly skilled and informed workforce for both the solar industry and ancillary fields related to solar deployment.	**+2,542**
Innovations in Manufacturing Competitiveness (IM): The funding increase is due to more ambitious manufacturing technology and commercialization projects as the solar industry matures in the U.S. Through cost-sharing requirements, the funds will be leveraged by private capital as well as investments at state and local governments. With demand for solar at a record high in the U.S. and globally, and solar job growth in the U.S., there is opportunity for U.S. businesses to capture a greater portion of the global solar value chain. The funding increase also represents the Incubator activity being transferred to and fully encompassed within the IM subprogram, a better fit as the industry evolves.	**+23,228**

	FY 2015 vs FY 2014 Enacted
NREL Site-Wide Facility Support: The delta is the result in a change in methodology used to allocate site-wide facility support contributions amongst programs. The FY 2015 value enables and directly equates to the program's estimated savings gained from the reduced labor multiplier.	**-2,800**
Total, Solar Energy	**+25,242**

Solar Energy
Concentrating Solar Power

Description
The near-term goal of the Concentrating Solar Power (CSP) subprogram is to reduce the levelized cost of CSP energy at utility scale to $0.125/kWh without subsidies by the end of FY 2015 from a baseline of $0.185/kWh in FY 2012 and $0.21/kWh in FY 2010. The goal endpoint is $0.06/kWh by 2020, cost competitive with traditional electricity sources.[5]

DOE supports research and development of CSP technologies as a unique path to achieve SunShot Initiative cost targets with systems that can supply solar power on demand through the use of thermal storage. CSP technologies use mirrors (the solar field) to reflect and concentrate sunlight onto receivers that collect solar energy and convert it to heat carried by a heat transfer fluid. This thermal energy can then be used to produce electricity via the power block – a steam turbine or heat engine driving a generator. Thermal energy can also be stored between collection and power generation using a thermal storage system – for example, to enable power generation in the evening.

Going forward, the CSP subprogram will advance its research, development and demonstration (RD&D) activities through a strong push towards grid parity, a levelized cost of energy (LCOE) of $0.06/kWh cost structure, and the innovations in the sub-system level required to achieve this. Technical and economic costs analysis has been performed on modeled systems to extract technical performance and cost targets for each of the critical subsystems.

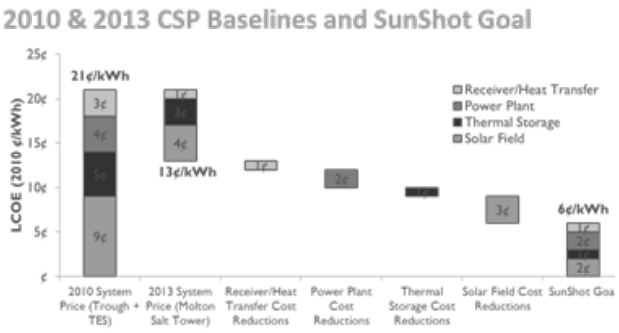


Figure 2. Concentrating Solar Power progress and goals.

To achieve the SunShot goals by 2020, subprogram activities are focused on the following key areas with cost and performance targets:

- Solar field: cost less than $75/m^2, lifetime greater than 30 years;
- Components including receiver and power block: cost less than $1,200/kWe at efficiency greater than 50 percent;
- Heat transfer fluids: cost less than $1/kg; thermal stability greater than 800 C; and
- Thermal storage: cost less than $15/kWh thermal.

The CSP subprogram seeks to accomplish these technical objectives through competitively funded research programs at industry, National Laboratories, and academia. Starting in FY 2013, the program has shifted its focus the majority of efforts CSP towers (from CSP troughs). This prioritization was made because towers offer higher temperatures and therefore higher efficiencies. FY 2015 funding will support the following portfolio of activities within the CSP subprogram.

<u>CSP Advanced Research ($21.4 million)</u>
In order to meet the 2020 SunShot goals, CSP systems will need to operate at higher temperatures, and solar field costs will have to be reduced by 50 percent to 75 percent. Higher temperature operation results in higher power block and overall system efficiency and enables thermal storage systems to be less costly. The R&D goals in this area are to: lower costs and improve performance and reliability of high temperature materials used in CSP systems; characterize and test materials developed in cooperation with industry; and broaden and unify test methods to standardize qualification requirements of CSP materials, components, and systems. Additionally, the National Laboratories will continue work on optical tool development and performance and techno-economic modeling software that assists the Solar Energy program and the

[5] 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.

industry in focusing research on critical cost/performance improvements. This funding buys down prior year mortgages and supports research at the National Laboratories. In FY 2014, funding in this area is $33.8 million. The buy down plan has enabled this area to be reduced to $21.4 million for FY 2015.

Advanced Solar Power Cycles R&D ($25.0 million)

Leveraging promising early research supported by the DOE in FY 2013 and FY 2014, the Advanced Solar Power Cycles R&D activity will develop advanced supercritical CO_2 (sCO_2) Brayton cycle power systems offering higher efficiency and lower cooling water needs compared with conventional steam-Rankine cycles. This technology pathway has the opportunity to not only enable CSP to achieve the SunShot objectives, but also to revolutionize the entire power generation industry. There would be significant benefit to CSP technologies as the high temperatures (~700°C) envisioned for this power cycle are in line with the CSP technology roadmap. This program-specific element of the broader supercritical carbon dioxide electricity production technology crosscutting collaboration within DOE will focus on sCO_2 Brayton cycle energy R&D relevant specifically to CSP, including the development of sCO_2 solar receivers and the study of the degradation mechanisms of sCO_2 containment materials. It will also help to define the operating parameters and conditions that are necessary considerations for the collaborative Supercritical Transformational Electric Power Generation (STEP) initiative led by the Office of Nuclear Energy, which seeks to demonstrate the supercritical CO_2 power cycle at the pilot (nominally $10MW_e$) scale.

COLLECTS ($15.0 million)

The COLLECTS activity will develop advanced lower cost concentrators with the goal of reducing the cost of the solar field, currently a dominant component of the cost of a CSP system. Through competitively selected R&D, this activity will explore novel collection strategies for CSP applications, including, but not limited to, high-quality optics, ultra-low-cost collectors, material-efficient structures, snap-in-place facets, lenses/membranes, gradient-index (GRIN) lenses, waveguides, collector pods, passive tracking, collector fluidics, photo-responsive materials. The low-cost high efficiency collection systems will directly contribute to meeting the 2020 SunShot targets and is in line with the CSP technology roadmap.

Through efforts forward-funded in FY 2014 and prior years, the program will continue to develop CSP technologies with thermal storage to reach the goal of baseload grid parity by 2020. The subprogram supports thermal storage and supporting systems research and optimization to provide baseload power on demand, even at night. Improved, cost-effective thermal storage would enable more widespread deployment of CSP and help achieve economies of scale to further reduce CSP system cost and enhance the ability of CSP systems to manage short-term and diurnal disruptions in solar output.

For CSP, explicit goals are to achieve the following targets by 2020 that add up to $0.06/kWh from a 2012 baseline of $0.185/kWh. Advances in the technology, especially for CSP towers, already have enabled a significant reduction of the benchmarked LCOE from $0.185/kWh to $0.135/kWh between 2012 and 2013:

- Average solar field cost goal for 2020: $0.02/kWh (2012 baseline: $0.08/kWh, 2013 baseline: $0.05/kWh);
- Average power plant cost goal for 2020: $0.02/kWh (2012 baseline: $0.04/kWh, 2013 baseline: $0.04/kWh);
- Average receiver cost goal for 2020: $0.01/kWh (2012 baseline: $0.03/kWh, 2013 baseline: $0.02/kWh); and
- Average storage cost goal for 2020: $0.01/kWh (2012 baseline: $0.035/kWh, 2013 baseline: $0.025/kWh).

Concentrating Solar Power

Activities and Explanation of Changes

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs FY 2014 Enacted
Concentrating Solar Power		
• New Thermal Storage R&D focused on high temperature fluids and thermal chemical processes - Phase 2. Increase salt temperature up to 800 C for higher systems efficiency. • CSP Component and Systems Development is focused on developing novel collection systems through use of new materials, new system configurations, and/or new rapid field installation methods; new solar receivers capable of operation in excess of 650°C with new solar selective coatings that have an absorptivity > 0.9 and emissivity < 0.4 at this temperature. • CSP hybrids overcome technology barriers to integration of CSP with conventional fossil fuel power plans, leveraging existing power generation equipment to demonstrate and validate CSP technologies and to develop CSP component technologies and supply chain.	• Advanced Solar Power Cycles R&D: Leveraging promising early research supported by the DOE in FY 2013 and FY 2014, Advanced Solar Power Cycles R&D will develop advanced supercritical CO_2 Brayton cycle power systems offering higher efficiency and lower cooling water needs compared with conventional steam-Rankine cycles. • Development of advanced and low cost concentrators: With the goal of reducing the cost of the solar field, currently a dominant component of the cost of a CSP system, the program will explore novel collection strategies for CSP applications.	• Funding reflects a shift in mission critical needs as the technical and economic landscapes for concentrating solar power evolve. Promising results have emerged from FY 2013 efforts utilizing supercritical CO_2 Brayton cycle power systems for thermal efficiency gains that could increase the performance of CSP systems. The cost of the solar field is now a dominant factor in overall CSP systems costs; this cost is targeted by focusing on lowering the cost and raising the efficiency of the collectors.

Solar Energy
Photovoltaic R&D

Description

DOE aggressively supports development of low-cost, high-efficiency photovoltaic (PV) technologies through the SunShot Initiative, which seeks to make solar electricity cost-competitive with other sources of energy by 2020. The near-term goal of the Photovoltaic R&D subprogram is to reduce the levelized cost of solar PV energy at utility scale (cents/kWh) to $0.11/kWh without subsidies by the end of FY 2015. The goal endpoint is $0.06 /kWh by 2020, cost competitive with traditional electricity sources.[6]

With respect to installed system prices, the explicit goals of the program are to achieve the following targets by 2020:

- Average utility-scale installed system price: $1.00/Wdc;
- Average commercial-scale installed system price: $1.25/Wdc; and
- Average residential-scale installed system price: $1.50/Wdc.

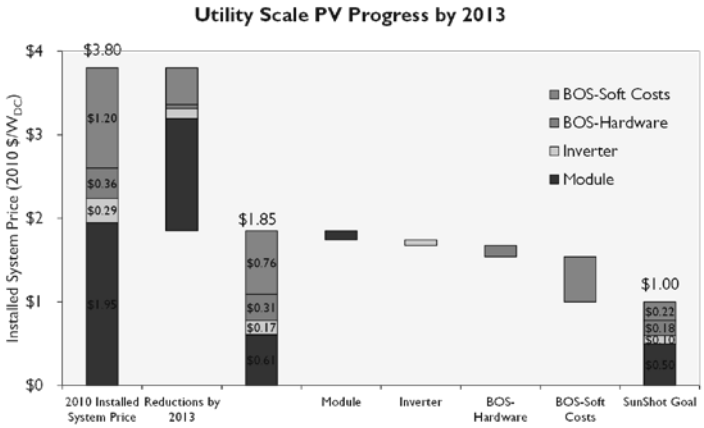


Figure 3. Progress of over 60 percent towards the 2020 goals have been achieved for utility scale PV systems

Achieving these goals will require significant technological innovations and reductions in cost in all PV system components. These components are broadly defined as modules, power electronics, and BOS, which includes all other components and costs required for a fully installed system, including permitting and inspection costs. For the PV utility scale system, a breakdown of the targeted $1/Wdc installed cost includes $0.50/Wdc for the module, $0.10/Wdc for the power electronics, and $0.40/Wdc for the BOS elements. By the end of 2013, reported prices in 2013 dollars were as follows: module price of $0.63/Wdc, average utility-scale inverter price of $0.18/Wdc, and BOS price for utility scale systems of $1.11/Wdc.

The DOE SunShot program advances the state-of-the-art in PV by taking a technology-agnostic approach to funding R&D across the technology type and readiness spectrum with industry, academic and National Laboratory partners through a competitive process. Specifically, the program does the following:

- Seeds funding for new types of materials and device approaches that enable higher PV performance, greater reliability, and reduced cost as manufacturing and deployment scale.
- Funds translational research and development to bridge gaps between applied research accomplishments and device and materials development and manufacturing environment needs.

Innovations such as those supported by the program over the past 30 years have enabled a dramatic decline in PV module prices of more than 95 percent, and more than half of the world record solar cell efficiencies over the past 30 years were achieved through Solar Energy program investments.

In addition to supporting R&D to significantly advance existing photovoltaic technologies, such as crystalline silicon, thin-film, and multi-junction (III-V) PV, SunShot supports research into emerging PV concepts that are still in the proof-of-concept phase. These projects, which are still being developed in a laboratory, have the potential to revolutionize the photovoltaic industry. In FY 2015, funding for the PV R&D subprogram supports ongoing R&D activities (postdoctoral research and NCPV R&D at NREL) as well as 2 new solicitations.

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[6] Key additional details of this target include:

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

SunShot Postdoctoral Research Awards ($2.0 million)
The SunShot postdoctoral research program funds emerging research leaders in the field that will pursue breakthrough solar energy technologies. These 2-year awards provide doctoral degree recipients the opportunity to conduct applied research at universities, National Laboratories, and other research facilities. This activity will include a program evaluation plan and will follow best practices to ensure a diverse applicant pool and an unbiased selection process.

National Center for Photovoltaics (NCPV) ($22.7 million)
This funding supports ongoing merit reviewed research activities at the National Laboratories. NCPV work covers foundational research applicable to applied problems (such as model systems for known materials), materials and device optimization and study to advance existing and emerging photovoltaic technologies, and the development of new measurement and characterization techniques. NREL also works in collaboration with industry through unique capabilities, such as specialized equipment that simultaneously allows the creation and analysis of PV devices. In FY 2015, the budget for the NCPV is separated out into these R&D tasks — described here — as well as a line item for NREL site-wide facility support for basic site services, functions, and infrastructure costs associated with the NCPV.

BRIDGE II ($9.7 million)
The Bridging Research Interactions through collaborative Development Grants in Energy II (BRIDGE II) program will be a second iteration of a successful program that funds collaborative research teams to significantly lower the cost of solar energy systems. The teams can access the tools and staff expertise at existing DOE Office of Science research facilities so fundamental scientific discoveries can be rapidly transitioned to existing product lines and projects.

The BRIDGE program provides engineers and scientists developing solar technologies with the tools and expertise of the Department's Office of Science research facilities, including major facilities for x-ray and neutron scattering, nano-scale science, advanced microcharacterization, environmental molecular sciences, and advanced scientific computing. This collaborative approach will accelerate innovations to lower the cost of solar technologies as well as provide a natural hand-off of the relevant activities funded by the Office of Science and the program.

Recycling R&D ($4.0 million)
In the last four decades, over 100GW of solar panels were installed worldwide. That capacity doubled from 50GW to 100GW in the last 2.5 years and is projected to double again in the next 3 years. Recycling R&D aims to find economical ways of reclaiming and disposing of PV modules that have either failed in the field or are at the end of the service life. The examples of the innovations required are reducing or neutralizing the toxicity of the residual compounds or improvements in chemical or mechanical processing that will make PV module recycling a more viable economic proposition than a simple disposal in the landfill. Furthermore, many of the materials used in solar cells have high value (silver) or may be critical materials (indium, tellurium) and recycling will reduce needs for new sources.

The remainder of the funds ($3.6 million) in the subprogram will buy down out-year mortgages.

Photovoltaic R&D

Activities and Explanation of Changes

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs FY 2014 Enacted
Photovoltaic R&D		
• Next Generation PV III: investigate new concepts for PV materials and cells that approach and exceed the practical efficiency limits for conventional solar cells of about 30 percent. • Postdoctoral Research awards: develop research leaders to enhance innovation in the U.S. • Incubator Round 9: early-stage assistance to help small businesses commercialize innovative technologies. • Core NCPV research in PV cells and modules.	• BRIDGE II connecting applied PV research to DOE National Laboratories Scientific User Facilities. • PV systems recycling R&D, supported by life-cycle analysis. • Postdoctoral Research awards: develop research leaders to enhance innovation in the U.S.	• Reduction in funding reflects the fact that the photovoltaic module is no longer the highest barrier to the SunShot initiative reaching $1/watt utility scale, $1.25/W commercial scale and $1.50/W residential scale by 2020. With continued innovation, module costs are currently on target to achieve $0.50/W by 2020; however, gaps remain in module efficiencies that can reduce balance of systems costs. Accordingly, we are shifting funds from PV R&D to other areas which represent proportionately larger cost barriers and cost reduction opportunities. The decrease in funding is also reflective of the transfer of the SunShot Incubator to the Innovations in Manufacturing Competitiveness subprogram so that it better reflects the cross-program focus of the Incubator program on addressing barriers and opportunities in not just PV, but also CSP, Systems Integration, and Balance of Systems

Solar Energy
Systems Integration

Description
The Systems Integration subprogram works closely with industry, universities, and the National Laboratories to overcome technical barriers to the large-scale deployment of solar technologies by:

- Reducing the costs of power electronics and BOS hardware;
- Reducing the technical risk associated with the use of new technologies (improving bankability); and
- Working with stakeholders to improve timely processes for integrating high-penetrations of solar technologies into the grid in a safe and reliable manner, such as within the context of Small Generator Interconnection Procedures (SGIP).

DOE supports the development of innovative, cost-effective solutions that allow increasing amounts of solar energy to integrate seamlessly into the electricity grid while mitigating associated risks. Such solutions can improve system reliability and encourage widespread deployment of solar technologies, such as PV and CSP.

As the cost associated with PV modules continues to fall, reducing power electronics and balance of system costs is increasingly important. This includes developing new approaches to installing PV systems such as building-integrated photovoltaics. In the course of bringing new technologies to scale, manufacturers must demonstrate "bankability" by validating their new technology to potential investors, potential customers, or insurance companies. The Systems Integration subprogram supports the National Laboratories and Regional Test and Evaluation Partnerships to test the reliability of new products and demonstrate their bankability in an unbiased manner. Finally, to enable the high penetration of solar technologies on the grid, the subprogram also focuses on technical areas such as variability, voltage regulation, power quality, protection, and unintentional islanding where systems continue to energize local electric loads after unplanned disconnection from the utility source. The approaches include developing advanced grid-friendly PV interconnection technologies, validating inverter and system models, proactively engaging with external stakeholders, and updating codes associated with PV systems.

As the deployments of photovoltaic systems in electric distribution systems have aggressively accelerated over the past few years, utilities, regulatory agencies, and developers have been faced with a significant number of integration challenges. Utilities are concerned with variability from solar, voltage regulation, unintentional islanding, protection coordination (planning for fault currents with distributed generation), and reverse power flows. Solar Energy technologies research, development, and demonstration aim to address these technical integration challenges. The Systems Integration subprogram supports ongoing R&D at the National Laboratories as well 2 new funding programs (SolarPEN and Stored Sun).

<u>National Laboratories Research ($26.0 million)</u>
Peer and merit reviewed ongoing research activities at the National Laboratories in systems and grid integration focus on a number of areas including:

- Reliability: In FY 2015, the subprogram will continue to conduct both outdoor testing as well as accelerated life-cycle testing in the laboratory, to identify failure modes and mechanisms in modules, inverters, and BOS components, in order to increase the reliability of new technologies and to reduce technical and financial risk.
- Test and evaluation: In FY 2015, the subprogram will continue to conduct performance studies on fielded systems as well as on components at the National Laboratories. Using this performance data, the subprogram will continue to develop, improve, and validate system performance models, testing and evaluation technology, and test procedures. This will provide tool, techniques, and information that help reduce the risk to the financial community investing in both the installation and manufacture of these technologies.
- Regional Test and Evaluation Partnerships (RTEPs): Evaluation of components, as well as whole systems will continue to be conducted in the field via university and private test laboratory partnerships. These field studies will continue to provide region-specific data from various climates throughout the country. Findings at the RTEPs (both field and laboratories) will continue to be used to both validate and complement National Laboratory and industry findings.
- Codes and standards: The subprogram will continue to fund National Laboratory support and leadership on numerous code and standard making panels and committees 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.
- System modeling and analysis: Activities will continue in benchmarking, modeling, and analysis for solar technology systems. Validation of models for annual energy production will continue to include data collected from PV

installations at select locations representative of the range of solar irradiation environments and weather conditions in the U.S. The inclusion of these representative datasets will further validate the modeling of performance of PV systems operating across the U.S.

- Solar resource assessment: In FY 2015, the subprogram will continue to improve resource maps for both PV and CSP focus areas with an emphasis on providing data to assist industry in site selection and better assurance to utilities and financial institutions on system performance. Support in FY 2015 will be at a reduced level compared to prior years, as these activities have begun to shift to other participants in the industry including businesses, and the subprogram has assisted this transition through a competitive solicitation for solar forecasting with awards starting in 2013.

SolarPEN ($12.2 million)

Research and development will focus on solar energy system technologies that will enable utilities to integrate higher levels of Solar Penetration. A new standard under development, IEEE 1547.8, will allow inverters to actively participate in managing PV as part of the distribution system. This activity will support development of technologies that meet this standard as well as demonstration and validation by utilities and equipment manufacturers that these technologies effectively meet both PV system and electricity grid requirements.

Stored Sun ($10.0 million)

This program will support applied research and development and adapt existing energy storage technologies for integration with distributed solar PV applications. The research aims to mitigate the impact of intermittency of PV by leveraging energy storage and intelligently using storage to maximize the value of the PV system while minimizing the capacity of the storage technology.

EERE Grid Integration Initiative ($7 million)

Customer owned electric vehicles, distributed renewable generation, and building equipment can be integrated to optimize their overall performance and designed to interact with the utility grid and better meet grid requirements as the concentration of these technologies on the grid increases. To enable customer options that address these integration issues in a comprehensive manner, EERE will implement a joint $19 million funding opportunity announcement sponsored by the Solar Energy program ($7 million), Buildings Technologies program ($7 million), and Vehicles Technologies program ($5 million) to solicit technology and tool development and demonstration activities. Specifically, the Solar Energy program will focus in the following areas:

- Voltage control: Develop technologies and techniques for photovoltaic systems to better integrate high penetrations of these systems with other distributed energy technologies and onto the grid while meeting the need to maintain the voltage of the distribution system within acceptable limits.
- Protection and restoration: Develop protection schemes that can accommodate photovoltaic and other distributed energy systems and two-way power flow with existing building-level protection equipment (fuses, circuit breakers, reclosers, etc.) and develop PV system management algorithms which improve restoration times or mitigate failures.
- Systems optimization: Develop controls and associated system architectures for photovoltaic systems needed to manage their integration into a diverse set of customer-side distributed energy resources and grid assets and to better meet grid distribution system requirements. These controls and architectures will be designed to use the communications protocols and standards under development by the Office of Electricity and others to ensure interoperability across the distribution system.
- Sensors and data: Collect higher resolution measurements on photovoltaic and associated distribution systems at strategic locations to determine real-time impacts on the feeder, including in conjunction with integrated PV, electric vehicle, and building energy management systems.
- Value proposition: Develop methodologies to evaluate the value proposition of photovoltaic systems in terms of grid reliability, resiliency, ancillary services, etc., observed over the course of the project, and explore mechanisms to incentivize market participation to create associated grid-support business opportunities.

The remainder of the funds ($1.7 million) in the subprogram will completely buy down out-year mortgages.

Systems Integration

Activities and Explanation of Changes

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs FY 2014 Enacted
Systems Integration		
• Initiation of new EERE cross-cutting Distributed Energy Resources Integration initiative. • Core National Laboratory research in reliability and systems integration.	• Solar PEN to develop solar energy system technologies that will enable utilities to integrate higher levels of solar penetration on the grid. • Stored Sun to integrate distributed battery storage with distributed solar systems. • EERE Distributed Energy Resources Integration Initiative to develop and demonstrate technologies and tools to ensure customer-owned electric vehicles, distributed renewable generation, and building equipment can be integrated to optimize their overall performance.	• The funding reflects continued emphasis on addressing system integration issues as the concentration of PV on the grid increases, and the need to store solar energy for times when solar energy is not being generated.

Solar Energy
Balance of Systems Soft Cost Reduction

Description
The goal of the Balance of Systems Soft Cost Reduction subprogram is to reduce the non-hardware barriers associated with the deployment of solar energy. The near term goals for this subprogram are to:

- In FY 2015, demonstrate a 50 percent reduction (from 2010 baseline) in non-hardware "soft costs" associated with residential and commercial PV systems. Balance of systems costs can still account for about $3/W-$4/W of the costs of these systems in many regions of the country, a long way from the SunShot goal of $0.60/W for residential systems.
- Achieve balance of system cost goal of $0.40/W for utility scale systems by 2020 compared to 2012 benchmark of $1.02/W.

Non-hardware costs or "soft costs" account for a growing proportion of the installed cost of solar energy, especially in the context of rapid declines in the cost of PV modules. These costs can amount to more than half of the total installed cost of a residential installation. DOE's SunShot Initiative partners with manufacturers, communities, universities, utilities, and other stakeholders to address these costs in order to meet the SunShot cost targets. The specific costs in this area include:

- Customer acquisition;
- Financing and contracting;
- System design and engineering;
- Permitting, interconnection, and inspection;
- Installation and performance; and
- Operations and maintenance.

In FY 2015, the Balance of Systems subprogram will support ongoing R&D at the National Laboratories as well as release 5 funding programs.

<u>Research and Analysis at the National Laboratories ($5.8 million)</u>
In FY 2015, ongoing research and analysis on key areas in reducing the balance of systems costs will be conducted at the National Laboratories, including financing costs as well as other non-hardware costs for solar installations. For example, there will be comparative research between residential solar costs in the U.S. and other countries to understand the differences in costs to the consumer that could be as high as twice that in Germany for systems that are similar in hardware. It also includes research in collaboration with the Federal Aviation Administration on the impacts of glint and glare and ways to mitigate these impacts as needed when solar installations are sited near airports.

<u>Increasing local solar accessibility through novel partnerships and challenge frameworks ($17.4 million)</u>
In FY 2015, this activity will partner local jurisdictions with researchers and solar market innovators to design pilot policies and programs that help communities effectively increase access to solar and to improve the performance of these pilots through low-cost evaluation and rapid, iterative design methodologies. Building on the tools introduced and refined during two rounds of DOE's successful Rooftop Solar Challenge program (i.e., rigorous, metric-driven assessments to reduce non-hardware costs and advance local market conditions), these activities will help increase solar deployment in emerging market segments like the commercial sector, schools, hospitals, and municipal buildings and lands. In addition, lessons learned at the regional level will be spread to electricity providers, communities, and states that have not yet seen significant growth in solar, using proven low-cost methods that enable these stakeholders to achieve their energy goals, such as: recognition/designation programs; streamlined and simplified IT tools; and community-based procurement strategies. These activities will be coordinated with the State Energy Program and DOE's broader effort on State and local engagement.

<u>Solar Training Networks ($8.0 million)</u>
FY 2015 funds will support a new competitive solicitation, through which DOE will work with industry and the educational community to develop strategies to anticipate growth in clean energy industries, and collaborate to close information and training gaps for solar energy technology integrators as well as related disciplines like finance, real estate, permitting, and inspection. This activity will leverage an existing network of community colleges and training providers to encourage greater deployment of solar energy. This work will complement the R&D activities of the combined EERE distributed energy resources integration focus by informing the development of business models where both electric utilities and customers are able to understand and evaluate the true value and costs of distributed solar energy generation.

Autonomous Energy Viability Assessor (AEVA) and partnership with the Bureau of Land Management (BLM) on solar on public lands ($6.0 million)

This activity will develop improved methodologies and tools for environmental, health, and safety impact assessment by evaluating and developing the potential for remote sensing, machine vision, and other assessment technologies to be used in streamlining and reducing costs associated with deploying solar on Federal lands. In FY 2015, the subprogram will also engage with Federal agencies, including, but not limited to, the U.S. Departments of the Interior and Defense, to provide technical advice for accelerated solar permitting on Federal lands.

Solar informatics ($5.0 million)

This activity will convene stakeholders and support the establishment of solar data and information asset standards to support consumer protection, increase access to financing, and reduce project risk through improved transparency and accessibility to solar performance data. For example, standardized solar information can support the valuation of solar insurance or mortgage products that make it easier for businesses and homeowners to own solar energy systems. Tools will be developed to leverage existing datasets and apply emerging data science tools to advance information technology solutions for local solar deployment.

Partnerships Uniting Localities, Students and Energy (PULSE) ($2.0 million)

This new program will create "business plan" and software development "hackathon" like competitions that connect the best and brightest in public policy, law, software development, coding, and business to the most pressing challenges facing renewable energy program/planning projects at the state and local levels. Example projects may include: strategy for low-cost adoption of streamlined and simplified solar permits, and development of a comprehensive design for shared and community solar installations. The funding provides prize incentives for winning teams and awards to implement winning plans.

The remainder of the funds ($0.9M) will completely buy down all remaining out-year mortgages in the Balance of Systems subprogram.

Balance of Systems Soft Cost Reduction

Activities and Explanation of Changes

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs FY 2014 Enacted
Balance of Systems Soft Cost Reduction		
• Utility Solar Challenge to develop viable business models that encourage greater penetration of solar on the grid. • Engage with state and local governments to reduce costs and timelines associated with permitting, interconnection, and inspection. • Create technical and professional standards for solar installers that would support an ecosystem in which small-scale solar installations do not require inspection by multiple entities.	• Solar Training Network to increase training at community colleges to meet the growing demand for workers in the solar industry. • AEVA (Autonomous Energy Viability Assessor) and partnership with BLM for solar on public lands. • PULSE (Partnerships Uniting Localities, Students and Energy). • Solar Informatics supporting the establishment of solar data and information asset standards. • Partnering local jurisdictions with researchers and solar market innovators and leveraging two rounds of DOE's successful Rooftop Solar Challenge program.	• The funding request reflects a shift from utility scale engagement towards a program more focused on building partnerships with state and local governments as well as other stakeholders. The program expects to leverage experience from previous rounds of the Rooftop Solar Challenge in the work with state and local governments. This funding level also supports developing the training framework to ensure a highly skilled and informed workforce for both the solar industry and ancillary fields related to solar deployment.

Solar Energy
Innovations in Manufacturing Competitiveness

Description

The Innovations in Manufacturing Competitiveness subprogram supports EERE's Clean Energy Manufacturing Initiative. The overall goal of this subprogram is to reverse the trend of offshoring of PV and CSP component manufacturing and assembly through technology and process innovations that can enable American companies to manufacture and deploy solar technologies competitively. It also seeks to strengthen the Nation's competitive advantage in the associated solar energy manufacturing supply chain. The goal for the subprogram is to increase America's market share for manufacturing value added commensurate with domestic market demand.

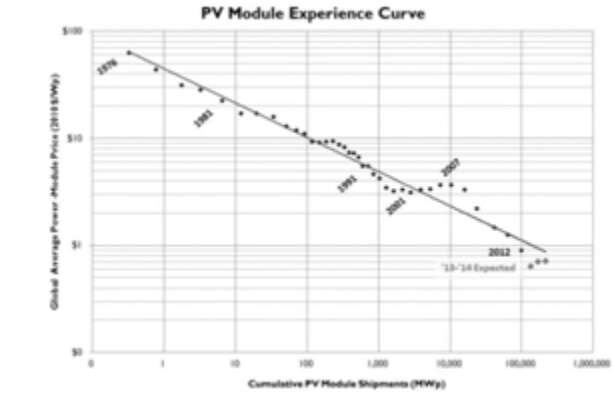


Figure 4: The PV module learning curve shows that for every doubling of manufacturing volume, the price of PV modules has fallen by about 95 percent over the past 35 years.

For the past 35 years, the average selling price of PV modules has declined on a trend line often referred to as a learning curve shown in Figure 3. In part through committed EERE investments in RD&D, the cost of solar PV modules has been reduced by 95 percent over the past 35 years, and by 75 percent over just the last 4 years.

PV innovations have helped enable the decline in PV module prices. These innovations include those supported by DOE – more than half of the world record solar cell efficiencies over the past 35 years were achieved through DOE investments. Despite U.S. technological leadership, intense international competition and support from foreign governments has created adverse conditions for manufacturers based in the U.S. as evidenced by the decline in PV cell and module manufacturing share. In order for American manufacturers to compete globally, innovation in manufacturing as well as innovation in technology will be required. To that end, the subprogram is focused on efforts to ensure that technologies developed in the U.S. can compete in the global marketplace, including focusing on segments of the value chain where America has defensible competitive advantages. The U.S. is unlikely to regain the entire value chain for solar manufacturing, but by focusing specifically on those areas where indigenous factors (such as innovation, low cost and reliable electricity, and abundant natural gas) as well as a focus on quality and deployment efficiency can provide domestic manufacturers a defensible competitive advantage, they can capture more value add in the final product. Analysis by NREL, shown in figure 5, has identified different segments of the value chain where the U.S. has unique manufacturing opportunities.[7]

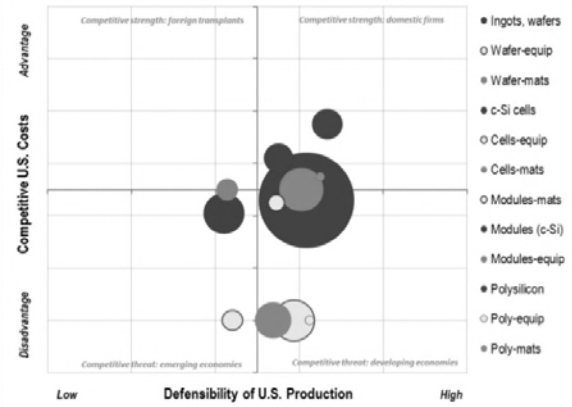


Figure 5: Competitive analysis by NREL has identified areas where the U.S. can have defensible long term advantages such as automated manufacturing equipment and advanced materials.

<u>SunShot Incubator 10 ($15.0 million)</u>

In FY 2015, The SunShot Incubator 10 will be the tenth round of the successful SunShot Incubator program which provides early-stage assistance to help small businesses cross technological barriers to commercialization while encouraging private sector investment. Since the program was launched in 2007, $90 million in competitively awarded government funds has leveraged more than $1.7 billion in follow-on venture capital and private equity investment. Successful awardees have been acquired by large U.S. corporations such as DuPont, GE, and First Solar or have

[7] A. Goodrich and T. James, NREL internal analysis (unpublished), March 2013.

gone on to help hundreds of megawatts of solar deployment by providing innovative information technology solutions. The SunShot Incubator program shortens the time between laboratory-scale proof of concept and prototype development. The project payments are made upon completion and verification of aggressive project deliverables.

SolarMAT III ($20.1 million)

Funding is requested for the third round of the Solar Manufacturing Technologies (SolarMAT) program that funds the development and demonstration of innovative, but commercially and technically viable, manufacturing technology that can achieve a significant market or manufacturing impact in 1 to 4 years from project completion. This activity is motivated by the need for manufacturing advances in both photovoltaic and concentrating solar power technologies to significantly reduce costs of solar-generated electricity in the U.S. and to provide U.S.-based manufacturers a manufacturing edge in a very competitive global marketplace. The focus is on developing manufacturing technology to drive down the cost of manufacturing and/or the cost of implementing technology that increases solar power conversion efficiency in manufacturing and deployment. This could include research in enhanced automation of manufacturing processes that would reduce capital and labor requirements at factories and installations in the U.S., thereby enhancing the ability for the private sector to achieve U.S.-based cost-effective manufacturing.

Massively Parallel Combinatorial Process Development for Competitive Manufacturing ($5.0 million)

Funding is requested for this new program in FY 2015 that will take advantage of combinatorial research technologies similar to that used successfully in the integrated circuit and pharmaceutical industries to rapidly screen and optimize processes to enable competitive U.S. manufacturing. Combinatorial process development has been shown to rapidly and cost effectively bring new technologies from initial development to full optimization for the marketplace and has just begun to be applied to the solar industry. This funding program will leverage smaller pilot projects that are currently underway in the areas of PV and CSP. Techniques developed in this program can also be useful if applied to other EERE technologies such as fuel cells or solid state lighting.

Scaling Up Nascent PV AT Home II: ($10.0 million)

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

PV Manufacturing Initiative ($17.6 million)

FY 2015 will represent the fifth and final full year of funding (out of 5) dedicated to the PV manufacturing initiative (PVMI). PVMI helps the solar power industry overcome technical barriers in PV manufacturing, to help the U.S. regain the lead in the global market for solar technologies. The competitively selected awardees engage with multiple companies across the PV supply chain to enable substantial cost reductions in PV module production and the associated equipment and materials. These collaborative organizations are developing and demonstrating new technologies for manufacturing scale-up and assisting with the transition to commercial production. This initiative accelerates the commercialization and cost reduction of PV technologies by coordinating solutions across industry that will facilitate PV manufacturing in the U.S. The initiative involves consortia of industry and university partners and multi-user manufacturing development facilities to speed the implementation of new cutting-edge technologies into production in the U.S. and to lay the foundation for self-sustaining pre-competitive collaboration among the domestic PV manufacturing base and supply chain.

Innovations in Manufacturing Competitiveness

Activities and Explanation of Changes

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs FY 2014 Enacted
Innovations in Manufacturing Competitiveness		
• PV Manufacturing Initiative: a consortia of industry and university partners and multi-user manufacturing development facilities to speed the implementation of new cutting edge technologies in industry manufacturing processes. • SolarMat II: development of defensible manufacturing technologies for U.S. leadership by reducing manufacturing costs through innovations in manufacturing technology.	• SolarMAT III: development of solar manufacturing technologies, such as supply chain R&D, to support U.S. manufacturing. • Incubator round 10: early-stage assistance to help small business commercialize innovative solar technologies. • SunPath II: supporting the initial ramp up to pilot-scale manufacturing of innovative new manufacturing processes and tools. • Massively Parallel Combinatorial Process Development for Competitive Manufacturing: to rapidly screen and optimize processes to enable competitive U.S. manufacturing. • PV Manufacturing Initiative: a consortia of industry and university partners and multi-user manufacturing development facilities to speed the implementation of new cutting edge technologies in industry manufacturing processes.	• The funding increase is due to more ambitious manufacturing technology and commercialization projects as the solar industry matures in the U.S. Through cost-sharing requirements, the funds will be leveraged by private capital as well as investments at state and local governments. With demand for solar at a record high in the U.S. and globally, and solar job growth in the U.S., there is opportunity for U.S. businesses to capture a greater portion of the global solar value chain. The funding increase also represents the Incubator activity being transferred to and fully encompassed within the IM program, a better fit as the industry evolves.

Solar Energy
NREL Site-Wide Facility Support

Description

In FY 2015, EERE will continue to 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. This practice is consistent with other National Laboratories. EERE began this practice in FY 2014 to reduce NREL's labor rate multiplier, thereby reducing the cost barrier to accessing unique NREL capabilities (such as facilities and staff expertise) by industry and academia. This practice also makes site operating costs more transparent in order to facilitate cost control and planning. In FY 2014, this practice resulted in a reduction in the Lab-wide direct labor multiplier of approximately 15 percent compared to FY 2013. The proposed FY 2015 budget continues this approach. The site-wide facility support funds cover maintenance and engineering support; fire, emergency, and custodial services; general utilities; network infrastructure and licenses; environment, safety, and health support; and sustainability. By moving these costs from laboratory overhead to direct funding, EERE accelerates technology transfer and mission impact by making it easier for companies and external researchers to access NREL capabilities and expertise.

This funding supports research programs by providing basic site services, functions, and infrastructure for Site Operations, which includes: management, building operations, building and grounds maintenance, fire and emergency response, engineering and construction support, minor construction projects, Electrical Safety Program, utilities, and facilities planning support; and activities within the Sustainability and Environmental Health and Safety (EHS) portfolios. These activities and their costs are relatively fixed and only vary significantly based upon variations in commodities, construction activity, emergencies, weather patterns, etc. They are considered to be the core functions for site operations, safety, environmental compliance, and sustainability at NREL. In FY 2015, this funding will support more than 60 full time equivalents that manage and provide support for these core functions. It will also fund site-wide subcontracts such as janitorial services, refuse and recycling, and subcontracts for minor construction. Additionally, this funding will support site-wide costs associated with maintaining NREL's leadership position, such as: maintaining International Organization for Standardization (ISO), American Association for Laboratory Accreditation (A2LA), and other lab-wide accreditations, managing facilities to enable mission goals, improving sustainability, pollution prevention, waste minimization, improving energy efficiency, reducing water use, and maintaining an effective emergency management system.

The FY 2015 contribution from each program differs from the FY 2014 allocation, because EERE has developed a more precise, equitable, and economically neutral method that ensures a net-zero impact on programs' funding. For each program, the contribution to direct funding for site-wide facility support is equivalent to the estimated contribution the program otherwise would have made through overhead charges. This method is based upon each program's level of funding to NREL, adjusted to account for anomalies from capital expenditures and major subcontracts.

NREL Site-Wide Facility Support

Activities and Explanation of Changes

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs FY 2014 Enacted
NREL Site-Wide Facility Support		
• Directly fund NREL site-wide facility support costs that are not included in the Facilities and Infrastructure budget rather than continue to fund these costs in the laboratory overhead rate.	• Directly fund NREL site-wide facility support costs that are not included in the Facilities and Infrastructure budget rather than continue to fund these costs in the laboratory overhead rate.	• The delta is the result in a change in methodology used to allocate site-wide facility support contributions amongst programs. The FY 2015 value enables and directly equates to the program's estimated savings gained from the reduced labor multiplier.

Solar Energy
Performance Measures

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

	FY 2013	FY 2014	FY 2015
Performance Goal (Measure)	**Photovoltaic (PV) - Reduce the unsubsidized LCOE from PV at large scale for utility, commercial, and residential applications (cents kilowatt hour); Targets in the table represent utility-scale installations**		
Target	15 cents/kWh	13 cents/kWh	11 cents/kWh
Result	Met – 15	N/A	N/A
Endpoint Target	6 cents /kWh by 2020, cost competitive with traditional electricity sources		

Wind Energy

Overview

The mission of the Wind Energy program is to accelerate widespread U.S. deployment of clean, affordable, and reliable wind power to promote energy security, economic growth, and environmental quality. Significant improvements in cost and performance for utility scale (both land-based and offshore) wind power plant systems and distributed wind systems will be required to achieve levelized cost of energy (LCOE) parity with energy generation from traditional sources. In addition, major market barriers and challenges must be addressed to enable wind cost-competitiveness and increased deployment, including access to transmission and mitigation of radar, environmental, and permitting issues which can impact access to higher wind classes and constrain siting locations.

FY 2015 activities are targeted at continuing to lower U.S. wind power costs to become directly cost-competitive with traditional electricity sources without subsides. An integrated systems approach in technology development encompassing the entire wind power plant is necessary, as no single component or subsystem improvement will achieve the required LCOE goal. The program will continue Department of Energy (DOE) investment in high-impact innovations that industry cannot adequately address on its own are critical to lower costs, particularly in research and development of whole wind power plant performance for maximum energy production and improved reliability. Program investment to develop and maintain world class testing facilities at the National Laboratories and through industry partnerships provides a critical component in improving the reliability and lowering the technical risk of new wind turbine components and improving the availability of existing systems. The program plans to set aside 5 percent of FY 2015 program funding to fund a Wind Energy Incubator FOA to invest in higher-risk "off-roadmap" innovations and approaches that are currently too early in development to be considered by any one program portfolio activity.

Land-based wind has the ability to continue to contribute to immediate, substantial growth if cost targets can be achieved and market barriers reduced. While there are currently no U.S. offshore wind installations, the program proposes investing to leapfrog global competition with an offshore wind program focused on deep-water technologies, innovative designs, and demonstrations that address U.S.-specific challenges. The program's efforts in distributed wind are structured to enable new approaches to wind deployment on the distribution side of the electricity grid network. All three types of wind deployment — land-based, offshore, and distributed — provide significant opportunities for U.S. clean energy manufacturing competitiveness and strong demand for wind power should continue to yield a robust U.S. wind manufacturing presence.

Highlights of the FY 2015 Budget Request

To address these opportunities, requirements, and strategies, in FY 2015, the program's approach and key investments are organized around the following major thematic areas:

<u>Resource Characterization and Technology RD&T (Land, Offshore, Distributed) ($38.4 million)</u>

- Under the Resource Characterization and Technology Research Development and Testing (RD&T) subprogram, the program has developed a new R&D paradigm to optimize the performance and cost of utility-scale land-based and offshore wind plants — "Atmosphere to Electrons" (A2e). A2e is an integrated research plan targeted towards the better understanding of the complex wind resource, improving the wind plant performance and reliability, and developing transformational technology innovations all within the context of integrated, multi-turbine, multi-megawatt wind power plants.
- The program will provide $3.2 million to continue development of distributed wind technology development to help maintain and expand U.S. manufacturing and will support progress towards improved characterization of highly turbulent wind resources, component innovation, system optimization, improved manufacturing, and product certification for distributed wind systems.
- The program will focus on characterization and analysis of the effect of atmospheric inflow conditions and turbine wake interactions. The field data and testing campaign for the "Wind Forecast Improvement Project (WFIP) 2.0" in complex terrain will come to a close and the full analysis to learn, understand, and model the physics of the atmosphere driving the wind resource will be the focus starting in FY 2015. Models will be improved to allow for forecasts of wind events instead of waiting for wind events to develop, tracking them,

and then giving short to little notice to wind plant owners and operators. This improved information will help plant operators make more timely operating decisions, enabling LCOE reductions. After wind forecasting is better understood, the reliability of the forecasts will increase and markets can then trade with reduced risk and with added confidence for all scales of wind from large wind plants onshore and offshore to the distributed wind systems throughout the grid.

- Data will be collected in field tests at the "Scaled Wind Farm Technology Facility" (SWiFT) at the Reese Technology Center in Lubbock, Texas and at the NREL National Wind Technology Center (NWTC) to study inflow, wake effects, and feed-forward control system architectures.

Technology Validation and Market Transformation ($42.6 million)

- The program will provide mechanisms that facilitate demonstration and validation of newly developed technical advances and methodologies in order to fully realize the intended impact of DOE investments in reducing the LCOE. These mechanisms include field demonstration projects; joint initiatives with industry to integrate innovative components into commercial products; and proactive engagement with industry and academia on technical advances, for instance through training on new design and analysis tools, and high profile forums on key topics.
- In FY 2015, the program will provide $42.6 million through the Offshore Wind Advanced Technology Demonstration Project FOA to support the establishment of a competitive U.S. offshore wind industry through offshore system development and demonstration.

Mitigate Market Barriers ($17.2 million)

- Operational wind forecasting tool development will provide support to the users to understand the confidence of the forecast as differing weather events carry higher or lower degrees of confidence with the forecast — as added information content in the forecast product. The program will continue its efforts in analysis and improved forecasting to continue to push forward the industry and increase the pace of deployment for land, offshore and distributed wind.
- The program will address public concerns such as land use conflicts (particularly with radar) and wildlife through analysis of impacts and development of solutions.
- Through offshore wind demonstration projects and distributed wind activities, the wind permitting system will be exercised and better understood, allowing streamlining of the permitting process.
- The program will support the development of new tools that better represent the variability and uncertainty of renewable non-dispatchable generation sources to system dispatchers through the development of stochastic dispatch tools that account for a variety of wind plant system states. The program will coordinate with the Solar Energy Technologies program and the Office of Electricity Delivery and Energy Reliability (OE) to support the development of such tools and to feed into OE's efforts in this area, on which more information can be found in OE's FY 2015 budget request under "Grid Planning Tools".
- The program will continue to evaluate the evolution of power system operating reserves in the context of variable wind power generation to help ensure economic operation. This will be accomplished through studies that provide more thorough evaluation and calculation of new types of reserves products such as flexibility reserves at the wind power plant which can be dynamically controlled in response to forecasted power system states. This effort will be coordinated with OE as to ensure efforts between the two programs are complementary and not duplicative.
- The program will continue to conduct a variety of wind integration studies to improve the understanding of power system operational impacts imposed by the deployment of increasing penetrations of wind power into the power system and to inform the development of wind plant technologies to better address these impacts. This effort will be coordinated with OE to ensure efforts between the two programs are complementary and not duplicative.

Key Opportunities

- Wind energy accounts for nearly 5 percent of U.S. electricity supply today and has tremendous potential for growth as a domestic U.S. energy resource that can further contribute to a diverse and clean U.S. energy portfolio. According to NREL resource estimates, there are 90 quads per year of U.S. land-based wind

potential and 50 quads per year of U.S. offshore wind potential, which, combined, are more than 10 times the total current annual U.S. delivered electricity consumption.[1]

- Achieving the program's wind power LCOE goals will help the program meet its aggressive wind energy deployment goals, which includes growth from 60 GW of total cumulative U.S. wind installed capacity in 2012 to 125 GW of total capacity by 2020 and 300 GW of total capacity by 2030, which would meet an estimated 20 percent of projected U.S. electricity demand in 2030.

[1] Delivered electricity consumption does not account for transmission and distribution losses.

Figure 1: Land-Based Wind Cost Reduction Targets (at a 7 percent discount rate)

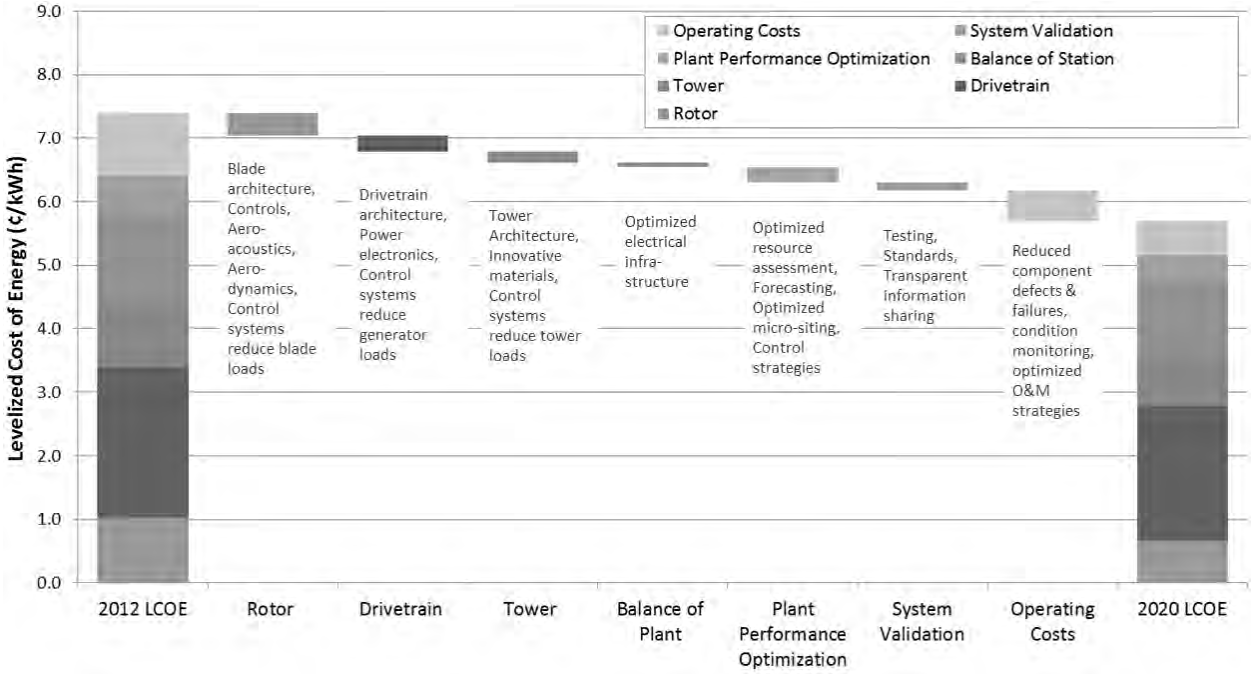
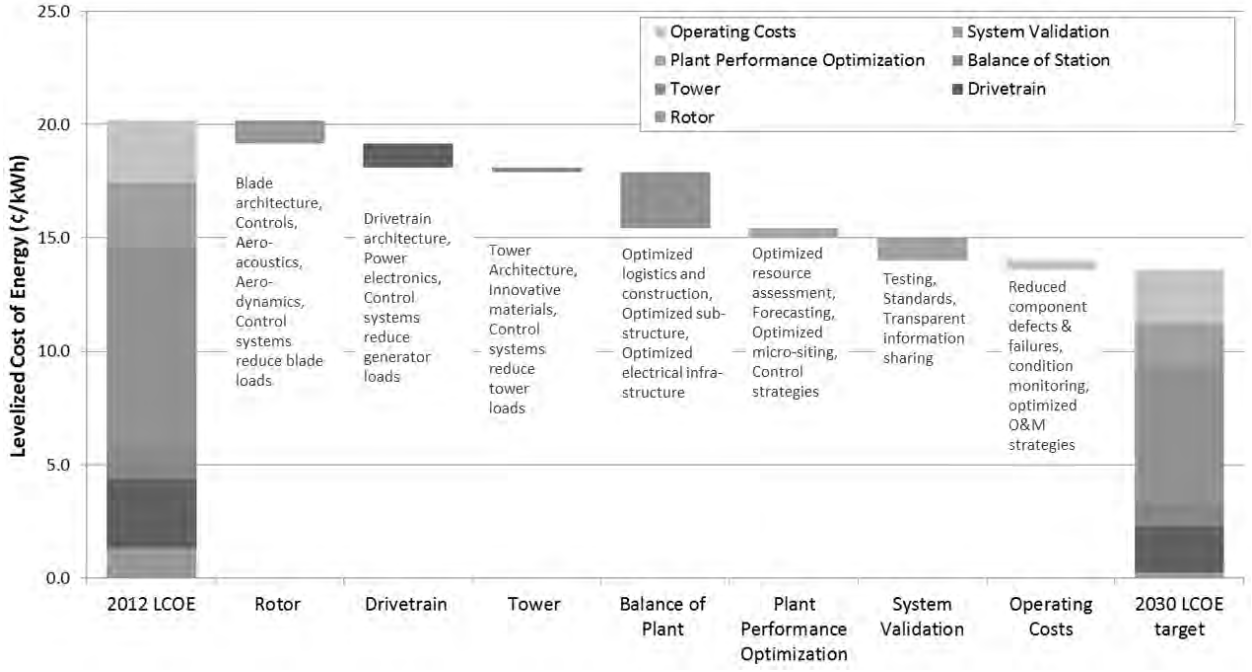


Figure 2: Fixed-Bottom Offshore Wind Cost Reduction Costs (at a 7 percent discount rate)



Wind Energy
Funding ($K)

	FY 2013 Current[2]	FY 2014 Enacted[3]	FY 2014 Current	FY 2015 Request	FY 2015 vs FY 2014 Enacted
Wind Energy					
Resource Characterization and Technology RD&T (Land, Offshore, Distributed)	0	0	0	38,416	+38,416
Technology Validation and Market Transformation	0	0	0	42,613	+42,613
Mitigate Market Barriers	0	0	0	17,209	+17,209
Modeling and Analysis	0	0	0	12,062	+12,062
NREL Site-Wide Facility Support	0	9,000	9,000	4,700	-4,300
Technology Development and Testing	62,399	61,006	61,006	0	-61,006
Technology Application	23,730	18,120	18,120	0	-18,120
Total, Wind Energy	**86,129**	**88,126**	**88,126**	**115,000**	**+26,874**

SBIR/STTR:

- FY 2013 Transferred: SBIR $1,815,000; STTR: $235,000
- FY 2014Projected: SBIR: $955,000; STTR: $136,000
- FY 2015 Request: SBIR: $1,141,000; STTR: $157,000

Wind Energy
Comparable Funding ($K)

	FY 2013 Current[4]	FY 2014 Enacted[5]	FY 2014 Current	FY 2015 Request	FY 2015 vs FY 2014 Enacted
Wind Energy					
Resource Characterization & Technology RD&T	52,939	34,409	34,409	38,416	+4,007
Technology Validation and Market Transformation	8,000	21,049	21,049	42,613	+21,564
Mitigate Market Barriers	11,301	10,129	10,129	17,209	+7,080
Modeling and Analysis	13,889	13,539	13,539	12,062	- 1,477
NREL Site-Wide Facility Support	0	9,000	9,000	4,700	- 4,300
Total, Wind Energy	**86,129**	**88,126**	**88,126**	**115,000**	**+26,874**

SBIR/STTR:

- FY 2013 Transferred: SBIR $1,815,000; STTR: $235,000

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

- FY 2014Projected: SBIR: $955,000; STTR: $136,000
- FY 2015 Request: SBIR: $1,141,000; STTR: $157,000

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

Wind Energy
Explanation of Major Changes (SK)
(Comparable Funding)

	FY 2015 vs. FY 2014 Enacted
Resource Characterization & Technology RD&T (Land, Offshore, and Distributed): The increase is due to an increased focus on high-fidelity modeling and experimental data campaigns. Funding for both the Technology Development and Market Barriers Offshore Wind Funding Opportunities completed. Reduced scope of work in Wind Forecast Improvement Project (WFIP) Phase 2.0 to include data archiving and analysis. Scaling back wind characterization and Mesoscale Dataset collection activities at the Reference Facility for Offshore Renewable Energy (RFORE) Research Facility. In FY 2015, funding for Phase I of the taller towers initiative is completed, and focus shifted to longer wind turbine blades to increase energy capture per turbine. Enhancing capabilities of the controllable grid interface at NWTC. Implementing new wake measuring instrumentation systems at the SWiFT facility. Initiating a competitive solicitation, Wind Smart Challenge, to improve local permitting and interconnection processes for distributed wind systems. The Wind Energy Incubator work scope continues ongoing efforts; there are no significant changes to the Incubator approach begun in FY 2014.	**+4,007**
Technology Validation and Market Transformation: An increase in comparable funding is due to a more capital-intensive budget period involving construction of Offshore Wind Demonstrations beginning in FY 2015, with fabrication, installation and commissioning of three offshore wind demonstration projects.	**+21,564**
Mitigate Market Barriers: The increase is due to a number of increased or new activities: Increased support for environmental research to support offshore wind permitting, in collaboration with BOEM. Increased scope for research on wind development effects on eagles, including an added emphasis on risk assessment and on-site impact avoidance and minimization measures. Increased scope for research on risk assessment and mitigation measures for sensitive bat species. Conducting a next generation wind integration study. Initiating an Offshore Wind grid impact study.	**+7,080**
Modeling and Analysis: The decrease in comparable funding is due to completion of Wind Vision Report and associated analysis activities; completion of data gathering initiative in preparation for significant LCOE model re-designs; and reduced support service at the labs and DOE headquarters.	**-1,477**
NREL Site-Wide Facility Support: The decrease is due to a change in methodology used to allocate site-wide facility support contributions amongst programs. The FY 2015 value enables and directly equates to the program's estimated savings gained from the reduced labor multiplier.	**-4,300**
Total, Wind Energy	**+26,874**

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

Description
The Resource Characterization and Technology RD&T (Land, Offshore, Distributed) subprogram consists of all program activities—from conceptual design to manufacturing process development to testing at scale – that are directed to improve wind component, system, and plant technologies for land-based, offshore, and distributed wind systems. To achieve the program's LCOE goals, which are for both land-based and offshore wind power to be cost-competitive with traditional sources of electricity generation without subsidies, the subprogram's efforts must extend beyond individual wind turbine component improvements into optimizing overall wind power plant performance and operations. Overall wind power plant performance improvements require a new suite of advanced modeling algorithms and software (requiring use of High Performance Computing, or HPC) for both boundary layer meteorological interactions impacting the area and the wind plant as a whole, as well as within the wind plant turbine-to-turbine interactions. The subprogram plans to address this multifaceted optimization challenge by developing new technology solutions currently unavailable to industry. Interagency data sharing, such as with the National Oceanic and Atmospheric Administration (NOAA), is essential to this effort as well. New wind turbine design models and controls approaches will need to take advantage of advancing insights into improving plant performance efficiency, which is one of the key drivers to reducing LCOE. Fully integrated systems engineering models, which empower full-system alternatives analysis for informing design reviews and prioritizations, are critical to the next generation of high-performance wind power plants.

In FY 2015, Resource Characterization and Technology RD&T (Land, Offshore, Distributed) subprogram activities will focus on the following key RD&T topics:

<u>Atmosphere to Electrons (A2e) ($14.4 million)</u>
Plant performance optimization activities will seek to understand the complex flow of the resource encountered by a wind turbine and the wake effect it imposes on surrounding turbines in order to more effectively operate the plant and improve the energy output of land and future offshore deployments. Research shows that wind plant losses due to wake effects can be as much as 20-30 percent. The A2e effort is aimed at better understanding the physics, identifying opportunities to reduce losses, and developing solutions to mitigate loss effects. The program will support the development of detailed product design tools, which will be used by industry, government, and universities to model both (1) the physics prior to the wind resource impacting the wind plant and creating aerodynamic inflows and (2) the wind turbine dynamic structural response for specific design implementations. Stakeholders will use these tools to integrate new designs into wind turbines in a simulation model in order to predict the impact of these innovations on performance. Research on advanced materials and components will enable new architectures for larger, light-weight turbines that reduce overall mass (reducing costs), provide access to better wind resources (larger rotors, taller towers), and improve systems performance (capacity factor). Additionally, improvements in turbine cost, strength, weight, and fatigue resistance aim to reduce O&M costs and reduce the failure rate for large components, such as blades, gearboxes, and generators. Through technology components R&D activities that provide better understanding of turbine loading and response, the subprogram provides a unique coordination role to help develop codes and standards for new turbine designs that enter the market. Wind plant performance optimization will also include analysis of existing best practices currently deployed.

<u>Offshore Specific Wind RD&T ($4.0 million)</u>
Consistent with the DOE and Department of Interior's National Offshore Wind Strategy, subprogram funding will support research including innovative fixed and floating substructure concepts, and the development of an offshore meteorology reference facility to drive instrumentation validation and model improvement.

<u>Resource Characterization ($4.6 million)</u>
A fundamental component needed to support the new A2e effort is the characterization and understanding of the inflow, wake and interaction of wind turbines for both land based and future offshore deployments. This requires testing that enables the collection of comprehensive data sets from scaled and full-scale operating wind turbines. The program will continue to support developments to improve the forecasting of wind power. This will be accomplished through continued improvements to foundational atmospheric models such as the Wind Resource Forecasting (WRF) model, the High-Resolution Rapid Refresh (HRRR) model, and others to provide the wind industry and other stakeholders with timely information. Additionally, the program will also continue the deployment of atmospheric measurement systems to enhance the information underlying the improvement of physics based knowledge of the atmosphere from those

observations. They will provide the necessary knowledge to improve the characterization of the physical drivers of the wind field impacting the wind plants. The program will continue to improve understanding of how forecast information is presented to system operators with: (1) a forecast in a form that can be used for decision support; (2) a range of probable outcomes of the forecast; and (3) an indicator as to the confidence in the forecast to relate to the user if the forecast is highly likely to occur or what may happen to make the forecast go in a different direction. (These efforts will be coordinated with OE efforts on development of system visualization for power system operators.)

Manufacturing Competitiveness ($3.5 million)

Wind-specific manufacturing R&D funding, complementary to EERE's Clean Energy Manufacturing Initiative (CEMI), seeks to enable much larger turbines for both land-based and offshore wind markets. This will include the designs, materials, and manufacturing processes to overcome existing transportation barriers and fabricate very large modular or onsite blades, towers, and generators. Specific R&D avenues include new composites applications, resins, automation processes and tools, and onsite assembly techniques.

Testing Infrastructure ($3.2 million)

Continued operation of world class testing infrastructure will provide a wide breadth of testing and research capabilities for all market segments. The program will continue to support its existing full scale, accredited test facilities and test engineers capable of developing test methods are critical for supporting U.S. wind energy innovation and cost of energy reductions. The test infrastructure supports wind turbine design testing and wind turbine component and system research. Additionally, the program supports test infrastructure needed to better understand turbine-to-turbine interaction at the SWiFT Facility.

Distributed Wind ($3.2 million)

At the end of 2012, U.S. wind turbines in distributed applications reached a 10-year cumulative installed capacity of more than 812 MW from more than 69,000 units across the U.S. and its territories. Domestic sales from U.S. small wind suppliers accounted for 86 percent of the U.S. small wind market in 2012, up from 80 percent in 2011, and supports U.S. workers in distributed wind manufacturing, retail, operations and maintenance jobs. The global market for small wind turbines is projected to double in next five years to more than 180 MW.[4] To capture the opportunities of this expanding market, an increased focus in distributed wind will support progress towards improved characterization of highly turbulent wind resources, component innovation, whole system optimization, improved manufacturing, and product certification. Development of a program strategy for distributed wind will begin in FY 2014 and be leveraged to help maintain and expand U.S. manufacturing.

Wind Energy Incubator ($5.5 million)

EERE's Incubator activities are an expansion of an already-proven innovative program that EERE's Solar Energy Technologies program piloted with a specific focus on partnering with businesses and researchers to bring "off-roadmap" impactful new technologies into the EERE portfolio. These awards have provided early-stage assistance to help businesses and researchers to shorten the time between laboratory-scale proof of concept and prototype development and to cross technological barriers to commercialization while encouraging private sector investment. Based upon this highly successful model, the Wind Energy program will continue to invest in a Wind Energy incubator activity in FY 2015.

[4] Navigant Research, first quarter 2013 Small Wind Power report.

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

Activities and Explanation of Changes

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs FY 2014 Enacted
Resource Characterization and Technology RD&T (Land, Offshore, Distributed)		
Atmosphere to Electrons (A2e) ($0) [Comparable: ($12,312,000)] In FY 2014, the following work scope will be conducted within the Technology Development and Testing subprogram: • Wind plant performance optimization R&D activities that will seek to understand the complex flow of the resource encountered by a wind turbine and the wake effect that a wind turbine has on surrounding turbines in a real world environment (SWiFT and NWTC). • Advanced component development (technology components R&D) focused on plant optimization and improvements in turbine cost, strength, weight, and fatigue resistance aimed at reducing O&M costs and reducing the failure rate for large components such as blades, gearboxes, and generators. • Completion of a multi-year plan to address plant optimization issues and annual energy production (AEP) losses. • Development of an R&D initiative around Complex Flow issues and its impacts on Component and Systems Design.	*Atmosphere to Electrons (A2e) ($14,454,000)* • Continue complex aerodynamics R&D and testing campaigns to determine the effect of wakes on plant performance. • Develop innovative control algorithms to optimize overall plant performance; innovative rotor development to explore aeroacoustic emissions reductions, advanced blade architectures, and active blade control to increase energy capture at low cost; and development of design tools capable of modeling wake losses and 3-D flow effects. • Include multi-disciplinary analysis and optimization in systems engineering models to simulate complex systems interaction and comprehensive cost models to determine O&M costs and LCOE impacts of technology pathways. • Continue scaled-wind farm testing of the turbine performance and operational loads associated with innovative technologies and designs (SWiFT). • Provide leadership in development of next generation design standards for utility turbines, taking into account better understanding of turbine loads encountered in wind farms. • Collect operational turbine data to identify causes for component failures & develop mitigation approaches and assess the effectiveness and benefits of the Continuous Reliability Enhancement of Wind (CREW) database, which collects data from operational wind farms to identify root causes of turbine downtime.	*Atmosphere to Electrons (A2e) (+$14,454,000)* [Comparable: (+$2,142,000)] • Implementing A2e initiative with increased focus on high-fidelity modeling and experimental data campaigns.

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs FY 2014 Enacted
	• Begin joint collaborative simulation model development, verification, and validation of high-fidelity, physics-based atmospheric and wind plant models to characterize complex atmospheric inflow conditions and wake array losses.	
Offshore Wind RD&T ($0) [Comparable: ($4,369,000)] In FY 2014, the following work scope will be conducted within the Technology Development and Testing subprogram: • Advanced Technology Demonstration FOA Mortgage. • Offshore Market Barrier Removal FOA Mortgage. • Offshore Technology Development FOA Mortgage. • Offshore Wind R&D focused on structural modeling and loads analysis. • Offshore Wind Offshore Demonstration Project instrumentation planning. • Focused R&D effort on Offshore Wind Structural Health Monitoring (SHM). • R&D Initiative on Large Rotor (100 meter) Development for Offshore Wind Turbines. • Focused R&D effort on Sediment Transport.	*Offshore Wind RD&T ($4,048,000)* • Development and validation of open-source models for different substructure types used in offshore foundations and participation in formulation of design standards for a wide range of offshore technology applications. • Developing and implementing unified data collection and analysis plans to maximize impact of demonstration projects, offshore meteorology reference data, and industry investments on technology performance and resource prediction. • Work with NOAA Hurricane Hunters to analyze the implications of data from extreme weather events for offshore wind plants. • Developing test best-practices to inform offshore data, metadata and field campaign efforts at SNL and NREL.	*Offshore Wind RD&T (+$4,048,000)* [Comparable: (-$321,000)] • Funding for both the Technology Development and Market Barriers Offshore Wind Funding Opportunities completed. • Key programmatic focus on the Offshore Wind Advanced Technology Demonstration projects.
Resource Characterization ($0) [Comparable: ($6,689,000)] In FY 2014, the following work scope will be conducted within the Technology Application subprogram: • Analysis effort to characterize Mesoscale Datasets for use as a tool to predict power production. • Initiative to develop InFlow Characterization Tools. • Support for the development of a mobile	*Resource Characterization ($4,561,000)* • The Wind Forecasting Improvement Project (WFIP) Phase 2.0 will analyze data gathered in FY 2014 and continue in FY 2015. This project is targeted at better understanding atmospheric phenomenon in complex terrain, compared to and coordinated with WFIP 1.0. Data will be archived into a common format for comparison for present and future research efforts. Standards for wind measurements will be introduced as part of the lessons learned for the	*Resource Characterization (+$4,561,000)* [Comparable: (-$2,128,000)] • Reduced scope of work in Wind Forecast Improvement Project (WFIP) Phase 2.0 to include data archiving and analysis. • Scaling back wind characterization and Mesoscale Dataset collection activities at the Reference Facility for Offshore Renewable Energy (RFORE) Research Facility.

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs FY 2014 Enacted
Advanced Doppler Radar at Texas Tech University for use in conjunction with SNL R&D efforts at the SWiFT Facility. • Funding Opportunity Announcement focused on Resource Data Collection and Analysis.	wind industry to adopt. The program's complex flow resource analysis efforts will integrate with WFIP to take information from the foundational models and drive the work on the Large Eddy Simulation (LES) models scales. This will be a major breakthrough as the analysis from the scale of models working on multi-state to 3 kilometer level is not passed in real time to the LES scale models.	
Manufacturing Competitiveness ($0) [Comparable: (*$2,638,000*)] In FY 2014, the following work scope will be conducted within the Technology Development and Testing subprogram: • Begin manufacturing initiative to address logistical and transportation constraints, thus enabling very large turbines that access better wind resources, lower energy costs, and can improve domestic manufacturing competitiveness. The initial focus will be very tall wind towers (120 meters and above) to access higher quality wind. This initiative builds on an FY 2013 request for information (RFI) and national laboratory study. • Focused trade flow analysis on wind energy system components. • Initiative focused on carbon fiber analysis for use in wind turbine systems. • Development of a focused initiative on manufacturing of large rotors to be launched in FY 2015. • Focused R&D initiative around the effects of manufacturing defects on component design. • Complete Offshore Wind Manufacturing & Supply Chain Development Report and disseminate to interested stakeholders.	*Manufacturing Competitiveness ($3,500,000)* • Continue manufacturing initiative to address transportation and logistics barriers of very large (~100 meter) turbine blades, including segmented or on-site manufacturing technologies. • Continue CEMI-related analysis to detail domestic and foreign trade flows of wind turbine components (blades, towers, generators, etc.) to inform future investments. • Continue focus on effects of manufacturing defects as part of the blade reliability collaborative (BRC). • Continue efforts to investigate, by supporting tests at the sub-blade component level, how wind-specific carbon fiber composites may be developed and utilized by industry.	*Manufacturing Competitiveness (+$3,500,000)* [Comparable: (+$862,000)] • In FY 2015, funding for Phase I of the taller towers initiative is completed, and focus shifted to longer wind turbine blades to increase energy capture per turbine.

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs FY 2014 Enacted
Testing Infrastructure ($0) [Comparable: ($1,659,000)] In FY 2014, the following work scope will be conducted within the Technology Development and Testing subprogram: • Support for the NREL 5MW Dynamometer Integrated Systems Test. • Funding for O&M/Site Safety at NWTC and SWiFT (site equipment, environmental compliance, safety and accreditation). • Support for the Clemson 15MW Dynamometer and Massachusetts Large Blade Test Facilities. • Support development of a data collection system for the Clemson Grid Simulator. • Support for the RFORE Offshore Wind Resource Characterization Reference Facility.	*Testing Infrastructure ($3,162,000)* • Perform capital and site equipment improvements and environmental compliance and safety support for NREL's NWTC facilities, including the existing blade structural test facility, 225kW, 2.5MW and 5.0MW dynamometers, and 7.0MVA Controllable Grid Simulator. These facilities will support development of innovative blade testing methodology, wind turbine controls testing, and full-scale field testing of utility scale wind turbines. • Perform industry testing of drive trains using the 5MW dynamometer facility which was commissioned in FY 2014. The dynamometer produces the huge forces needed to test the new generation of larger wind turbines and builds on the capabilities of the NWTC 2.5MW dynamometer to meet drive train testing needs of industry. • Support the development of blade and drive train test procedures and methods through partnerships with the Massachusetts blade test facility and the Clemson drive train facility. These state of the art facilities have unique testing capabilities and are sized to support the trend toward larger wind turbines for both utility scale and offshore wind. • Enhance the capabilities of the controllable grid interface at NWTC, a critical test capability which allows industrial users and researchers to subject wind turbine drivetrains to severe electrical power anomalies in a safe, controlled, laboratory environment. The controllable grid interface provides the capability to conduct grid fault tests in compliance with international standards at significantly reduced time and cost when compared to field testing.	*Testing Infrastructure (+$3,162,000)* [Comparable: (+$1,503,000)] • Enhanced capabilities of the controllable grid interface at NWTC. • Implement new wake measuring instrumentation systems at the SWiFT facility.

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs FY 2014 Enacted
	• Implement new wake measuring instrumentation systems at the SWiFT facility capable of measuring airflows at the wind turbine and wind plant level using systems such as high spectral resolution imaging lidars and mobile research radars. Data from field measurement campaigns will be used to better understand and address wind turbine design and wind plant performance characteristics. Partner with industry to instrument SWiFT test turbine components to better understand wind turbine array effects on wind turbine design and loading. • Continue development of a Reference Facility for Offshore Renewable Energy (RFORE). The facility will serve two primary purposes. The first is to provide reference measurements for the validation of new measurement technologies for renewable wind and Wind Energy resource assessment and characterization in the marine environment. The second is to enable research to fill knowledge gaps that degrade the ability to adequately describe and predict characteristics of the marine environment that affect the design, installation, and operation of offshore renewable energy facilities.	
Distributed Wind ($0) [Comparable: ($2,242,000)] In FY 2014, the following work scope will be conducted within the Technology Development and Testing subprogram: • Continuation and expansion of the Distributed Wind Competitiveness Improvement Program (CIP) to improve component design, develop improved manufacturing processes and promote system certification. • Continuation of Built Environment Wind Turbine R&D .	*Distributed Wind ($3,191,000)* • Leverage FY 2014 Distributed Wind Deployment System (DWDS) deployment modeling capability to proceed with scenario modeling and program vision plan development. Provide leadership by continuing to develop a strategic vision and roadmap for a competitive U.S. distributed wind industry. Identify pathways to achieve targeted performance and deployment. • Leverage FY 2014 wind data collection to: (1) develop a low-cost site assessment tool ("virtual met tower") to accurately estimate the wind	*Distributed Wind (+$3,191,000)* [Comparable: (+$949,000)] • Initiate a competitive solicitation, Wind Smart Challenge, to improve local permitting and interconnection processes for distributed wind systems.

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs FY 2014 Enacted
• Development of standards for small wind turbine loads analysis. • Completion of the Annual Distributed Wind Market Report. • Planning for the Wind SMART Challenge. • Development of Computer Aided Engineering Tools for small wind turbine development.	resource potential in distributed wind applications and reduce underperformance in order to improve stakeholder confidence; and (2) develop and validate new design tools for distributed wind applications operating in highly turbulent urban environments. • Leverage FY 2014 vertical axis wind turbine (VAWT) code development to validate new small wind turbine load cases and design standards. • Continue lab run competitive solicitation to develop and test innovative, next-generation small and midsize wind technology. • Continued market data collection, analysis, and reporting for performance tracking and to inform program strategy. • Initiate a competitive solicitation, Wind Smart Challenge, to improve local permitting and interconnection processes for distributed wind systems. The objective of the Wind Smart Challenge is to engage state and local governments and utilities in a collaboration to develop and implement innovative permitting and interconnection processes for the purpose of eliminating market barriers and reducing soft (non-hardware balance of station) costs. Achieving the end goal of implementing streamlined processes will make it faster and cheaper for homeowners, businesses, and communities to deploy distributed wind systems in high impact markets.	

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs FY 2014 Enacted
Wind Energy Incubator ($0) [Comparable: ($4,500,000)] In FY 2014, the following work scope will be conducted within the Technology Development and Testing subprogram: • Specific focus on partnering with businesses and researchers to bring "off-roadmap" impactful new technologies into the Wind Power portfolio.	*Wind Energy Incubator ($5,500,000)* • Specific focus on partnering with businesses and researchers to bring "off-roadmap" impactful new technologies into the Wind Power portfolio. The Wind Energy program will continue to invest in a Wind Energy incubator program in FY 2015.	*Wind Energy Incubator (+$5,500,000)* [Comparable: (+$1,000,000)] • The work scope continues ongoing efforts; there are no significant changes to the Incubator approach begun in FY 2014.

Wind Energy
Technology Validation and Market Transformation

Description
The Technology Validation and Market Transformation subprogram seeks to demonstrate and validate new wind energy technologies—for land-based, offshore, and distributed applications—in the U.S. In FY 2015 the focus is on overcoming the significant hurdles faced in building a U.S. offshore wind industry. The U.S. offshore wind industry is in its very early stages, with no commercial scale offshore wind turbines having yet been installed in the nation's waters. In order to succeed, industry must be able to show that offshore wind generation can be cost-competitive within the unique and regionally-diverse physical and market constraints of the U.S. In additional to cost, challenges include extreme wind and wave events such as hurricanes, technology refinement for U.S. waters operating conditions, development of efficient port and manufacturing infrastructure, reduction of permitting timelines, performance validation to reduce financing risks, and other market barriers.

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

In early 2011, the Secretaries of Energy and Interior jointly released the "National Offshore Wind Strategy: Creating an OSW Industry in the United States". Based on extensive public and Federal input, the Strategy presents a long-range plan of key activities to address the full set of risks and challenges facing offshore wind. In 2012, the Department announced funding to seven offshore wind energy technology demonstration projects as well as its plan to down-select to three projects in 2014. Through a set of cooperative agreements providing funding, technical assistance, and inter-agency coordination to accelerate the implementation of these projects, the program intends to validate new technologies to reduce costs through innovative designs for deep-water resource areas, eliminate uncertainties by tackling large-scale market and permitting barriers, and demonstrate innovative technologies that address key local concerns (e.g., marine mammal protection and electro-magnetic interference (EMI)) to support growth of a robust offshore wind energy industry. Projects are required to be grid-connected and producing power by the end of 2017.

<u>Advanced Technology Demonstration ($42.6 million)</u>
The DOE Advanced Technology Demonstration activity will be funded at $42.6 million in FY 2015 to provide important evidence to the global market — from financiers to original equipment manufacturers to engineer-procure-construct contractors to utilities — that offshore projects in the U.S. can actually be realized despite the challenges identified above, especially the need for technology optimized to U.S. conditions that provide a pathway to meet LCOE goals.

All of the projects will be well-instrumented and required to collect data for five years post-commissioning, which will be leveraged by the program to establish a U.S.-specific performance baseline, inform improvements to design codes and standards, and identify further opportunities for technology refinement. By working through regulatory processes in both state and Federal waters, DOE, in coordination with appropriate sister agencies, can overcome uncertainties by quantifying and reducing the risks and timelines associated with permitting and siting. Broad inter-agency collaboration with the DOE offshore wind effort is enabling areas of improvement and lessons-learned to be acted upon for the benefit of future projects.

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

Technology Validation and Market Transformation

Activities and Explanation of Changes

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs FY 2014 Enacted
Technology Validation and Market Transformation		
In FY 2014, the following work scope will be conducted within the Technology Application subprogram: • Completion of the down-select process for final award, design and development of up to three offshore wind projects. • Completion in FY 2014 of NEPA processes approval of Construction and Operations Plans and completion of all necessary grid interconnection requirements under Offshore Wind Demonstration FOA.	• 100 percent front-end engineering design and installation reports from three Offshore Wind Technology Demonstration projects, including design review of proposed technologies and computational simulation models, and independent verification of cost factors determining LCOE. The reports will detail the relevant innovations and provide pathways toward deepwater deployment of offshore wind systems. • Complete the environmental and permitting process for three Offshore Wind Technology Demonstration projects that provide timelines to commissioning in the 2017 timeframe. • Fabrication, installation and commissioning of three Offshore Wind Technology Demonstration projects.	In FY 2015, all work scope was moved to this new activity: • The work scope continues ongoing efforts. An increase in comparable funding is due to a more capital-intensive budget period involving construction of Offshore Wind Demonstrations beginning in FY 2015, with fabrication, installation and commissioning of three offshore wind demonstration projects.

Wind Energy
Mitigate Market Barriers

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

In FY 2015, subprogram activities will continue to focus on (1) improving the understanding of risks to sensitive wildlife species to better inform regulatory and permitting decision makers; (2) research to develop solutions to wind turbine-radar interactions; (3) developing tools and analysis that better describe wind plants for grid system planning and grid operations analysis purposes; (4) education and outreach to disseminate information and promote public understanding of wind technologies; and (5) engagement with permitting agencies to promote regulatory efficiency and ensure viable regulatory pathways for evolving technology.

<u>Addressing Market Barriers ($17.2 million)</u>
Market barrier reduction activities will focus on mitigating wildlife impacts and siting concerns (e.g., radar), developing a well-trained workforce, and accelerating the development of wind energy markets by helping stakeholders and officials understand wind energy technologies and how wind can be integrated into their local, state, and regional energy system. Specific activities include the following:

- Develop wind turbine-radar interaction solutions, which seek to mitigate electromagnetic interference and enable industry to identify and employ mitigation technology and/or techniques.
- Develop wildlife impact mitigation monitoring and mitigation tools to facilitate environmentally responsible deployment of wind technologies. The program will continue a focused multi-year effort to support the research necessary to ensure wind-wildlife interactions – including Bald and Golden Eagles, bats, and prairie grouse – are considered and addressed effectively in permitting.
- Continue an interagency initiative assessing the environmental impacts of the first installed U.S. offshore wind projects as necessary to support NEPA and other environmental permitting of future commercial offshore wind energy facilities.
- Wind power specific grid-integration activities, will include the development of active power controls for turbines, next generation studies and analysis tools that expand understanding wind plant interactions with the power system.
- Support the development of stochastic system dispatch tools that better represent wind power variability and uncertainty. (This will be coordinated with related efforts in OE).
- Continue evaluation of new types of power systems reserves integrated into wind power plants that are better suited to support high penetrations of variable wind power generation. As an example a product called "flex reserves", which would be dynamically controlled at the wind plant, will be evaluated that allows for adjustments in the amount of generation held in reserve and is adjusted based on forecasted wind conditions. (This will be coordinated with related efforts in OE).
- Continue work with various partners and agencies to promote fact-based information and education on wind topics via continued to support Regional Resource Centers (RRCs).
- Support development of tomorrow's wind energy workforce through the Collegiate Wind Competition (CWC).

Mitigate Market Barriers

Activities and Explanation of Changes

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs FY 2014 Enacted
Mitigate Market Barriers		
Addressing Market Barriers In FY 2014, the following work scope will be conducted within the Mitigate Market Barriers subprogram: • R&D focused on the completion of land-based radar RCS mitigation activities. Publish final report on land-based wind energy-radar mitigation technologies. • Completion of Integration Studies and Generator Modeling for Grid System Planning. • Initiation of Distributed Wind Generation integration studies. • R&D on eagle impacts and mitigation measures, including support for a collaborative Wind-Eagle Research initiative. • R&D on development of effective bat deterrent technologies to reduce mortality risks around wind turbines. • Development of advanced monitoring tools and technologies to accurately assess potential wildlife impact risks at offshore and land-based wind farms. • R&D in collaboration with the Bureau of Ocean Energy Management (BOEM) on environmental risks to support offshore wind permitting. • Develop new information resources, such as wind resource maps that account for new low-wind speed technologies that are opening up significant opportunities for development in previously non-viable markets such as the Southeast. • Support to develop a network of Wind RRCs to ensure that decisions are informed by the best	*Addressing Market Barriers* • Radar Mitigation - the subprogram will continue to work in close collaboration with Federal agencies (DOD, DHS, and FAA) on the development and deployment of technologies that mitigate the effects of wind turbines on long range surveillance and airport radars. DOE will also deploy a wind farm modeling tool for wind farm developers and government agencies so that wind turbines can be sited without causing interference when in the line of sight of radar sensors. • Wildlife Impact Research and Mitigation. To facilitate environmentally responsible deployment of wind technologies, the program will continue a focused multi-year effort to support the research necessary to ensure wind-wildlife interactions are considered and addressed effectively. In FY 2015, the subprogram will: ▪ Continue funding wind-eagle research to refine risk assessment methods, assess and refine advanced conservation practices, and evaluate compensatory mitigation methods to facilitate efficient permitting. ▪ Assess development of effective bat deterrent technology options and continue R&D into innovative methods for detecting and mitigating wildlife impacts at wind facilities. ▪ Continue investments in risk and impact assessment to enable responsible, low-impact, co-location of wind farms in eagle,	*Addressing Market Barriers* • Increased support for environmental research to support offshore wind permitting, in collaboration with BOEM. • Increased scope for research on wind development effects on eagles, including an added emphasis on risk assessment and on-site impact avoidance and minimization measures. • Increased scope for research on risk assessment and mitigation measures for sensitive bat species. • Conduct a next generation wind integration study • Initiate an Offshore Wind grid impact study.

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs FY 2014 Enacted
available science around wind energy. • Initiate the CWC to provide wind-related experience to undergraduate students in engineering, business, and social science disciplines. • Development of objective stakeholder engagement and technical assistance tools to inform consideration of wind deployment. • Develop analysis and recommendations to overcome critical regional barriers to wind deployment. • Complete three-year survey of baseline environmental conditions in mid-Atlantic Offshore Wind Energy Areas. • Develop interagency offshore wind Real-time Opportunity to Develop Environmental Observations (RODEO) effort.	bat, and prairie grouse habitat. ▪ Offshore Wind Environmental Assessment - the subprogram will continue an interagency initiative assessing the environmental impacts of the first installed U.S. offshore wind projects as necessary to support NEPA and other environmental permitting of future commercial offshore wind energy facilities: • FY 2015 work will build off of FY 2014 work to develop novel monitoring techniques and technologies and begin to aggregate environmental data gathered by developers for later development.	
	Systems Integration: In FY 2015, the subprogram will: ▪ Continue analysis of high wind-penetration scenarios to inform wind technology roadmaps for better meeting power system operational requirements. ▪ Conduct a next generation wind integration study based on a 10-year meso-scale wind resource data set ▪ Continue detailed Distributed Wind generation integration studies to better understand impacts of increased distributed wind generation on existing grid infrastructure. ▪ Initiate an Offshore Wind grid impact study to better understand the resultant impact of adding offshore generation to existing and currently planned U.S. grid infrastructure. • Engagement and Outreach. The subprogram aims to accurately portray the nature and	

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs FY 2014 Enacted
	scale of wind's impacts, and then deliver the information in clear, relevant, and actionable forms to wind stakeholders and the public. In FY 2015, the subprogram will: ▪ Continue to support RRCs and stakeholder engagement: The program will develop a new generation of information resources, such as wind resource maps that account for new low-wind speed and other technologies that are opening up significant opportunities for development in previously non-viable markets such as the Southeast. RRCs and related information resources will ensure that decisions are informed by the best available science around wind energy, helping to reduce permitting and deployment timelines and uncertainties. ▪ Continue the CWC: In FY 2015, the CWC will continue to challenge undergraduate college students to attack a multidisciplinary wind energy engineering and business problem.	

Wind Energy
Modeling and Analysis

Description
The Modeling and Analysis subprogram consists of all program activities to support crosscutting tool development and analysis to support effective, proactive annual, multi-year and multi-decade program planning and project management and assessment. Use of analysis tools—including reference models, systems engineering models, and deployment models—is critical in providing a solid basis and justification for maintaining and/or modifying project areas to support successful strategies. Analysis helps prioritize the highest impact program activities and planning helps identify needed analysis tools and improvements.

The Modeling and Analysis subprogram also includes all program activities to effectively plan, integrate, implement, and report the activities in accordance with the annual operating plan and Multi-Year Program Plan (MYPP), and to provide strategic support to the DOE Wind and Water Power Technologies Program (WWPTP) and other DOE national laboratories and technology partners supporting the program. This includes activities that support overall program communications needs and requirements and plays an important role in disseminating the success of program initiatives. Under communications, the program develops, provides, and disseminates meaningful, impactful communications that inform stakeholders of DOE's efforts in managing the public's investment in wind technologies as well as improving the performance and lowering the cost of wind power.

<u>Modeling and Integrated Systems Economic Analysis ($12.1 million)</u>
Modeling includes wind-specific estimations of electricity production cost, electric sector capacity expansion, and national energy-economy modeling activities. Specific focus areas include wind technical and economic feasibility analysis, and technology deployment analysis.

FY 2015 Modeling and Analysis subprogram activities include wind techno-economic and life-cycle assessments to help the program focus its technology development priorities and identify key drivers and hurdles for wind energy technology commercialization. In FY 2015, the program will release an integrated wind plant system model that integrates cost models with system dynamics models that will be a major improvement over the existing LCOE model currently in use. This enhanced capability will allow the program to better identify and fund technology improvement opportunities that will have a significant and more immediate impact on the wind industry. FY 2015 subprogram activities include the following:

- Market trends reporting and analysis.
- Wind cost (LCOE) and Capacity Expansion (GW) modeling and analysis.
- Impact (cost/benefit) evaluation.
- Strategic planning, including multiyear program plans (MYPP), technology roadmaps, and vision reports.
- Communications and information disclosures and program management controls.

Modeling and Analysis

Activities and Explanation of Changes

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs FY 2014 Enacted
Modeling and Analysis		
In FY 2014, the following work scope will be conducted within the Technology Application subprogram: • Completion of Wind Vision Report and all associated modeling, ReEDS runs, and policy impact studies. • Completion of data gathering and analysis in preparation for revision of the Wind Plant and Turbine LCOE Model. • Completion of the LCOE Report for Wind. • Completion of the 2013 Wind Market Report by LBNL. • Focused R&D on Offshore System Cost Analysis.	Market trends reporting and analysis: • Collection and analysis of 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 the Annual Wind Market Report that provides unbiased information to stakeholders on the health of the domestic wind market in the U.S. Wind cost (LCOE) modeling and analysis: • Technology characterization, system cost analysis and sensitivity analysis. • Develop an integrated wind plant system model that integrates cost models with system dynamics models (blade models, drivetrain models, floating platform models, etc.). This will be a first of its kind model, which will be used to link engineering metrics to the cost of energy model, thereby allowing the program to better identify Technology Improvement Opportunities. Wind deployment (GW) modeling and analysis: • Apply and improve core capacity expansion models—including ReEDS, Plexos and NEMS—to identify and leverage opportunities for accelerated wind deployment. • NREL ReEDS revised to incorporate Distributed Wind Generation estimates. • Complete the Distributed Wind Vision Report and disseminate to stakeholders for comment	In FY 2015, all work scope was moved to this new activity: • The work scope continues ongoing efforts. A decrease in comparable funding is due to completion of Wind Vision Report and associated analysis activities; completion of data gathering initiative in preparation for significant LCOE model re-design; and reduced support service at the labs and DOE headquarters.

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs FY 2014 Enacted
	and review. Impact (cost/benefit) evaluation: • Lower barriers to wind energy deployment by increasing the familiarity with variable wind generation's actual costs and benefits. • Develop and implement processes to gather, evaluate, verify, and analyze data and information regarding technical and project management performance and progress relative to the program's cost and performance goals. • Support and participate in program comprehensive wind energy project reviews. Strategic planning: • Multiyear program plans (MYPP), technology roadmaps, and vision reports.	

Wind Energy
Technology Development and Testing

Description

The Technology Development and Testing subprogram consists of all FY 2014 program activities—from conceptual design to manufacturing and testing at scale – that are directed to improve wind component, system and plant technologies for land-based, offshore and distributed wind technologies. To achieve the program's LCOE goals, which are for both land-based and offshore wind power to be cost-competitive with traditional sources of electricity generation without subsidies, the subprogram's efforts must extend beyond individual wind turbine component improvements into optimizing overall wind power plant performance and operations. Overall wind power plant performance improvements require a new suite of advanced modeling HPC for both boundary layer meteorological interactions, as well as turbine-to-turbine interactions. The subprogram plans to address this multifaceted optimization challenge by developing new technology solutions currently unavailable to industry and academia alone. Interagency data sharing, such as with NOAA, is essential to this effort as well. New wind turbine design models and controls approaches will need to take advantage of advancing insights into improving plant performance efficiency, which is one of the key drivers to reducing LCOE. Fully integrated systems engineering models, which empower full-system alternative analysis reviews and prioritizations, are critical to the next generation of high-performance wind power plants.

There is no discontinuation of existing activities as proposed in the FY 2014 budget. Activities have been realigned to a structure of four subprograms instead of two to more clearly delineate the program's activities. As described below, the program proposes that Technology Development and Testing activities be categorized under the Resource Characterization and Technology RD&T (Land, Offshore, and Distributed) and Technology Validation and Market Transformation subprograms.

Technology Development and Testing

Activities and Explanation of Changes

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs FY 2014 Enacted
Technology Development and Testing		
Testing Infrastructure ($3,914,000) • Continued operation and enhancement of world class testing infrastructure will provide a wide breadth of testing and research capabilities for all market segments.	*Testing Infrastructure ($0)* • All activities will be conducted in the Resource Characterization and Technology RD&T subprogram.	*Testing Infrastructure (-$3,914,000)* • All work has been moved to the Resource Characterization and Technology RD&T subprogram.
Distributed Wind Technology ($2,716,000) • An increased focus in distributed wind will support progress towards improved characterization of highly turbulent wind resources, component innovation, whole system optimization, improved manufacturing, and product certification.	*Distributed Wind Technology ($0)* • All activities will be conducted in the Resource Characterization and Technology RD&T subprogram.	*Distributed Wind Technology (-$2,716,000)* • All work has been moved to the Resource Characterization and Technology RD&T subprogram.
Plant Optimization ($15,806,000) • Plant performance optimization activities will seek to understand the complex flow of the resource encountered by a wind turbine and the wake effect that a wind turbine has on surrounding turbines in order to more effectively operate the plant and improve the energy output.	*Plant Optimization ($0)* • All activities will be conducted in the Resource Characterization and Technology RD&T subprogram.	*Plant Optimization (-$15,806,000)* • All work has been moved to the Resource Characterization and Technology RD&T subprogram.
Technology Components R&D ($0) • Advanced component development (technology components R&D) focused on plant optimization and improvements in turbine cost, strength, weight, and fatigue aimed at reducing O&M costs and reducing the failure rate for large components such as blades, gearboxes, and generators. No new funding for these activities in FY 2014.	*Technology Components R&D ($0)* • All activities will be conducted in the Resource Characterization and Technology RD&T subprogram.	*Technology Components R&D ($0)* • All work has been moved to the Resource Characterization and Technology RD&T subprogram.

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs FY 2014 Enacted
Offshore Wind ($30,927,000) • Completion of the down-select process for final award, design and development of up to three offshore wind projects. • Completion in FY 2014 of NEPA processes approval of Construction and Operations Plans and completion of all necessary grid interconnection requirements under Offshore Wind Demonstration FOA.	*Offshore Wind ($0)* • Activities will be conducted within both the Resource Characterization and Technology RD&T subprogram and the Technology Validation and Market Transformation subprograms.	*Offshore Wind (-$30,927,000)* • All work has been moved to the Resource Characterization and Technology RD&T subprogram and the Technology Validation and Market Transformation subprogram.
Manufacturing Competitiveness ($3,196,000) • Wind-specific manufacturing R&D funding will enable much larger turbines for both land-based and offshore wind markets. This will include the designs, materials, and manufacturing processes to overcome existing transportation barriers and fabricate very large modular or onsite blades, towers, and generators.	*Manufacturing Competitiveness ($0)* • All activities will be conducted in the Resource Characterization and Technology RD&T subprogram.	*Manufacturing Competitiveness (-$3,196,000)* • All work has been moved to the Resource Characterization and Technology RD&T subprogram.
Wind Energy Incubator ($4,500,000) • EERE's Incubator activities are an expansion of an already-proven innovative program that EERE's Solar Energy Technologies program piloted with a specific focus on partnering with businesses and researchers to bring "off-roadmap" impactful new technologies into the EERE portfolio.	*Wind Energy Incubator ($0)* • All activities will be conducted in the Resource Characterization and Technology RD&T subprogram.	*Wind Energy Incubator (-$4,500,000)* • All work has been moved to the Resource Characterization and Technology RD&T subprogram.

Wind Energy
Technology Application

Description
The Technology Application subprogram consists of all program activities to reduce the costs and timing of market barriers, including wildlife, environmental, radar, and transmission integration barriers. One of the primary objectives of this subprogram is to improve the permitting and mitigation procedures needed to address wildlife, environmental, and radar concerns. The subprogram activities decrease permitting time and costs and enable realistic capital and operating cost estimates for financing purposes.

There is no discontinuation of existing activities as proposed in the FY 2014 budget. Activities have been realigned to a structure of four subprograms instead of two to more clearly delineate the program's activities. As described below, the program proposes that Technology Application activities be categorized under the Resource Characterization and Technology RD&T (Land, Offshore, and Distributed) and Mitigate Market Barriers subprograms.

Technology Application

Activities and Explanation of Changes

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs FY 2014 Enacted
Technology Application		
Resource Characterization ($7,208,000) • A fundamental component needed to support the new A2e effort is the characterization and understanding of the inflow, wake and interaction of wind turbines. This requires the collection of comprehensive data sets from scaled and full-scale operating wind turbines (testing), that will be used to validate new, high-fidelity HPC codes.	*Resource Characterization ($0)* • All activities will be conducted in the Resource Characterization and Technology RD&T subprogram.	*Resource Characterization (-$7,208,000)* • All work has been moved to the Resource Characterization and Technology RD&T subprogram.
Grid Optimization ($4,149,000) • Development of active power controls, advanced grid integration studies, and expanded understanding of power system flexibility to develop, validate, and/or support the adoption of advanced power system operations to aid in accommodating wind energy's added variability through R&D and collaboration with industry, national laboratories, other Federal agencies and universities.	*Grid Optimization ($0)* • All activities will be conducted in the Mitigate Market Barriers subprogram.	*Grid Optimization (-$4,149,000)* • All work has been moved to the Mitigate Market Barriers subprogram.
Addressing Market Barriers ($6,763,000) • Activities will focus on the completion of land-based radar mitigation activities, the initiation of new focused research in land-based and offshore wind environmental issues, and launching regional resource centers.	*Addressing Market Barriers ($0)* • All activities will be conducted in the Mitigate Market Barriers subprogram.	*Addressing Market Barriers (-$6,763,000)* • All work has been moved to the Mitigate Market Barriers subprogram.

Wind Energy
NREL Site-Wide Facility Support

Description
In FY 2015, EERE will continue to 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. This practice is consistent with other National Laboratories. EERE began this practice in FY 2014 to reduce NREL's labor rate multiplier, thereby reducing the cost barrier to accessing unique NREL capabilities (such as facilities and staff expertise) by industry and academia. This practice also makes site operating costs more transparent in order to facilitate cost control and planning. In FY 2014, this practice resulted in a reduction in the Lab-wide direct labor multiplier of approximately 15 percent compared to FY 2013. The proposed FY 2015 budget continues this approach. The site-wide facility support funds cover maintenance and engineering support; fire, emergency, and custodial services; general utilities; network infrastructure and licenses; environment, safety, and health support; and sustainability. By moving these costs from laboratory overhead to direct funding, EERE accelerates technology transfer and mission impact by making it easier for companies and external researchers to access NREL capabilities and expertise.

This funding supports research programs by providing basic site services, functions, and infrastructure for Site Operations, which includes: Management, Building Operations, Building & Grounds Maintenance, Fire & Emergency Response, Engineering & Construction support, Minor Construction projects, Electrical Safety Program, Utilities, and Facilities Planning Support; and activities within the Sustainability and Environmental Health and Safety (EHS) portfolios. These activities and their costs are relatively fixed and only vary significantly based upon variations in commodities, construction activity, emergencies, weather patterns, etc. They are considered to be the core functions for site operations, safety, environmental compliance, and sustainability at NREL. In FY 2015, this funding will support more than 60 full time equivalents that manage and provide support for these core functions. It will also fund site-wide subcontracts such as janitorial services, refuse and recycling, and subcontracts for minor construction. Additionally, this funding will support site-wide costs associated with maintaining NREL's leadership position, such as: maintaining International Organization for Standardization (ISO), American Association for Laboratory Accreditation (A2LA), and other lab-wide accreditations, managing facilities to enable mission goals, improving sustainability, pollution prevention, waste minimization, improving energy efficiency, reducing water use, and maintaining an effective emergency management system.

The FY 2015 contribution from each program differs from the FY 2014 allocation, because EERE has developed a more precise, equitable, and economically neutral method that ensures a net-zero impact on programs' funding. For each program, the contribution to direct funding for site-wide facility support is equivalent to the estimated contribution the program otherwise would have made through overhead charges. This method is based upon each program's level of funding to NREL, adjusted to account for anomalies from capital expenditures and major subcontracts.

NREL Site-Wide Facility Support

Activities and Explanation of Changes

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs. FY 2014 Enacted
NREL Site-Wide Facility Support		
• Directly fund NREL site-wide facility support costs that are not included in the Facilities and Infrastructure budget rather than continue to fund these costs in the laboratory overhead rate.	• Directly fund NREL site-wide facility support costs that are not included in the Facilities and Infrastructure budget rather than continue to fund these costs in the laboratory overhead rate.	• The delta is the result in a change in methodology used to allocate site-wide facility support contributions amongst programs. The FY 2015 value enables and directly equates to the program's estimated savings gained from the reduced labor multiplier.

Wind Energy
Performance Measures

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

	FY 2013	FY 2014	FY 2015
Performance Goal (Measure)	**Onshore Wind- Cost of land-based wind energy (cents/kWh)**		
Target	7.7 cents/kWh	7.2 cents/kWh	6.9 cents/kWh
Result	Met – 7.7 cents/kWh	N/A	N/A
Endpoint Target	5.7 cents/kWh by 2020 4.2 cents/kWh by 2030		

Water Power

Overview

The mission of the Water Power program is to lead the Nation's efforts in developing innovative water power technologies which can provide 80 percent of U.S. electricity needs from clean energy sources by 2035. In FY 2015, the program will focus on leading-edge research, development, demonstration, and deployment (RDD&D) of innovative technologies that could generate cost-effective renewable electricity from a wide range of water power resources. These efforts, in combination with a targeted set of activities that address non-technical market barriers, will accelerate widespread deployment of clean, affordable, reliable, and domestically manufactured water power technologies that promote energy security, economic growth, and environmental quality, while simultaneously growing global market opportunities for U.S. manufacturers.

The program oversees near, mid, and long-term RDD&D efforts for both marine and hydrokinetic (MHK) and hydropower technologies. Water power systems utilize the kinetic and/or potential energy of water to generate electricity. MHK technologies capture the energy of waves and currents (e.g., tides or ocean current). Hydropower technologies capture energy contained in the Nation's vast network of reservoirs, rivers, streams, and water conveyance systems. Additionally, the hydropower portfolio includes pumped storage systems proven to provide grid-scale energy storage and other valuable ancillary services. Through a balanced portfolio approach, the program makes strategic investments in both the MHK and Hydropower subprograms, including transformational technology innovations that seek to maximize generation from water power resources and address key market deployment and environmental performance challenges. Additionally, the program invests in high-risk, early-stage technologies that, due to market considerations, the private sector is unable to address on its own.

<u>Hydropower Technology</u>

- Hydropower has been providing reliable, flexible base load power generation in the U.S. for more than a century. With 78 Gigawatts (GW) of installed capacity, hydropower accounts for 7 percent on average of all U.S. annual electricity generation, and it is the Nation's largest source of renewable electricity (representing 56 percent of all renewable energy generation in 2012). Hydropower also provides many strategically valuable ancillary benefits that are uniquely suited to support further integration of other variable renewable energy technologies. Yet, significant opportunities remain to significantly expand generation from this highly valuable resource. Key opportunities include:

- Existing Water Resources Infrastructure: There is significant opportunity to cost-effectively improve performance and increase generation of existing hydropower facilities. Previous DOE investments under the American Recovery and Reinvestment Act in this area led to significant improvements in generation—between 12 percent and 37 percent—as a result of modernized, more efficient equipment installed at these sites.
- New Stream-Reach Development: A recently completed study of more than 3 million stream-reaches in the U.S. shows that a tremendous opportunity exists for new hydropower development in stream segments that do not currently have hydroelectric facilities. These new hydro development opportunities show a resource potential between 60-80 GW.
- Pumped-Storage Hydropower (PSH): Worldwide, PSH is a proven and successful grid-scale energy storage and grid reliability solution. It is called upon to cost-effectively provide a wide range of ancillary benefits and facilitates the integration of other variable generation resources, and its flexibility enables large thermal generating sources to operate at optimum conditions. Although there are 22 GW of installed capacity in the U.S. today, PSH has been slow to achieve wide-scale domestic acceptance and adoption. Most U.S. PSH facilities were built during the 1960s-1980s, typically for balancing base-load nuclear generation, and the last U.S PSH plant was completed in 1995 (the 1,046 MW Rocky Mountain plant in GA). As traditional PSH systems range in size from 1 GW – 2 GW, they face significant permitting, financing and environmental "footprint" challenges. An innovative approach being considered is modular PSH (m-PSH) that could resolve these challenges. In size ranges of 1-100 MW, closed-loop m-PSH systems could be more readily financed and realize broader acceptance with smaller reservoir requirements and/or by leveraging existing infrastructure, they could be cost effectively developed while still delivering the high value services of larger facilities.
- Market Acceleration: The program works to design, develop, and test new ways of reducing adverse environmental and ecological impacts from hydropower which has slowed the development of new hydropower generation and improvements in operational flexibility.

Marine and Hydrokinetic Technology

With more than 50 percent of the American population living within 50 miles of the Nation's coasts, MHK technologies hold significant potential to supply electricity to consumers in coastal load centers, especially in areas with high hurdle rates. A cost-effective MHK industry could provide a substantial amount of electricity for the Nation due in large part to its unique advantages which include close proximity to major coastal load centers, predictability and forecastability, and the ability to leverage solutions and lessons learned from more mature renewable industries, such as wind and solar. Through significant investments in this new and innovative industry, the DOE has rapidly evolved from merely "partnering" with industry, to a position of strong leadership within the MHK sector over a very short period of time in areas in which the unique capacities of the Federal Government can play a high leverage role. The program is committed to a three pronged effort that will allow the MHK sector to advance forward and achieve cost-competitiveness with local hurdle rates in major coastal load centers by 2030.

- Technology Advancement and Demonstration: Program investments will help ensure a comprehensive approach to next-generation technology development, support supply chain formation ahead of technology convergence, and drive industry innovation to achieve the program's 2030 levelized cost of energy (LCOE) goals. To support these objectives, the program will aim to demonstrate the technical readiness of U.S. MHK systems, drive innovation to develop next-generation systems that are cost-competitive, and compress the design cycle for MHK technologies. By supporting in-water demonstrations, the program will have the opportunity to evaluate the entire process from inception to completion, validating construction, generation, and operating expenses, as well as building confidence for MHK devices in the investor community.
- Advanced Design Tool Development: Computational device design tools are an efficient and cost-effective means of comparing device designs in terms of power production, device reliability, and device survivability in extreme conditions. Accurate, predictive design tools will allow developers to decrease costs if they can reduce the safety margins currently built into designs to account for uncertainties. Availability of these codes in open source to both developers and the academic community eliminates the burdensome costs of using proprietary codes, spurs innovative device designs, and creates expertise within the user community.
- Market Acceleration and Resource Characterization: DOE has a unique ability to reduce MHK environmental barriers. Lack of scientific information and monitoring costs can drive environmental and regulatory expenses to 30-50 percent of total early-stage MHK project cost. Program investments focus on addressing non-technical barriers to the development, deployment, and evaluation of these systems to reduce the cost and time for developers. This includes undertaking research and developing tools to identify, mitigate, and prioritize environmental risks; providing data to accelerate permitting time frames and drive down costs; and engaging in ocean planning to ensure that MHK is considered in the Nation's marine spatial plans.

Highlights of the FY 2015 Budget Request

Hydropower Technology ($31.5 million)

- In FY 2015, DOE will undertake a bold new initiative, HydroNEXT, to greatly expand the renewable generation of clean hydropower in the U.S., with the goal of doubling hydropower generation by 2030. Key components of HydroNEXT include:
  - HydroMax (Existing Assets): There is significant opportunity to cost-effectively improve performance and flexibility, and sustainably increase generation at existing hydropower facilities (50 percent of which are more than 50 years old). Through research and development, DOE will work with manufacturers to identify necessary modifications and the associated investments/re-investments needed to maintain and improve our Nation's existing hydropower fleet.
  - Low-Impact New Development (LIND) Technologies: A new set of hydro technologies is needed to capture the wide range of low impact development opportunities that are currently available from new stream-reach development. LIND technologies will be designed for high performance across a wide range of heads, and they will be packaged "drop in" modular systems to minimize capital costs and environmental impacts, and will seek to maximize design for manufacturing criteria to further reduce unit costs.
  - LIND Technology Environmental Performance Analysis and Testing Campaign: Conducting high-level, predictive analyses of how new LIND technologies under development are likely to perform for key environmental issues like fish passage and water quality.
  - Regulatory Process Improvement: Develop critical tools and technologies to identify, prioritize and mitigate environmental and market risks by providing data to improve performance, accelerate permitting timeframes and drive down costs for all types of new hydropower development.
  - Additionally, the program will analyze the benefits and begin evaluating innovative modular PSH (m-PSH) system

designs that exhibit cost competitiveness with existing large-scale designs.

- The program will continue to support collaborative interagency efforts through the existing memorandum of understanding (MOU) with the Army Corps of Engineers and Bureau of Reclamation to investigate a framework for reliability and cost impacts of operational changes and technology deployments, assess the impacts of climate change on Federal hydropower, and optimize water use at hydropower plants.

Marine and Hydrokinetic Technology ($30.5 million)

- Develop and validate open-source wave energy conversion (WEC) design tools for broad application by wave energy developers, especially burgeoning entrepreneurs that will benefit greatly from independently developed freeware. The tools will be evaluated through a test plan on WEC designs in tank tests, integrating instrumentation and data acquisition systems to validate the performance and accuracy of the tools, which will be released to developers and the general public in FY16 to stimulate widespread investment and innovation in the sector.
- The program will support applied research efforts geared towards advancing MHK technology. These efforts include field studies and applied research in marine environments; integrating innovative component technologies designed specifically for the challenges of the marine environment into advanced MHK systems and demonstrating the viability of MHK systems at a pre-permitted site.
- Support supply chain development and U.S. manufacturing competitiveness by supporting and demonstrating the comprehensive reengineering of innovative MHK system designs along "design for manufacturability" principles to reduce LCOE and increase production volume through economies of scale. Pursuing activities to accelerate the pace of permitting and industry development by addressing environmental and ecological uncertainties related to MHK technologies. In FY 2015, market acceleration activities include the direct monitoring of project environmental performance, laboratory research, and the continued development of environmental instrumentation to monitor devices.

Additionally, the program seeks to support "off-roadmap" emerging technology approaches via its incubator activity for both MHK and Hydropower technologies. This initiative is an annual funding mechanism to support the investigation of innovative solutions and potentially breakthrough approaches that can help accelerate meeting the overall goals of the program. For FY 2015, incubator funding ($3.5 million) represents more than 5 percent of the program's total budget.

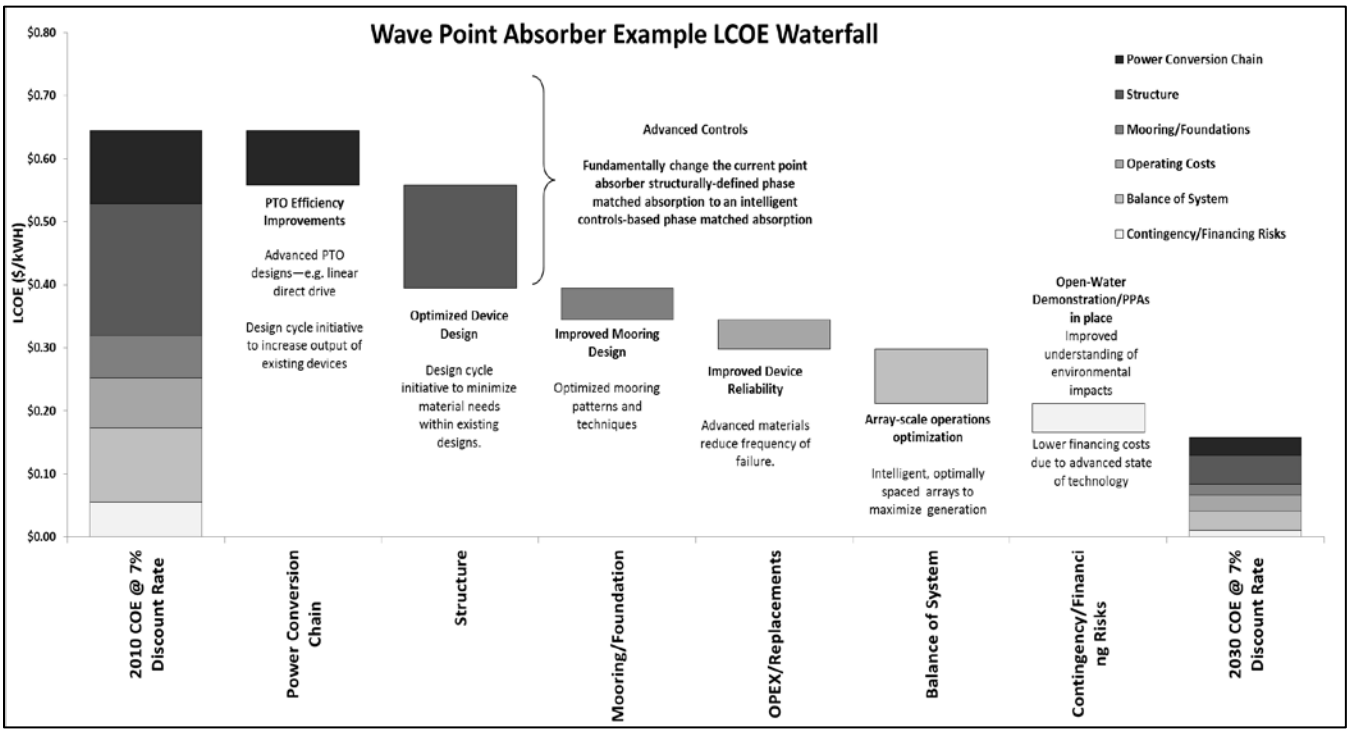

Figure 1: Example potential pathway for driving down MHK cost to levels competitive with local hurdle rates.

Water Power
Funding ($K)

	FY 2013 Current[1]	FY 2014 Enacted[2]	FY 2014 Current	FY 2015 Request	FY 2015 vs FY 2014 Enacted
Water Power					
Hydropower Technologies	19,231	17,290	17,290	31,500	+14,210
Marine and Hydrokinetic Technologies	35,456	41,275	41,275	30,500	-10,775
NREL Site-Wide Facility Support	0	0	0	500	+500
Total, Water Power	**54,687**	**58,565**	**58,565**	**62,500**	**+3,935**

SBIR/STTR:

- FY 2013 Transferred: SBIR: $798,000; STTR: $103,000
- FY 2014 Projected: SBIR: $640,000; STTR: $91,000
- FY 2015 Request: SBIR: $1,102,000; STTR: $152,000

[1] Funding reflects the transfer of SBIR/STTR to the Program of Science.
[2] FY 2014 Enacted funding reflects the contractor foreign travel rescission of $34,956.00.

Water Power

Explanation of Major Changes ($K)

	FY 2015 vs. FY 2014 Enacted
Hydropower Technologies: Additional funding is requested to support increased program efforts on existing and new hydropower under the HydroNEXT campaign which aims to double hydropower generation by 2030. Integration and PSH efforts increase as efforts are launched for the design on modular pumped storage. Environmental performance and permitting activities are increased in FY 2015 as several new efforts under HydroNEXT are launched to double hydropower by 2030. Additional funding would also support the program's water quality improvement activities under the HydroNEXT initiative.	**+14,210**
Marine and Hydrokinetic Technologies: Computational modeling and analysis activities increase as the subprogram shifts from WEC modeling and tidal device field measurement work to validating open-source design tools. Technology demonstration activities decrease as the program fully funds major demonstration efforts in FY 2014. FY 2015 priorities shift to supporting scaled demonstrations at pre-permitted sites and an emphasis on integrating innovative component technologies into advanced system designs. Testing infrastructure and instrumentation activities are completed in FY 2014 to develop and test wave and tidal sensors.	**-10,775**
NREL Site-Wide Facility Support: The delta is the result in a change in methodology used to allocate site-wide facility support contributions amongst programs. The FY 2015 value directly equates to the estimated savings gained from the reduced labor multiplier.	**+500**
Total, Water Power	**+3,935**

Water Power
Hydropower Technologies

Description
The global hydropower industry is currently focused on non-U.S., large-scale conventional hydropower projects. DOE is focused on new opportunities needed to invigorate industry innovation, identify or enable opportunities; and solve unique hydropower challenges in the U.S., which include smaller projects (less than 50 MW). This includes actively engaging and collaborating with regulatory and permitting agencies to accelerate and reduce the cost of permitting new hydropower projects, and increase development of hydropower at existing Federal water resource infrastructure. This strategy supports a goal of doubling the contribution of hydropower, an additional 300 terawatt hours, to the U.S. electricity system by 2030. With more than 2,500 U.S. companies supporting the Nation's hydropower industry, doubling generation from hydropower will create a large and enduring economic benefit in the U.S. by revitalizing the domestic manufacturing and hydropower industry.

Hydropower currently provides approximately 7 percent of the Nation's electricity and produces 56percent of all renewable generation, with 78 GW of installed capacity. In 2013, Congress passed two significant pieces of legislation that call attention to the near-term importance and opportunities of increased hydropower development in the U.S.
The Hydropower Regulatory Efficiency Act (H.R. 267) and the Bureau of Reclamation Small Conduit Hydropower Development and Rural Jobs Act (H.R. 678), aim to improve conditions for domestic hydropower development by streamlining the Federal regulatory process for many types of hydropower development.[3]

<u>HydroNEXT ($20 million)</u>
In FY 2015, DOE will launch a new initiative that aims to more fully realize the full potential of hydropower in the U.S. The initiative—HydroNEXT—will focus on accelerating the use of hydropower through program activities to lower the cost, improve the performance, and reduce the environmental impacts of hydropower. In addition to new hydro development, HydroNEXT also aims to improve the flexibility of the existing hydropower fleet to provide ancillary services to the utility grid, as well as facilitate the deployment of advanced pumped storage technologies, thus enabling greater penetrations of other variable renewables.

To increase hydropower generation in the U.S. in the near-term, the program is pursuing aggressive goals as part of the HydroNEXT initiative. These efforts include the successful demonstration of high performance LIND hydro technologies in order to validate their technical, economic, and environmental performance in the field. Additionally, the program will successfully demonstrate an environmentally enhanced, fish-friendly turbine for new hydro development (a technology that has been under development for more than 10 years). HydroNEXT investments will leverage additional private capital to validate these innovative technologies that will enable the sustainable development of new hydropower opportunities in the U.S.

DOE can demonstrate an instrumental leadership role by making investments in innovative technologies that seek to capture new development opportunities, facilitating information sharing and collaboration amongst key stakeholders and asset managers to improve the performance of existing hydropower assets, and supporting the implementation of innovative approaches that can accelerate licensing for minimal impact projects with commensurate process cost reductions to developers. In support of these objectives, the HydroNEXT initiative will include the following elements:

FOA for Low-Impact New Development (LIND) Hydro Technologies ($8 million): Currently, new development of hydropower is limited by two key factors: (1) economics driven by high civil costs of construction, and (2) lengthy permitting processes as environmental impacts are evaluated. To address these barriers, HydroNEXT will support technologies that reduce high capital costs and improve environmental performance of hydropower. The initiative's most significant investment of will be aimed at spurring the development of LIND Hydro technologies through a cost-shared FOA for LIND Hydro technology development and demonstration. A variety of low impact technologies will need to be developed to capture the wide range of heads (between 5 and 200 feet) associated with this opportunity. Modular "drop in" systems

[3] Specifically, H.R.267 increases the small hydro exemption from 5 MW to 10 MW; removes conduit projects under 5 MW from Federal Energy Regulatory Commission (FERC) jurisdiction; increases conduit exemptions to 40 MW for all projects; provides FERC the ability to extend preliminary permits; and requires FERC examine a two-year licensing process for non-powered dams and closed-loop pumped-storage projects. H.R. 678 authorizes small hydroelectric development at existing Bureau of Reclamation-owned canals, pipelines, aqueducts, and other manmade waterways.

that minimize civil works and maximize ease of manufacture will be critical design parameters. Collaboration with the U.S. Army Corps of Engineers and Bureau of Reclamation could serve to identify and prioritize Federal water resource sites suitable for these new technologies, if such access will not lead to competing uses of water resources. These investments will simultaneously strengthen the position of U.S. industry to capture burgeoning international hydro development opportunities in this market space as well.

HydroMax ($6 million): There is significant opportunity to cost-effectively improve performance and flexibility, and increase generation of existing hydropower assets. Current studies show that performance improvements of up to 20 percent can be cost-effectively achieved. In addition to increased generation, these existing assets also provide valuable ancillary benefits and can play a key role in enabling the greater penetration of other variable renewables. However, 50 percent of these hydro power assets are more than 50 years old, and reinvestment by owners and operators is needed to ensure their continued reliable and safe operation in a sustainable manner. In FY 2015, this initiative will identify and prioritize necessary improvements needed to improve our Nation's existing hydropower fleet. A key element will be conducting research and development on environmentally enhanced turbines. The results of these studies stimulate competitive interests in improving the state of technology at existing hydroelectric facilities and lay the groundwork for future investments.

LIND Technology Environmental Performance Analysis and Testing ($5 million): The program has invested in the development and demonstration of several new types of low-head hydropower technologies that are appropriate for deployment at new low-impact sites. Resource studies released by DOE in FY 2014 demonstrate that these new stream reaches offer the largest contribution of new hydropower opportunities. Conducting high-level, predictive analyses of how these technologies are likely to perform for key environmental issues like fish passage and water quality, potentially followed by environmental performance testing could help to proactively provide objective data that would ease the permitting processes for future deployments of these technologies at projects with environmental performance requirements. Through HydroNEXT, the program will begin "LIND Technology Environmental Performance Analysis and Testing" to assess current technology designs and inform future design requirements.

Regulatory Process Improvement ($1 million): The hydropower regulatory process involves many participants and while the system strives to promote development and protect important environmental values, it contains redundancies and inefficiencies that slow or even halt deployment of clean, renewable hydropower, even at existing water resource infrastructure. Better understanding of these barriers, and effective regulatory and stakeholder engagement will help preserve and expand the Nation's hydropower resources. The program will develop critical tools and technologies to identify, prioritize and mitigate environmental and market risks by providing data to improve performance, accelerate permitting timeframes and drive down costs for all types of new hydropower development. A specific action in this regard is participation in the development of the "Renewable Energy Application Toolkit/Permitting Tool." This tool will aim to reduce permitting barriers and increase efficiency and transparency for Federal permitting processes. The program will also provide leadership in examining of current policies that affect hydro development, spur the development of innovative approaches that can accelerate licensing for minimal impact projects, and leverage/support MOU partnerships to facilitate hydropower development on Federal facilities. The continued operation of the Nation's existing hydropower asset base must also be taken into consideration, so improvements for relicensing are also essential, and will be a key element of this effort.

<u>Modular Pumped Storage Hydropower ($4 million)</u>

Pumped storage (PSH) is a proven, economical means of storing energy, it provides valuable ancillary benefits that ensure grid reliability, and it supports increased penetration of other variable renewables. In size ranges of 1-100 MW, m-PSH could potentially solve many of the deployment issues associated with its GW-scale counterparts. With its smaller scale, m-PSH could be more readily financed and realize broader acceptance, and it could be cost-effectively developed while still delivering the high-value services of larger facilities. Building on the Modular Pumped Storage Feasibility Study conducted in FY 2014, the program will begin developing innovative m-PSH system designs that exhibit cost-competitiveness with existing large-scale system designs. Assessments of available existing water resource infrastructure and various topographical criteria will lead to a set of preferred operational parameters. Based on the operational criteria, combined with a focus on modularity, design criteria for appropriately sized m-PSH systems will be developed in FY 2015.

<u>Tools and Technologies for Environmental Performance ($4 million)</u>

Key activities addressing hydropower's market barriers will include new research that can improve the environmental performance of both existing and potential new hydropower facilities. The subprogram is working with its Federal partners including Bureau of Reclamation, Army Corps of Engineers, Fish and Wildlife Service, and others to improve operational modeling tools to characterize water quality, and is working with manufacturers to utilize biological design criteria in the production of their generating units. The subprogram will invest in activities focused on improving the computational simulation of water-quality issues and associated measurement infrastructure to enhance hydropower systems optimization and operation—increasing energy generation, system flexibility, and environmental benefits. The subprogram will also monitor and document the environmental performance of new technologies to validate effectiveness and spur new development. Finally, the subprogram will aggregate and disseminate all information learned in these activities into an annual Hydropower Market Report to provide an analysis product of the status of the hydropower industry with respect to cost, production, development and regulatory change. The results will allow the subprogram to proactively identify trends and optimize its investments to maximize impact on the hydropower industry.

Clean Energy Manufacturing Initiative ($2 million)

The program supports EERE's CEMI effort to reduce both manufacturing and structural costs for these components; the program will invest in EERE's manufacturing initiative to develop advanced material hydropower components that reduce both manufacturing and structural costs. These innovations can dramatically reduce LCOE for a variety of sites around the country and enable cost-competitive hydropower generation.

Incubator Program ($1.5 million)

Additionally, the program supports EERE's Incubator effort to support off-roadmap transformational new energy technologies into the EERE portfolio, dramatically increasing the rate of technology innovation in the hydropower industry.

Hydropower Technologies

Activities and Explanation of Changes

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs FY 2014 Enacted
Hydropower Technologies		
• Standardize unit designs, develop advanced electrical conversion technologies for high efficiencies, and reduce the footprint and cost of new hydropower development through targeted civil structure R&D. • Launch CEMI for composite turbine development. • Explore feasibility and economics of modular pumped storage designs. • Evaluate the future impacts of water availability and water use changes on the existing hydropower fleet to provide essential information for long-term water and power infrastructure planning.	• Initiate HydroNEXT to focus on accelerating the use of hydropower through program activities to lower the cost, improve the performance, and reduce the environmental impacts of hydropower. • Launch effort to develop innovative m-PSH technology concepts. • Continue modeling and analysis of hydro/PSH flexibility and its ability to facilitate integration of other variable renewables. • Continue development of tools and technologies that monitor environmental performance, inform stakeholders, and supports accelerated permitting. • Support CEMI effort is continued for the research and advancement of innovative manufacturing processes that can be used to develop lightweight materials for hydropower turbines to drive down LCOE from reduced equipment and powerhouse costs. • Incubator activities that will enable introduction of off roadmap transformational new energy technologies into the EERE portfolio, dramatically increasing the rate of technology innovation.	• Efforts focused on existing and new hydropower increase from FY 2014 as the program launches the new initiatives under the HydroNEXT campaign which aims to double hydropower generation by 2030. • Integration and PSH efforts increase as efforts transition from the design to the development of modular pumped storage. • Environmental performance and permitting activities are increased in FY 2015 as several new efforts under HydroNEXT are launched to double hydropower by 2030. Additional efforts are focused on water quality improvements increases as several new efforts focused on are launched under the HydroNEXT campaign.

Water Power

Marine and Hydrokinetic Technologies

Description

Marine and Hydrokinetic Technology (MHK): DOE plays a critical role in MHK technologies because of their nascent stage of development, which is similar to that of wind and solar technologies 20 years ago. Without strong DOE involvement and leadership, the domestic water power industry will not progress at the pace needed to reach its full potential as part of a diverse U.S. energy portfolio.

The objective of the MHK subprogram is to compress technology development timelines with the goal of reducing the LCOE for MHK devices to local coastal hurdle rates of $0.12-$0.15 per kilowatt-hour (kWh) by 2030 (see Figure 1 for an example of a potential pathway for driving down MHK LCOE (wave) from a reported cost of $0.61-$0.77 cents today). The program will accomplish this through a series of core activities, including the following:

- Establishing baseline costs and transparently identifying LCOE reduction pathways and opportunities;
- Working with industry to reduce the cost of MHK technologies to $0.12-$0.15 per kWh by 2030 through investments in a portfolio of technologies aimed at improving MHK system extraction efficiency, reliability, survivability, manufacturability, and serviceability;
- Quantifying cost and time associated with permitting and environmental monitoring with the intention of establishing metrics for Programmatic effectiveness in reducing these barriers; and
- Addressing environmental uncertainties to ensure efficient and responsible development.

MHK Technologies include devices that harness energy from waves and currents - e.g., tides. DOE completed assessments of U.S. wave, tidal, ocean-thermal, and river in-stream hydrokinetic energy resources in 2012. Based on quantitative estimates of resource and deployment potential, the subprogram will place priority focus on technology development for wave energy devices, yet will also continue to support key tidal and current energy developments, as well as the reduction of deployment barriers through market acceleration activities.

The MHK subprogram aims to achieve cost-competitiveness at local coastal hurdle rates, which is approximately $0.12–$0.15 per kWh by 2030. To accomplish this, in-water MHK demonstrations are required to gather baseline performance data, gain operational experience, and identify key cost drivers of leading device designs.

<u>Validate Open Source Advanced Design Tools ($6.0 million)</u>

As devices are tested and performance data is generated, the subprogram will continue to compile, analyze, and disseminate information to accurately characterize and evaluate the performance of MHK technologies. This activity will support continued efforts to develop and validate open source advanced design tools. In addition, this effort includes a field measurement campaign to collect the most comprehensive set of performance data for an MHK turbine operating in the open water. Accordingly, data gathered as part of this project will enable DOE National Laboratory researchers to validate and improve the accuracy of their numerical modeling tools. The subprogram will provide industry with freely available datasets to allow for the simulation of device array designs and array impacts on marine surroundings.

<u>MHK Research and Design ($12.5 million)</u>

The program will advance system designs of marine energy conversion devices through applied research and development efforts.

- In FY 2015, the program will continue to perform applied research. Research will target the application of innovative corrosion resistant materials, such as composites, non-toxic coatings and non-destructive inspection that will double intervals between major device rehabs, thus significantly reducing O&M costs and extending device lifetime. Additionally, the program will support efforts in advanced controls research, structural loads measurement and analysis, field studies, and applied research in marine environments.
- The program aims to integrate innovative component technologies into advanced system designs. This effort will drive to realize the impact of integration of these new innovative component technologies to deliver better performance and reliability to full scale MHK systems. Developers today continue to rely on commercial off-the-shelf components for their designs. These components are often not purpose-designed products capable of performing within the operating ranges and under the harsh marine conditions/environments specific to MHK devices and systems. Successfully proven component technologies from prior program funding opportunities, once integrated, will drive the costs down for multiple energy conversion system solutions. Expected component technology improvements include advanced

controls to tune devices to extract the maximum energy from each sea state, compact high-torque low-speed generator technologies, and corrosion and biofouling resistant materials and coatings.

- The program also aims to demonstrate the viability of MHK systems at pre-permitted site(s) – that is, sites for which FERC licenses and environmental assessments have already been secured. Focusing on competitively selected companies with devices ready for testing at a pre-permitted open-water location, the program will facilitate data acquisition to serve standards development, numerical tool validation, and device certification. Data collected around the device including resource characterization and any environmental measurements will be made publicly available, and opportunities to collect and share non-proprietary, pre-commercial performance data will also be sought. The benefit to industry in this effort is substantiated performance and cost metrics to increase private investors' confidence in the techno-economic viability, in addition to identification of further cost savings related to design innovations and the development of installation techniques and procedures.

Monitoring Technology Testing and Research ($5 million)

The subprogram will also pursue activities that address key environmental and ecological uncertainties as they arise within the rapidly developing industry. Investments will focus on research to evaluate the environmental impacts of MHK technologies, including direct monitoring of project environmental performance, laboratory research, and the continued development of cost-effective instrumentation to monitor devices. This work coupled with opportunities for testing and demonstrating new instrumentation in the open water – including at existing sites and test facilities that DOE has helped to develop – will help inform design improvements that minimize environmental impact and will help accelerate the pace of permitting and development for the industry.

Clean Energy Manufacturing Initiative ($2 million)

Additional R&D under DOE's Clean Energy Manufacturing Initiative (CEMI) will leverage advanced manufacturing principals to lightweight MHK devices—reducing installation and manufacturing costs and increasing survivability. The subprogram will invest in activities that include the re-engineering of innovative MHK system designs along "design for manufacturability" principles to reduce LCOE and increase production volume through economies of scale. Activities will also focus on the testing and application of high-strength, light-weight materials, such as composites, to the design of MHK systems—further reducing installation and operations and maintenance costs through reduced weight and resistance to corrosion.

Incubator Program ($2 million)

The program supports EERE's Incubator effort to support off-roadmap transformational new energy technologies into the EERE portfolio, dramatically increasing the rate of technology innovation in the MHK industry.

Tidal Energy Demonstration Project ($3 million)

In FY 2015, the program will fund nearly half of the remaining mortgage from the MHK Technology Readiness Advancement Initiative Funding Opportunity Announcement (FOA) for a grid-connected tidal energy demonstration project. The primary purpose of the project is to gather data to advance the viability of commercial tidal energy generation from a technical, economic, social, and environmental standpoint.

Marine and Hydrokinetic Technologies

Activities and Explanation of Changes

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs FY 2014 Enacted
Marine and Hydrokinetic Technologies		
• Initiate the "Wave Energy Converter (WEC) Prize" competition to develop breakthrough wave energy technology. • Support MHK demonstrations at the pre-permitted Navy Wave Energy Test Site to identify wave energy conversion designs that will be cost competitive at local hurdle prices without subsidies. • Continue to support meritorious and competitive selections from the Systems Performance and Advancement Initiative to advance the technical maturity of MHK projects. • Develop advanced marine monitoring technologies to lower the cost of licensing compliance and allow access to sensitive (but high-resource) sites. • Conduct RD&D toward innovative technologies and to improve the reliability and technology readiness of MHK.	• Continue efforts to validate open-source advanced design tools. The subprogram will provide industry with freely available data sets/codes to allow for the simulation of device array designs and array impacts on marine surroundings. Advance system designs of MHK devices for test, evaluation, and comparison through applied research efforts. • Support tidal projects awarded under the MHK Technology Readiness Advancement Initiative FOA. • Establish a manufacturing competitiveness initiative to leverage advanced manufacturing principals and lightweight MHK devices—reducing installation and manufacturing costs and increasing survivability. • Support the EERE Incubator effort to support "off-roadmap" emerging technology approaches. • Develop monitoring technology, conduct research that addresses key environmental uncertainties and develop strategic information-sharing partnerships.	• Computational modeling and analysis activities increase as the subprogram shifts from the WEC modeling and tidal device field measurement campaign to validating open-source design tools. • Technology demonstration activities decrease as the program fully funds major demonstration efforts in FY 2014. FY 2015 priorities shift to supporting scaled demonstrations at pre-permitted sites and an emphasis on integrating innovative component technologies into advanced system designs. • Testing infrastructure and instrumentation activities are completed in FY 2014 to develop and test wave and tidal sensors.

Water Power
NREL Site-Wide Facility Support

Description
In FY 2015, EERE will continue to 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. This practice is consistent with other National Laboratories. EERE began this practice in FY 2014 to significantly reduce NREL's labor rate multiplier, thereby reducing the cost barrier to accessing unique NREL capabilities (such as facilities and staff expertise) by industry and academia. This practice also makes site operating costs more transparent to facilitate cost control, as well as to identify and to plan for future facility and infrastructure investments. In FY 2014, this practice resulted in a reduction in the Lab-wide direct labor multiplier of approximately 15 percent compared to FY 2013. Within the proposed FY 2015 budget, NREL's direct labor rate multiplier will remain competitive on this basis by directly funding site-wide facility support. The site-wide facility support funds cover maintenance and engineering support; fire, emergency, and custodial services; general utilities; network infrastructure and licenses; environment, safety, and health support; and sustainability. By moving these costs from laboratory overhead to direct funding, EERE is able accelerate its impact by making it easier for its stakeholders to access NREL capabilities.

This funding supports research programs by providing basic site services, functions, and infrastructure for Site Operations, which includes: management, building operations, building & grounds maintenance, fire & emergency response, engineering & construction support, minor construction projects, electrical safety program, utilities, and facilities planning support; and activities within the Sustainability and Environmental Health and Safety (EHS) portfolios. These activities and their costs are relatively fixed and only vary significantly based upon variations in commodities, construction activity, emergencies, weather patterns, etc. They are considered to be the core functions for site operations, safety, environmental compliance, and sustainability at NREL. In FY 2015, this funding will support more than 60 full time equivalents that manage and provide support for the Site Operations, Sustainability, and Environment, Health, and Safety. It will also fund site-wide subcontracts such as janitorial services, refuse and recycling, and subcontracts for minor construction. Additionally, this funding will support site-wide costs associated with maintaining NREL's leadership position, such as: maintaining International Organization for Standardization (ISO), American Association for Laboratory Accreditation (A2LA), and other lab-wide accreditations, managing facilities to enable mission goals, improving sustainability, pollution prevention, waste minimization, improve energy efficiency, reduce water use, and maintain an effective emergency management system.

The FY 2015 contribution from each program differs from the FY 2014 allocation, because EERE has developed a more precise, equitable, and economically neutral method that ensures a net-zero impact on programs' funding. For each program, the contribution to direct funding site-wide facility is equivalent to the estimated contribution the programs would have made through overhead charges. This method is based upon each program's level of funding to NREL, adjusted to account for anomalies from capital expenditures and major subcontracts.

NREL Site-Wide Facility Support

Activities and Explanation of Changes

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs. FY 2014 Enacted
NREL Site-Wide Facility Support		
• No funding requested in FY 2014.	• 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.	• The delta is the result in a change in methodology used to allocate site-wide facility support contributions amongst programs. The FY 2015 value directly equates to the estimated savings gained from the reduced labor multiplier.

Water Power
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 2013 Annual Performance Report.

	FY 2013	FY 2014	FY 2015
Performance Goal (Measure)	**Marine & Hydrokinetic (MHK) - Demonstrate component improvements that will allow increase in wave energy conversion system power-to-weight ratio (PWR) of 50 percent (baseline for wave is 0.25kW/ton)** **2014: Reduce the cost of energy from Marine & Hydrokinetic technologies (cents/kWh)** **2011 - 2013: Test marine and hydrokinetic devices and components to determine baseline cost, performance, and reliability. (all targets cumulative)**		
Target	10 MHK devices tested	$0.60/kWh	50% increase in power-to-weight ratio
Result	Met – 10 MHK devices tested.	N/A	N/A
Endpoint Target	Competitive with local coastal hurdle rates by 2030.		

Geothermal Technologies

Overview

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

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

The geothermal industry operates in a challenging 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. Further, market adoption is a critical issue for the geothermal sector, given its small size and traditionally risk-averse nature. Consequently, DOE involvement in applied research provides the geothermal community with critical access to cutting-edge technologies research that expands potential for domestic geothermal energy production in new regions.

Early DOE and government investments helped catalyze the oil and gas sector in making dramatic breakthroughs in stimulating and fracturing shales, which has led to the U.S. natural gas revolution. The program sees a similar opportunity for the geothermal sector to leverage targeted government investment into innovative technologies for accessing new subsurface environments, and dramatically advancing geothermal energy as a broad-based, domestic renewable energy source.

Highlights of the FY 2015 Budget Request

Geothermal Technologies will launch the following major focus areas in FY 2015:

- The initial site characterization of the Frontier Observatory for Research in Geothermal Energy (FORGE), a DOE-managed, industry/stakeholder-operated site dedicated to creating a commercial pathway to EGS. In FY 2014, the program issued the funding opportunity announcement (FOA) that culminates in a competitive downselect of potential FORGE sites with associated project operator and partners.
- Research, development, and demonstration (RD&D) activities to more aggressively transfer select oil and gas exploration, drilling, and well-completion technologies to the geothermal industry and modify them for geothermal subsurface environments, as well as further refinement of geophysical and geochemical technologies and methodologies—both will advance our ability to identify and access undiscovered hydrothermal resources.
- Acceleration of "play fairway" analyses, which is an assessment of exploration risk and the probability of finding new resources on a regional scale, through the analysis and integration of diverse datasets. The objective is to quantitatively identify the most prospective areas for new geothermal exploration and development. Play fairway mapping leverages and modifies practices from traditional oil and gas analysis, and will be a first-of-its-kind endeavor for geothermal mapping in both the U.S. and internationally. The resulting maps and studies will reduce overall exploration costs and increase geothermal development by providing more targeted exploration and drilling

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

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

opportunities, leading to a more accurate assessment of exploration risk in a region and reducing finding-and-development costs.

- 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.
- A Geothermal Incubator activity to support "off-roadmap" new approaches that are not currently well represented within the research and development (R&D) portfolio and Multi-Year Program Plan (MYPP). This activity is meant to facilitate new technologies and approaches into the portfolio. Proposed funding for this effort is 5 percent of the program's overall budget request.

Additionally, in FY 2015, the program will strengthen subsurface R&D collaboration with offices across DOE—including the Office of Fossil Energy, the Office of Nuclear Energy, the Office of Science, and the Office of Environmental Management—on crosscutting geology and engineering initiatives related to common technical challenges underlying geothermal reservoir development, waste storage, and CO_2 sequestration. Key subsurface challenges that are common to our R&D programs are: 1) efficiently and accurately discovering, characterizing, and predicting the location of target subsurface geologic environments and quantitatively inferring their evolution under future engineered conditions; 2) safely and cost-effectively accessing the subsurface through drilling or mining with properly managed reservoir integrity; 3) engineering or constructing the desired subsurface conditions in challenging high-pressure/high-temperature environments; 4) maintaining these conditions over multi-decadal or longer time frames; and 5) monitoring the subsurface, which includes improving observational methods and advancing understanding of the microscopic basis of macroscopic complexity throughout system lifetimes.

The goal of the Geothermal Technologies program is to make geothermal energy a fully competitive and widely available component of the national energy mix. Subprogram objectives include technology development that will drive industry deployment of a targeted 30 GW of new undiscovered hydrothermal resources (nearly 10 times the current level of geothermal power deployment) and 100+ GW of EGS. The pathway for achieving these objectives includes developing new exploration tools and techniques to lower the upfront risk of geothermal resource exploration, reducing the levelized cost of electricity (LCOE) of newly developed geothermal systems—including EGS—from current costs of 22.4 cents/kWh to 6 cents/kWh (market prices) by 2030 (see Figures 1 and 2), conducting RD&D on technologies to harness available lower temperature resources more effectively, and developing improved methods to create new EGS reservoirs.

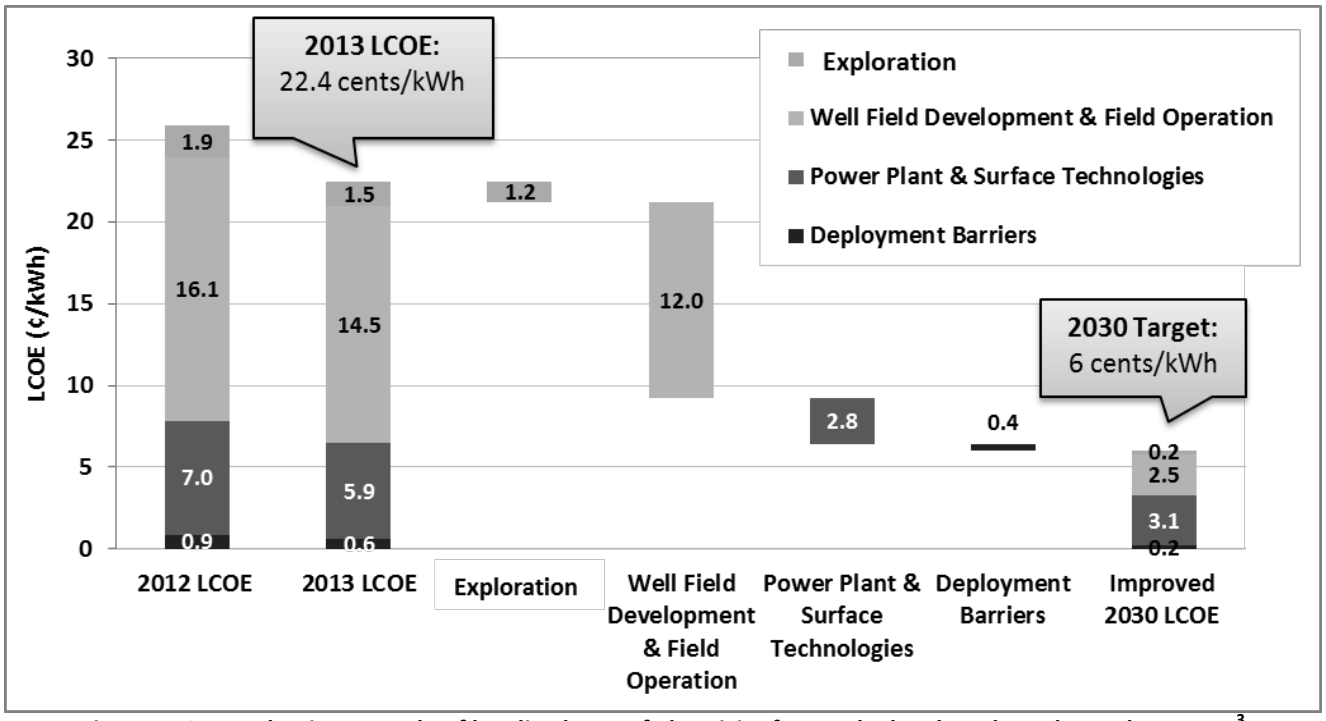

Figure 1: Cost reduction cascade of levelized cost of electricity for newly developed geothermal systems.[3]

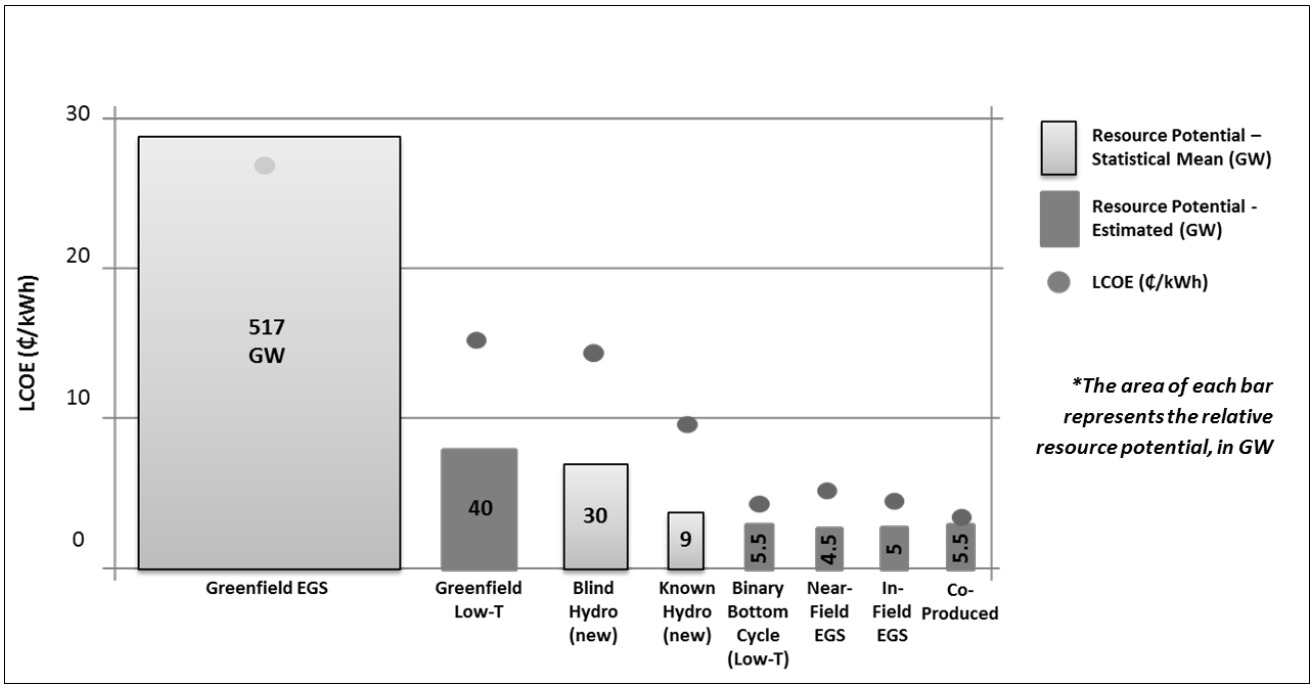

Figure 2: Resource potential (GW) and current modeled levelized cost of electricity, by geothermal resource category.

[3] Modeled with Geothermal Electricity Technology Evaluation Model.

Geothermal Technologies
Funding ($K)

	FY 2013 Current[4]	FY 2014 Enacted[5]	FY 2014 Current	FY 2015 Request	FY 2015 vs. FY 2014 Enacted
Geothermal Technologies					
Enhanced Geothermal Systems	20,103	27,084	27,084	33,500	+6,416
Hydrothermal	8,092	10,285	10,285	17,500	+7,215
Low Temperature and Coproduced Resources	2,942	4,708	4,708	6,000	+1,292
Systems Analysis	3,888	3,698	3,698	4,000	+302
NREL Site-Wide Facility Support	0	0	0	500	+500
Total, Geothermal Technologies	**35,025**	**45,775**	**45,775**	**61,500**	**+15,725**

SBIR/STTR:

- FY 2013 Transferred: SBIR $687,000; STTR: $89,000
- FY 2014 Projected: SBIR: $851,000; STTR: $122,000
- FY 2015 Request: SBIR: $696,000; STTR: $96,000

[4] Funding reflects the transfer of SBIR/STTR to the Office of Science.
[5] FY 2014 Enacted funding reflects the foreign contractor travel rescission of $27,322.

Geothermal Technologies
Explanation of Major Changes ($K)

	FY 2015 vs. FY 2014 Enacted
Enhanced Geothermal Systems: The increased funding reflects a critical step in the FORGE initiative: site characterization, which allows the selected awardee(s) to initiate robust geological and geophysical characterization of the proposed site and to complete all NEPA activities including the required Environmental Information Volume. Activities will also include the initial planning for R&D technology testing and evaluation at FORGE.	**+6,416**
Hydrothermal: This increased funding reflects the launch of the Geothermal Incubator activity and the Subsurface crosscut. Incubator funding will provide early-stage assistance to help industries cross technological barriers to commercialization with potentially high-impact "off-roadmap" new technologies associated with overall cost and risk reduction of developing geothermal power, or technologies associated with thermal energy generation such as low-temp/desalination, or advanced direct use. The Subsurface crosscut effort will promote enhanced collaboration on subsurface technology and engineering R&D across DOE subsurface programsto ensure effective technical leveraging, find synergies, and avoid unproductive overlap or duplication of effort. The Geothermal Technologies program'scontributions in FY 2015 will target Subsurface crosscut roadmapping and R&D, including subsurface characterization and initial development for an in-field geothermal reservoir stimulation protocol that can accelerate the addition of 10s-100s MW of new geothermal capacity at existing hydrothermal sites.	**+7,215**
Low Temperature and Coproduced Resources: This increased funding reflects an expanded Low Temperature subprogram to include advancements in co-produced Strategic Materials as well as additional funding for advanced direct use, cascaded surface technologies whose applications extend the reach of geothermal beyond the western U.S. Specifically, FY 2015 funding will support a follow-on Strategic Materials funding opportunity that leverages successful feasibility projects funded in FY 2014. It also includes funding for innovative direct use R&D focused on the thermal component of geothermal resources in new areas beyond more traditional geothermal regions.	**+1,292**
Systems Analysis: Minimal change in funding is requested to reflect the subprogram's continued focus on analysis and tools that help to reduce barriers to "speed and scale" adoption of geothermal in the U.S. and validate technical progress across the geothermal sector.	**+302**
NREL Site-Wide Facility Support: The delta is the result in a change in methodology used to allocate site-wide facility support contributions amongst programs. The FY 2015 value enables and directly equates to the program's estimated savings gained from the reduced labor multiplier.	**+500**
Total, Geothermal Technologies	**+15,725**

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. In an EGS project, fluid is injected into the subsurface at low pressures under a safe, controlled, and well-engineered stimulation process, causing pre-existing fractures or weaknesses in the rock fabric to open. Low pressure is utilized to impose a shear stress on the fracture planes, which results in increased permeability and allows fluid to circulate throughout the rock. This fluid then transports heat to the surface where electricity can be generated. In the long term, EGS success would potentially enable the utilization of an enormous, geographically diverse energy resource on the order of 100+ GW.

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

Key recent accomplishments in the EGS subprogram include the following:

- In FY 2013, DOE supported the first sustained enhanced geothermal system (EGS) demonstration success in the U.S. at The Geysers. Following a year-long stimulation along the outer edges of an operating geothermal field, this EGS demonstration project in northern California successfully accessed a new and distinct reservoir in a very low-permeability, high-temperature region, yielding a clearly demonstrated commercial-strength 5 MW resource.
- Also in FY 2013, the Desert Peak project in Nevada completed an 8-month, multi-stage stimulation of an existing yet underperforming well, making it the first grid-connected EGS project in America to generate commercial electricity by providing an additional 1.7 MW at the existing well-field.
- In FY 2014, the Raft River EGS demonstration project in Idaho will complete two phases of thermal stimulation that commenced in FY 2013, and will complete a large injection volume hydraulic stimulation of an existing sub-commercial well. Multiple phases of thermal stimulation have created near wellbore tensile fractures that will connect to the existing geothermal reservoir during hydraulic stimulation. Through this combination of wellbore thermal conditioning and hydraulic stimulation, this currently sub-commercial is targeted to become a commercial production/injection well.
- In FY 2014, first-of-a-kind, high temperature (575°F), U.S. made, logging and wellbore pumping systems will be deployment-ready. Technologies include a Geothermal Ultrasonic Fracture Imager, electronic submersible pump, and downhole orientation module, representing best-in-class temperature rated systems.

To address critical challenges to EGS development, in FY 2015 the EGS subprogram will pursue the development of innovative technology solutions via two complementary technical pathways: tightly directed strategic R&D, which may include competitively awards for R&D at industry-run EGS demonstration projects; and a Frontier Observatory for Research in Geothermal Energy (FORGE). FORGE is a dedicated EGS field lab site where novel technologies and techniques can be tested, with a central focus on EGS optimization and validation. FORGE is a critical step toward creating a commercial pathway to EGS; it will promote transformative and high-risk science and engineering that the private sector is not financially or operationally equipped to undertake. The program envisions FORGE as a collaborative and inclusive effort among all forms of geothermal and subsurface stakeholders; participation and contribution from industry, National Laboratories, and academia will be 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 knowledge of initiating and sustaining fracture networks in low permeability rock formations will inform the design and testing of a methodology for reproducing large-scale, economically sustainable heat exchange systems. A critical part of creating a repeatable development methodology involves the consideration of various well configurations to determine which design most efficiently and effectively exploits in-situ stress directions manifested through fracture orientations (see Figure 3). Equally essential to informing the future

direction of EGS is the comprehensive capture of high-fidelity data that ensures a deep understanding of created systems and reproducibility in a variety of geologic environments. Real-time dissemination of technical data to all stakeholders will revolutionize our understanding of EGS creation and evolution and pave the way for a rigorous and reproducible methodology that reduces industry development risk.

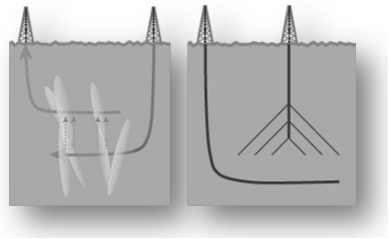

Figure 3: On left: Representation of horizontal well configuration; on right: Representation of combined horizontal and vertical well pair. Testing innovative well designs and orientations may play an integral role in increasing the efficiency of and production from EGS systems.

Frontier Observatory for Research in Geothermal Energy (FORGE) ($29.0 million)

FORGE will be defined by an expansive and competitive R&D program, open to the broader scientific and engineering community and other key partners. FORGE is designed to be a finite, non-permanent operation.

In FY 2014, the program released the first competitive solicitation to launch FORGE, with a maximum of ten teams comprised of Site Owners and Operators selected to participate in Phase 1. During this Phase, all existing site data will be aggregated and incorporated into an initial geologic and subsurface model, including its suitability as an EGS site. Teams are also required to develop comprehensive operational plans for the site, as well as Data Dissemination and I.P., Core and Sample Curation, Induced Seismicity Mitigation, Communications, and Environmental Health & Safety plans with the intent of enabling broad access to government-supported research and development results and to ensure safe operations.

In FY 2015, the FORGE site(s) will be selected for further site characterization from the ten initial teams via a merit review process that will weigh a number of technical factors related to the proposed sites, as well as operational, regulatory, and cost-share factors. The priority will be to identify a candidate site(s) that maximizes scientific and operational return on investment with the broadest applicability to future EGS activity by industry, with the intent of down-selecting to a single site and operator for the full implementation phase. The selected FORGE site(s) operations will be managed by a Site Management Team, comprised of the Site Operator, the Site Owner, and a "Science, Technology, and Analysis Team" (STAT) made up of DOE representatives as well as experts from industry, academia, and national laboratories. The Site Operator, DOE, and the STAT, will together oversee the technical strategy of FORGE by developing the topics for subsequent R&D solicitations based on the EGS Roadmap and the progress of research and testing at FORGE. DOE will have final authority on the selection of research and testing projects and for determining their continuation based on review of their progress. The Site Operator will direct day-to-day activities at FORGE, under the oversight of the program, including scheduling and execution of all R&D and site management activities while maintaining operational, safety, and regulatory responsibility. The Site Operator will report to the DOE federal FORGE Manager, and DOE will retain ultimate decision authority on all aspects of FORGE operations and technology development.

At the conclusion of Phase 1, in mid-FY 2015, the FORGE site(s) will be selected and Phase 2 activities will commence, including: activities to initiate National Environmental Policy Act (NEPA) compliance, detailed geologic and geophysical site characterization and establishment of a long-term monitoring infrastructure with associated data sharing, implementation of relevant plans as developed in Phase 1, and initial planning for R&D technology testing and evaluation in Phase 3. Operations planning at FORGE will be informed in large part by the results of the existing EGS demonstration projects currently underway—all of which will have completed the stimulation phase by the end of FY 2014. These five demonstration projects represent the cutting edge in EGS technology testing today and are already achieving groundbreaking success. Consequently, successes and lessons learned from stimulation methodologies, as well as other technologies employed over the life of these projects, will provide the basis for the detailed technical strategy and explicit goals set at FORGE.

After a Go/No-Go decision made by DOE at the end of Phase 2, the full implementation of FORGE (Phase 3) would commence, including continuous testing and evaluation of new and innovative EGS tools and techniques. Phase 3 would include competitive R&D projects spanning multiple technology-readiness levels to test or validate technologies at FORGE. In addition, as a result of the ongoing comprehensive instrumentation and data collection/sharing effort, other research

institutions and entities would have full access to publically available data and samples for conducting further studies (e.g., U.S. Geological Survey scientists, National Science Foundation-supported researchers, etc.), which would offer tremendous leverage for the scientific community. Requirements for Phase 3 would include drilling of operational, full sized, and likely highly deviated or horizontal wells; continuous monitoring and real-time data sharing; reservoir stimulation; and flow testing efforts that manifest in significantly increased performance per well over that realized at prior EGS field demonstrations.

Targeted EGS R&D ($4.5 million)

Strategic R&D remains a key and fundamental part of the EGS subprogram and will run in parallel with the early preparatory work at FORGE. In FY 2015, the subprogram will continue to address key challenges through new and acutely targeted, competitively selected R&D focused on zonal isolation, novel stimulation methodologies, and unique well designs and configurations, to complement work taking place at FORGE. The subprogram will continue to support critical FY 2014 work in joint geophysical techniques and advanced tracer technologies for fracture and reservoir imaging seeking to meet the FY 2015 goal of prototype testing of innovative tracer technologies to estimate reservoir surface area, volume, and temperature, through in-situ interrogation, a quantitatively-coupled multi-geophysical technique for imaging fracture evolution at meter scales in an EGS setting.

Super-critical phase CO_2

The program will fund the first-ever super-critical phase CO_2 EGS field pilot test, through the continuation of a competitively-selected project focused on the design of an innovative heat extraction methodology for EGS that does not require the use of water or reservoir stimulation. A successful outcome from this activity would represent proof-of-concept for efficiently producing electric power from super-critical phase CO_2. Additionally, this project leverages significant prior-year infrastructure investments made by DOE's Office of Fossil Energy, which had developed the site for a CO_2 sequestration demonstration. This project is an program-specific element of the broader super-critical CO_2 crosscutting collaboration within DOE, which is focused on the RD&D of super-critical CO_2 technologies with the potential for significant improvements in energy and environmental performance over current power generation systems.

Enhanced Geothermal Systems

Activities and Explanation of Changes

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs. FY 2014 Enacted
Enhanced Geothermal Systems		
Frontier Observatory for Research in Geothermal Energy (FORGE) ($10,000,000) • Initiate site viability scoping and planning for candidate FORGE sites focusing on technical (high temperatures in the target formation in the range of 350-450°F; moderate permeability and porosity; 1.5 - 4 km target depth to avoid excessive drilling costs) and operational (NEPA requirements, risks and impacts; adequacy of existing facilities, equipment, and infrastructure; quality of data dissemination, core duration, communications, environmental, health & safety, and induced seismicity mitigation plans) qualifications.	*Frontier Observatory for Research in Geothermal Energy (FORGE) ($29,000,000)* • Complete down-select of up to ten Phase 1 teams to up to two potential FORGE sites and complete cooperative agreement negotiations with the Phase 2 awardee(s) for further site characterization. • Finalize Environmental Information Volume for submission to DOE and appropriate regulatory agencies to initiate the NEPA process for FORGE activities. • Initiate site characterization and monitoring activities at FORGE including development and deployment of high-resolution surface and subsurface seismic monitoring systems. • Complete initial R&D topic scoping and develop and release the first R&D RFP for projects at FORGE.	*Frontier Observatory for Research in Geothermal Energy (FORGE) (+$19,000,000)* • The increased funding for FORGE allows the selected awardee(s) to initiate robust geological and geophysical characterization of the proposed site and to complete all NEPA activities including the required Environmental Information Volume.
Targeted EGS R&D ($17,084,000) • Strategic R&D remains a key and fundamental part of the EGS subprogram and must run in parallel with the preparatory work at FORGE. ▪ EGS R&D FOA ($10,000,000) focused on addressing reservoir characterization—a key barrier to EGS success—through the development of improved technologies or techniques for imaging and monitoring the subsurface. ▪ Critical research and development efforts at the National Laboratories funded through the Annual Operating Plans, including funding for preparation and initial testing of the first-of-its-kind,	*Targeted EGS R&D ($4,500,000)* • Mission-critical R&D focused on addressing EGS barriers will continue to feed out-year activities at FORGE. Topics will focus on zonal isolation, novel stimulation methodologies, and unique well designs and configurations. • First-of-its-kind super-critical phase CO_2 EGS field pilot test, through the continuation of a competitively-selected project focused on the design of an innovative heat extraction methodology for EGS that does not require the use of water or reservoir stimulation. This project crosscuts the geothermal energy and carbon capture and geologic sequestration sectors. A successful outcome from this activity	*Targeted EGS R&D (-$12,584,000)* • The program will reduce its FY 2015 funding for targeted EGS R&D due to forward-funded FY 2014 R&D that allows the subprogram to focus on implementation of FORGE in FY 2015.

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs. FY 2014 Enacted
competitively selected super-critical phase CO_2 EGS field pilot project (LBNL) ($7,084,000).	would demonstrate the viability of the thermosiphon effect, and represent proof-of-concept for efficiently coupling CO_2 sequestration with geothermal energy production.	

Geothermal Technologies
Hydrothermal

Description
The U.S. Geological Survey's (USGS) 2008 Geothermal Resource Assessment estimated that 30,000 MW (range was from a P95 of 7,900 MW to a P5 of 73,000 MW) of undiscovered hydrothermal resources could still be found in the western U.S. alone, representing the potential to increase current U.S. geothermal energy production capacity by a multiple of 10 from the current 3.4 GW installed. These resources are defined by the presence of three key elements associated with geologically active areas: heat, fluid, and permeability (the ability for fluid to flow through rock). However, most of these resources are categorized as undiscovered or "blind" systems (i.e., showing little to no surface expression). The risks and costs associated with geothermal development in these poorly characterized areas are high, and the inability to consistently drill economically viable wells is therefore a major barrier to near-term capacity expansion. The Hydrothermal subprogram addresses this challenge through critical research, development and technical analysis.

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

Key recent accomplishments in the hydrothermal subprogram include the following:

- In FY 2013, an innovative exploration project at Caldwell Ranch in California culminated in the confirmation of an initial 11.4 MW of equivalent steam—50 percent more than early estimates—from three previously abandoned wells. This was the first geothermal project where an abandoned steam field has been successfully re-opened for production after approximately 20 years of thermal regeneration. With a dramatic improvement of well productivity, this success creates the potential to bring commercial increases at unproductive geothermal wells nationwide. The project also succeeded in lowering carbon dioxide concentrations and other deleterious gases in the steam by more than 65 percent.
- Also in FY 2013, the program completed a project that takes advantage of essentially free geothermal fluid production for emission-free geothermal power generation—as a byproduct of gold mining—to generate electricity for less than 6 cents/kWh. This patented plug-and-play technology is the first in the nation to employ cost-free geothermal brine at a mine operation and the technology has the potential for extremely broad application in many parts of the country and internationally, including oil and gas operations.

To address critical challenges to the development of undiscovered hydrothermal, in FY 2015 the subprogram will pursue the following initiatives:

<u>Targeted R&D and Leveraging O&G Technologies ($4 million)</u>
In FY 2015, this activity will work to more aggressively transfer select oil and gas exploration, drilling, and completion technologies to the geothermal industry—and to and modify them for typical geothermal subsurface environments—via laboratory R&D funding as well as competitive FOA funding. These funds will support blind resource characterization, downhole completion tool development, and technologies for geochemical and isotope signals that can also provide important clues to the presence of "blind" geothermal systems but that currently do not provide consistently reliable, low risk results.

<u>Play Fairway Analysis ($4.5 million)</u>
Results from ongoing projects, discussions with the private industry, and the subprogram's exploration technologies roadmapping have conclusively shown that industry needs better tools to predict heat and permeability in the subsurface as well as reduce the overall risk of geothermal exploration. In FY 2014, the subprogram initiated a new regional exploration effort in Play Fairway Analysis to collect data and perform the initial mapping of prospective areas on a regional basis, and quickly provide these maps and analyses to industry, demonstrate and validate the value of this approach.

Integral to this effort was identification of critical data gaps, where the mapping in highly ranked areas could be made far more accurate through additional, select data collection such as temperature gradient wells. This FY 2014 effort was the first geothermal play fairway effort in the world.

In FY 2015, the subprogram will continue to focus on development of Play Fairway Analysis through the completion of Phase II of previously funded competitive awards. These regional exploration efforts will provide informational tools and techniques that allow developers to more successfully target exploration areas, improve the accuracy of maps, augment the probability of success and certainty of resource size, and develop resources economically (see Figure 4). Additional laboratory R&D funding will be provided to support the development of key indicators to inform exploration for blind geothermal systems and to also develop new tools and applications to reduce the overall cost of drilling geothermal wells. New FOAs will then target exploration slim hole and/or temperature gradient well drilling to confirm and characterize in more detail the prospective geothermal areas derived from the Play Fairway Analysis maps.

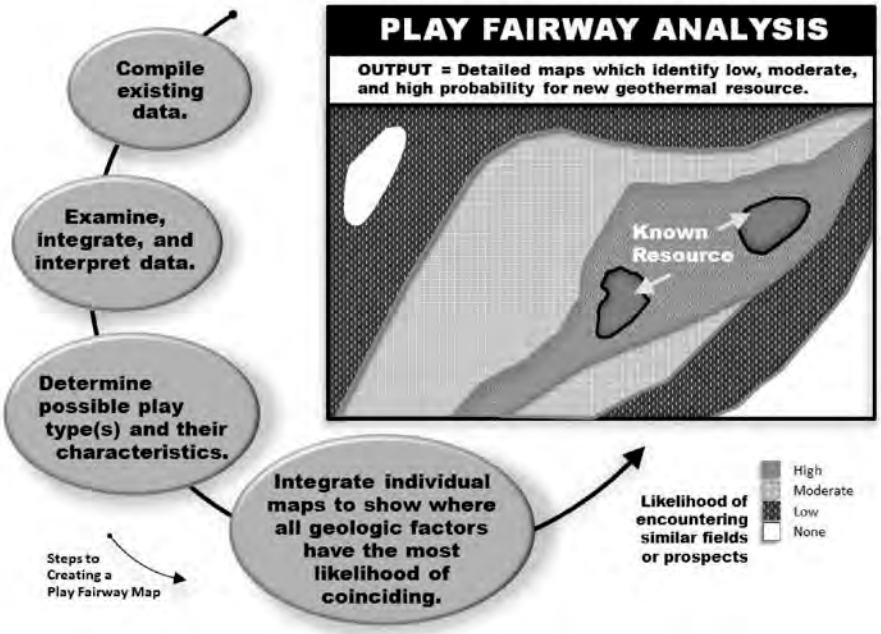

Figure 4: Illustrative Example of Geothermal Play Fairway Map

<u>Incubator activity ($3.0 million)</u>
In FY 2015, Geothermal Technologies will provide up to $3.0 million via a focused FOA for the Geothermal Incubator activity to support the funding of early-stage development projects. The Incubator will provide early-stage assistance to help industries, including new start-up businesses and/or new business units within an existing commercial entity, to cross technological barriers to commercialization with potentially high-impact "off-roadmap" technologies associated with overall cost and risk reduction of developing geothermal power, or technologies associated with thermal energy generation such as low-temp/desalination, or advanced direct use.

<u>Subsurface Crosscut Roadmapping and R&D activity ($6.0 million)</u>
The program will address select subsurface challenges that are critical to geothermal energy production and that share commonalities across DOE program offices, including the Offices of Fossil Energy, Nuclear Energy, Environmental Management, and Science. As previously mentioned, key subsurface challenges are identified as 1) efficiently and accurately discovering, characterizing, and predicting the location of target subsurface geologic environments and quantitatively inferring their evolution under future engineered conditions; 2) safely and cost-effectively accessing the subsurface through drilling or mining with properly managed reservoir integrity; 3) engineering or constructing the desired subsurface conditions in challenging high-pressure/high-temperature environments; 4) maintaining these conditions over multi-decadal or longer time frames throughout complex thermal-hydrological-mechanical-chemical (THMC) system evolution; and 5) monitoring the subsurface, which includes improving observational methods and advancing understanding of the microscopic basis of macroscopic complexity throughout system lifetimes. FY 2015 activities will

target common R&D challenges in the geothermal portfolio, including subsurface characterization and an initial scoping and planning for an In-Field EGS Initiative to accelerate the addition of 10s-100s of MW of geothermal capacity at existing hydrothermal power plants through development of an in-field geothermal reservoir stimulation protocol. The National Renewable Energy Lab estimates 7-10 GW of resource from in-field and near-field EGS Is available in the U.S. This effort will promote industry dialogue, planning, and collaboration; leverage expertise and interest from other subsurface sectors; and coordinate with federal agencies, DOE National Labs, and other subsurface stakeholders.

Hydrothermal

Activities and Explanation of Changes

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs. FY 2014 Enacted
Hydrothermal		
• The subprogram will focus on supporting the development of technologies necessary to effectively find and access "blind" resources at lower cost, enabling them to be developed and brought online by the private sector. Planned activities under this funding level include: ▪ Initiation of Play Fairway Analysis, an assessment of exploration risk on a regional scale based on the analysis of data to highlight the most prospective parts of a region ($3,000,000); ▪ Targeted IET R&D activities focused on HT/HP tool development, blind resource characterization and exploration, downhole completion tool development, and O&G drilling/completion transfer ($6,535,000); and ▪ Initiate subsurface crosscut roadmapping and R&D activities to address R&D issues common across DOE program offices ($750,000).	• The subprogram will focus on Play Fairway analysis through the completion of Phase II of previously funded competitive awards. These regional exploration efforts will allow developers to more successfully target exploration areas, improve the accuracy of maps, augment the probability of success and certainty of resource size, and develop resources economically. New FOAs will target exploration slim hole and/or temperature gradient well drilling to characterize the prospective geothermal areas derived from the Play Fairway Analysis maps ($4,500,000). • Targeted IET R&D activities focused on blind resource characterization and exploration, downhole completion tool development, and O&G drilling/completion transfer ($4,000,000). • Initiation of Geothermal Incubator - provide early-stage assistance to help industries – including new start-up businesses and/or new business units within an existing commercial entity – cross technological barriers to commercialization with potentially high-impact "off-roadmap" new technologies ($3,000,000). • Subsurface crosscut roadmapping and R&D activities in FY 2015 will focus on common challenges including subsurface characterization and initial development for an in-field geothermal reservoir stimulation protocol that can accelerate the addition of 10s-100s MW of new geothermal capacity at existing hydrothermal power plants ($6,000,000).	• This increased funding reflects the launch of the Geothermal Incubator activity and the Subsurface crosscut roadmapping and R&D as well as slightly decreased funding for exploration technologies.

Geothermal Technologies
Low Temperature and Coproduced Resources

Description
The Low Temperature and Coproduced Resources subprogram is focused on targeted RD&D for geothermal resources below a temperature of 300°F (150°C); as well as geothermal resources that can be co-developed with existing well-field infrastructure, with strategic or critical materials or in combination with other clean energy technologies. Although these low-temperature resources have a lower efficiency of power conversion than other geothermal resources—due to the lower temperature fluids—this resource is abundant; highly accessible across the U.S.; and as in the case of co-produced fluids, have much of the necessary infrastructure in place, thereby lowering the LCOE. Improving the efficiency of lower temperature geothermal systems enables near-term development of innovative geothermal technologies in geographically diverse areas of the U.S. The subprogram also includes consideration of the high value for direct use/direct heating applications, as these can displace the need for less thermally-efficient energy sources.

In FY 2014, the subprogram focused on initiating feasibility studies of strategic mineral extraction from geothermal brines in conjunction with power production. This combined production path approach will improve the value proposition of low-to-moderate temperature resources. The objectives of this initiative include improving industry's ability to develop, adapt, and validate extraction technologies, as well as to ultimately convert the materials extracted by these technologies into saleable products. Importantly, many of these materials have national strategic value or application to advanced energy or manufacturing technologies, particularly for renewable energy technologies.

Strategic Materials ($4.0 million)
In FY 2015, the subprogram will expand upon the strategic materials initiative begun in FY 2014 by releasing a new competitive FOA focused on transitioning the most successful feasibility studies to technology prototype development or field demonstration project(s). The program views strategic materials as having the ability to augment commerciality of low temperature geothermal systems, while also addressing critical national needs. By collaborating with geothermal and mineral industry stakeholders to develop additional revenue streams from brines, the economic viability of geothermal projects will increase while also increasing the potential geographic distribution of this base-load energy resource. This FOA will bridge the gap between applied R&D and commercial adoption of geothermal mining technologies by allowing cost-shared demonstrations of extraction technologies at geothermal mining and power production sites. The USGS, due to their expertise in mineral deposits, will be a critical partner in this effort.

Low Temperature R&D ($1.0 million)
In FY 2015, the subprogram will dedicate targeted RD&D to innovative energy conversion, additional revenue-stream creation and further advancement of the traditional organic Rankine cycle, based upon strategic planning that indicated these areas should continue to be supported by the subprogram. Specific developments in this area will include renewable power hybrid cycles, advanced desalination technologies coupled with geothermal generation, and power cycle improvements—with the goal of steadily increasing the value of geothermal brine. These R&D activities will promote the expansion of the geothermal market through the development of technologies that increase the brine effectiveness (efficiency) of produced fluids.

Direct Use Activity ($1.0 million)
Additionally, the subprogram will issue a competitive funding solicitation to conduct feasibility studies for assessment and evaluation of prospective direct use/low temperature systems in geologically distinct parts of the country that currently lack geothermal development. Direct use geothermal applications have the potential to provide cost-effective, renewable energy in large portions of the country. Many of these opportunities will exist in sedimentary basins, where legacy oil and gas drilling data can provide valuable technical information to identify and confirm direct use targets. Further, since direct use geothermal can replace the need for conventional high-temperature power generation for the relatively modest temperature requirements of heating and cooling, it may assist in valuable grid management by providing utilities with effective demand management and demand reduction. This effort will be a first-of-its-kind, large-scale feasibility and resource assessment for direct use applications in the U.S., and could benefit large sites such as college and university campuses, business districts and complexes, and similar large-scale applications. Importantly, many of these opportunities may have existing in-place infrastructure.

This direct use initiative could also lead to dramatically expanded geothermal development in the central and eastern US through a combination of deep wells coupled with advanced low temperature electricity generation units and cascaded-use surface technologies. If the results of the initial feasibility studies are positive, there is potential for the direct use market to grow in size to approximate that of geothermal heat pumps, displacing the use of an equivalent 1.0+ GW of electricity and, via this substitution, reducing greenhouse gas emissions.

Low Temperature and Coproduced Resources

Activities and Explanation of Changes

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs. FY 2014 Enacted
Low Temperature and Coproduced Resources		
• Begin the Strategic Materials initiative by issuing a Phase I FOA to fund feasibility studies of extraction technology prototype development or field demonstration projects ($3,000,000). • Targeted R&D of hybrid cycles for binary power plants. • Show 20 percent efficiency improvements for hybrid cycles compared to current binary power plant technology. • Complete the validation of the economics of binary units in commercial O&G applications. • Disseminate the Low-Temperature Geothermal Resource Assessment digital data series in cooperation with the U.S. Geological Survey.	• Initiation of Phase II of Strategic Materials FOA ($4,000,000). • Continuing from FY 2014 funded efforts, transition the most successful feasibility studies to technology prototype development or field demonstration project(s) • Fund cost-shared demonstrations of extraction technologies at geothermal mining and power production sites • R&D of value-added surface technologies ($1,000,000). • Demonstrate a commercial-ready hybrid cycle binary power plant in cooperation with National lab and industry partners. • Through the use of Metal Organic Heat Carriers (MOHCs) in a commercial binary plant, improve the heat transfer coefficients in the plant's heat exchanger by at least 5 percent • Successfully demonstrate that the thermal energy in low-temperature geothermal fluid is sufficient to drive a Forward Osmosis water purification process. • Initiation of Direct Use FOA to identify and assess new geothermal resource opportunities ($1,000,000).	• The increase is due to funding of a follow-on opportunity that leverages successful FY 2014 Strategic Materials feasibility project and initiation of a funding opportunity for innovative direct use projects focused on the thermal component of geothermal resources in new areas beyond more traditional geothermal regions.

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 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 subprogram primarily conducts analyses in the following areas: the environmental impacts of geothermal; the policy and regulatory barriers to development and deployment; economic modeling and validation of geothermal technologies; and collecting and disseminating data for public use to spur geothermal development. Lessons learned resulting from these analyses are subsequently incorporated into the program's Multi-Year Program Plan and either validate or refine the program's overall strategic direction. The subprogram conducts these activities in partnership with the National Labs, Federal agencies, academic institutions, and industry stakeholders.

Key recent accomplishments in the Systems Analysis subprogram include the following:

- In FY 2013, Geothermal Technologies issued a Geothermal Regulatory Roadmap (GRR) for ten geothermal-rich states to help developers navigate regulatory requirements to deploy geothermal energy projects—a key step to reducing the permitting time required for geothermal power plant development. By strengthening collaboration and facilitating the accelerated review of proposed projects, the GRR can ultimately lower development costs and reduce financial risk for utilities. In a White House Report to the President issued in May 2013, [6] the GRR is highlighted as a best practice for improving the performance of federal permitting and review of infrastructure projects.
- In FY 2014, the program will deploy the National Geothermal Data System (NGDS), a "best-in-class" data collection and dissemination effort. This initiative aggregates data from all 50 state geological surveys and DOE-funded projects, and is critical to advancing geothermal research and resource development. Further, NGDS was developed in alignment with the Administration's goals[7] for promoting readily accessible "open data" as well as expanding public access to federally-funded R&D data.[8]

In FY 2015, the subprogram will fund the following activities:

- Environmental analysis of regionally based life-cycle use of water for different geothermal technologies including the development of best practices for minimizing life-cycle water consumption, as well as life-cycle greenhouse gas (GHG) emission for geothermal energy, including potential opportunities for GHG reduction.
- Techno-economic analysis and validation of the impact of investments on the geothermal sector, including tracking the commercialization of funded R&D investments.
- Economic analysis of regional geothermal power plant production and injection data to gain a better understanding of reservoir and well productivity over time.
- Regional modeling and analysis of power generation, as well as commercial geothermal resources ("geothermal reserves") that will allow us to develop updated assessment of resource targets in the U.S., which complements the program's Play Fairway initiative.
- Content sustainability for the National Geothermal Data System, which will fund a competitive funding announcement to support transitional year one operations of the NGDS by ensuring the continued collection of critical data into the system.
- Economic analysis of geothermal direct use applications, including the displacement of other energy source requirements for heating and cooling, as well as an associated environmental and greenhouse gas reduction benefits.
- Analysis of the unique baseload value of geothermal energy, as well as the ability for geothermal to be a load following energy source.

[6] http://www.whitehouse.gov/sites/default/files/omb/reports/report-to-the-president-rebuilding-americas-infrastructure.pdf.
[7] http://www.whitehouse.gov/sites/default/files/omb/memoranda/2013/m-13-13.pdf.
[8] http://www.whitehouse.gov/sites/default/files/microsites/ostp/ostp_public_access_memo_2013.pdf.

Systems Analysis

Activities and Explanation of Changes

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs. FY 2014 Enacted
Systems Analysis		
• The subprogram will continue to conduct analyses and develop tools to reduce development and deployment barriers to geothermal development in the U.S.; as well as conduct cross-cutting analysis to identify, validate, and assess progress being made across the geothermal sector. Planned activities under this funding level include: ▪ Completing design and testing of the NGDS—an interactive, open-source database that includes geothermal data from providers across the U.S., including all 50 states' geological surveys, leading academic geothermal centers, and various federal agencies—for deployment in spring 2014; ▪ Developing permitting flow charts for geothermal projects for an additional 2 western states; ▪ Conducting Best Practices analyses to identify opportunities to further streamline the permitting process; ▪ Conducting analysis of commercial geothermal resource in the U.S., including resource potential estimates for in-field EGS, shallow EGS, and low-temperature for direct used and co-generation; Assessing the environmental factors, policies, and regulations effecting enhanced geothermal systems; and Updating the analysis of LCOE breakdown by drilling, exploration, and reservoir creation using the Geothermal Electricity Technology Evaluation Model (GETEM).	• The subprogram will continue to conduct analyses and develop tools to reduce development and deployment barriers to geothermal development in the U.S.; as well as conduct cross-cutting analysis to identify, validate, and assess progress being made across the geothermal sector. Proposed work under this budget request include: ▪ Environmental analyses that continue to assess the lifecycle greenhouse gas and water use impacts of geothermal systems, incorporating the latest data on EGS; ▪ Policy and regulatory analysis including an updated assessment of financial policies and market drivers effecting the geothermal sector, as well as continued collaborations with federal and state governments to streamline the permitting and environmental review process for geothermal projects; ▪ Techno-economic analysis including an impact assessment study of the emerging and commercialized technologies initially funded by the R&D portfolio; and ▪ Data collection and tools development including development of a node-in-a-box repository for public sharing of data resulting from the FORGE initiative.	• Minimal change in funding is requested to reflect the subprogram's continued focus on analysis and tools that help to reduce barriers to "speed and scale" adoption of geothermal in the U.S. and validate and assess technical progress across the geothermal sector.

Geothermal Technologies
NREL Site-Wide Facility Support

Description

In FY 2015, EERE will continue to 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. This practice is consistent with other National Laboratories. EERE began this practice in FY 2014 to reduce NREL's labor rate multiplier, thereby reducing the cost barrier to accessing unique NREL capabilities (such as facilities and staff expertise) by industry and academia. This practice also makes site operating costs more transparent in order to facilitate cost control and planning. In FY 2014, this practice resulted in a reduction in the Lab-wide direct labor multiplier of approximately 15 percent compared to FY 2013. The proposed FY 2015 budget continues this approach. The site-wide facility support funds cover maintenance and engineering support; fire, emergency, and custodial services; general utilities; network infrastructure and licenses; environment, safety, and health support; and sustainability. By moving these costs from laboratory overhead to direct funding, EERE gains a faster and greater impact on renewable energy and energy efficiency technology transfer by making it easier for universities and companies to access NREL capabilities and expertise.

This funding supports research programs by providing basic site services, functions, and infrastructure for Site Operations, which includes: Management, Building Operations, Building & Grounds Maintenance, Fire & Emergency Response, Engineering & Construction support, Minor Construction projects, Electrical Safety Program, Utilities, and Facilities Planning Support; and activities within the Sustainability and Environmental Health and Safety (EHS) portfolios. These activities and their costs are relatively fixed and only vary significantly based upon variations in commodities, construction activity, emergencies, weather patterns, etc. They are considered to be the core functions for site operations, safety, environmental compliance, and sustainability at NREL. In FY 2015, this funding will support more than 60 full time equivalents that manage and provide support for these core functions. It will also fund site-wide subcontracts such as janitorial services, refuse and recycling, and subcontracts for minor construction. Additionally, this funding will support site-wide costs associated with maintaining NREL's leadership position, such as: maintaining International Organization for Standardization (ISO), American Association for Laboratory Accreditation (A2LA), and other lab-wide accreditations, managing facilities to enable mission goals, improving sustainability, pollution prevention, waste minimization, improving energy efficiency, reducing water use, and maintaining an effective emergency management system.

The FY 2015 contribution from each program differs from the FY 2014 allocation, because EERE has developed a more precise, equitable, and economically neutral method that ensures a net-zero impact on program's funding. For each program, the contribution to direct funding for site-wide facility support is equivalent to the estimated contribution the program otherwise would have made through overhead charges. This method is based upon each program's level of funding to NREL, adjusted to account for anomalies from capital expenditures and major subcontracts.

NREL Site-Wide Facility Support

Activities and Explanation of Changes

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs. FY 2014 Enacted
NREL Site-Wide Facility Support		
• No NREL site-wide facility support costs funded through Geothermal Technologies.	• 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.	• The delta is the result in a change in methodology used to allocate site-wide facility support contributions amongst programs. The FY 2015 value enables and directly equates to the programs' estimated savings gained from the reduced labor multiplier.

Geothermal Technologies
Performance Measures

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

	FY 2013	FY 2014	FY 2015
Performance Goal (Measure)	**Reduce the LCOE from newly developed geothermal systems (cents/kWh)**		
Target	22.5 cents/KWh	22.4 cents/kWh	22.3 cents/kWh
Result	Met – 22.5	N/A	N/A
Endpoint Target	6 cents/kWh by 2030		

Advanced Manufacturing

Overview

Manufacturing converts a wide range of raw materials, components, and parts into finished goods that meet market expectations. Manufacturing provides 12% of U.S. Gross Domestic Product (GDP), employs 12 million Americans, and is critical to future U.S. innovation, global economic competitiveness, and job growth. Public investments can bring together manufacturers, research institutions, suppliers, and universities to develop critical foundational technologies. EERE's Advanced Manufacturing program makes such investments across three pillars: (1) industry-specific manufacturing efficiency investments targeting energy-intense industries, (2) widely applicable energy efficiency investments as a platform for manufacturing competitiveness in multiple industries, and (3) cross-cutting materials and manufacturing process technologies investments with potential use across a range of clean energy applications. The Advanced Manufacturing program seeks to ensure that clean energy innovations developed through public support ultimately lead to manufacturing competitiveness and advanced manufacturing jobs in the U.S.

The Advanced Manufacturing supports a targeted technology portfolio that accelerates research, development, demonstration, and deployment of these technologies to increase the energy efficiency, productivity, and competitiveness of U.S. manufacturing. Advanced Manufacturing's sub-programs in Figure 1 are:

- Next Generation Manufacturing R&D Projects will focus on the development of industry-specific and cross-cutting manufacturing technologies.
- Advanced Manufacturing R&D Facilities will create Institutes and facilities where industry and research institutions conduct shared, pre-commercial R&D on high-impact cross-cutting advanced manufacturing innovations applicable to clean energy products and industrial energy productivity to advance their readiness toward domestic commercial production.
- Industrial Technical Assistance will support the deployment of energy-efficient manufacturing technologies and practices through corporate commitment engagement, tools and training, site assessments, and expert advice.

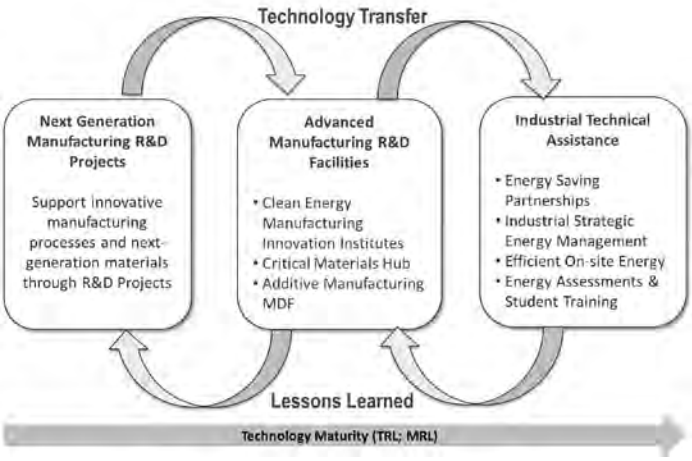

Figure 1: Advance Manufacturing Structure

Cutting-edge R&D and technical assistance activities will strengthen American manufacturing competitiveness and leadership in energy efficient and clean energy products manufacturing. The program's main objectives are to:

- Improve industry-specific and cross-cutting foundational industrial technologies and processes to save energy and/or enable new manufacturing capabilities across multiple clean energy industries.
- Reduce life-cycle energy consumption by 50% through next generation materials and manufacturing for selected high-energy-use products.
- Address top critical materials issues facing the clean energy manufacturing industry.
- Develop, demonstrate, and assist industry with adoption of cost-competitive combined heat and power technologies.
- Demonstrate technical and economic viability of improved energy management approaches with market leaders.
- Support off-roadmap emerging approaches with the potential for high-impact manufacturing technology breakthroughs.

Highlights of the FY 2015 Budget Request

The FY 2015 budget request is $125 million above the FY 2014 enacted level, which enables support for new R&D projects, R&D facilities with significant forward-funding, and industrial technical assistance. The program conducts systems analysis and strategic planning to assess opportunities for industrial energy savings, life cycle and cross-sector energy impacts, and improved energy productivity, through (1) technology workshops with industry, lab, and academic experts; (2) detailed technical analysis of the potential for advancement from the energy requirements for current economically viable state-of-the-art processes toward the minimum energy requirements achievable through new technologies in specific manufacturing industries; and (3) determining cross-sector impacts of current and potential investments. Supported areas include:

- Next generation materials that can enable the manufacture of low-cost, high-performance products with broad applicability, including for the energy intensive and clean energy industries. Example materials include low-cost carbon fiber, low-cost titanium, functional coatings, next generation semiconductors for power electronics, and lightweight materials. These cross-cutting materials technologies have the potential to impact multiple clean energy applications. While they may be suited for multiple specific applications, their cost-effective manufacturing might not be addressed in any other program.
- Wide Bandgap Semiconductor Devices for Efficient Energy Systems: Wide bandgap (WBG) semiconductors that are being commercialized for lighting applications (following R&D investments by DOE and other Federal agencies) are expected to yield energy savings of about 12% of U.S. electricity for lighting.[1] The program targets new uses of WBG semiconductors, especially electric motors, which use about 38% of U.S. electricity and a large share of electricity for the energy-intensive manufacturing.[2]
- Low Temperature Industrial Heating and Processing: Replacements for current high-temperature materials processing for producing and/or recovering materials offer significant potential savings across a broad set of applications. Applications include water-based selective extraction of critical materials from low-grade ores, obsolete electronic equipment, and waste landfills and low-temperature/high-efficiency chemical or electrochemical processes. Opportunities for alternate thermal processes include new applications of electromagnetic energy such as microwave, radio frequency, ultra-violet or electron-beam processing to heat selected materials.[3]
- Additive Manufacturing and Efficient Composite Fabrication Techniques: The development of highly efficient manufacturing technologies for the next generation of materials and products will enable substantial energy savings across our economy. Additive manufacturing can reduce materials consumption by up to 95% and energy consumption by up to 50%. Automated lay-up and out-of-the-autoclave composite fabrication techniques can produce high-performance composites with lower energy requirements and faster production throughput. Both of these materials processing technologies have the potential to substantially reduce energy use and improve efficiency across key sectors of the U.S. economy.
- Efficient Chemical Processes and Separations: Improved reactions and separations can enable energy and cost savings, reduced water usage and a lower carbon footprint in energy-intensive industries such as desalination, chemical production, food processing, helium extraction[4], and oil refining. Innovative membranes with higher selectivity and low fouling characteristics have the potential to reduce energy requirements by up to 20% for high-demand chemicals, including oxygen and nitrogen.
- Smart Manufacturing: New technologies with broad applicability to manufacturing processes can reduce energy consumption as well as the use of materials and related costs. For example, the development of advanced forming and fabrication technology allows for the manufacture of components in near-final form, reducing post-processing, required materials, and energy input. Sensors and advanced process controls to automate processes also offers significant energy savings.
- Industrial Efficiency Technical Assistance: Technical assistance offers manufacturers the opportunity to establish energy savings targets and improve energy management with significant energy savings. Efforts include identifying and publishing best practices, technical assistance for efficient on-site distributed generation, and catalyzing the use of energy management and assessment tools. Effective industrial strategic energy management includes standardized energy management tools and protocols. They enable established and emerging industries to identify and invest in energy efficiency improvements; comply with international energy management standards (ISO 50001); adopt new flexible/adaptable processes and materials; and educate, re-train and certify the U.S. workforce.

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[1] Annual Energy Outlook, EIA, 2011.
[2] Waide and C. Brunner, "Energy-Efficiency Policy Opportunities for Electric Motor-Driven System." (Paris, France: International Energy Agency, 2011).
[3] Quadrennial Technology Review, U.S. DOE. September 2011, p. 75.
[4] Helium Stewardship Act of 2013, PL 113-40 (2013) http://www.gpo.gov/fdsys/pkg/PLAW-113publ40/pdf/PLAW-113publ40.pdf.

Advanced Manufacturing
Funding ($K)

	FY 2013 Current[5]	FY 2014 Enacted[6]	FY2014 Current	FY 2015 Request	FY 2015 vs FY 2014 Enacted
Advanced Manufacturing					
Next Generation Manufacturing R&D Projects	41,745	76,971	76,971	86,000	+9,029
Advanced Manufacturing R&D Facilities	55,009	81,500	81,500	190,500	+109,000
Industrial Technical Assistance	17,500	22,000	22,000	28,500	+6,500
NREL Site-Wide Facility Support	0	0	0	100	100
Total, Advanced Manufacturing	**114,254**	**180,471**	**180,471**	**305,100**	**+124,629**

SBIR/STTR:

- FY 2013 Transferred: SBIR: $2,546,000; STTR: $330,000
- FY 2014 Projected: SBIR: $4,437,000; STTR: $634,000
- FY 2015 Request: SBIR: $8,019,000; STTR: $1,106,000

[5] Funding reflects the transfer of SBIR/STTR to the Office of Science.
[6] FY2014 Enacted funding reflects the contractor foreign travel rescission of $107,720.

Advanced Manufacturing
Explanation of Major Changes ($K)

	FY 2015 vs FY 2014 Enacted
Next Generation Manufacturing R&D Projects: With R&D project award funding completed in FY 2014 for the previous Innovative Manufacturing Initiative FOA, the increased funding enables three to four new R&D project FOAs at approximately $20 million each. Moreover, the amount of funding available for the Advanced Manufacturing Incubator activity will be increased substantially to more broadly seek potentially revolutionary manufacturing advances.	**+9,029**
Advanced Manufacturing R&D Facilities: The increase in funding will allow the program to award and fully fund at least one additional Clean Energy Manufacturing Innovation Institute, as well as provide support for significant pay down of commitments to the existing Institutes that were awarded in previous years. In addition, this funding level will maintain support for the Critical Materials Hub.	**+109,000**
Industrial Technical Assistance: The program plans to maintain support for the IACs and SEP at levels similar to FY 2014 funding. The increase in funding reflects an intensified investment in CHP deployment activities through competitively awarded technical assistance to States and regions.	**+6,500**
NREL Site-Wide Facility Support: The delta is the result in a change in methodology used to allocate site-wide facility support contributions amongst the programs. The FY 2015 value enables and directly equates to the program's estimated savings gained from the reduced labor multiplier.	**+100**
Total, Advanced Manufacturing	**+124,629**

Advanced Manufacturing
Next Generation Manufacturing R&D Projects

Description

Through competitively-selected investments in foundational technologies, the program will increase the impact of its R&D in areas relevant to energy-intensive industries, widely applicable energy efficiency platform technologies, and clean energy manufacturing across multiple industries. The Next Generation Manufacturing R&D Projects subprogram will support projects at innovative American companies and research organizations that focus on specific high-impact manufacturing technology and process challenges in order to increase energy productivity as a central element of EERE's Clean Energy Manufacturing Initiative (CEMI). These projects will target successful development and transition of high-impact next generation production technologies into industrial implementation in domestic production facilities. This subprogram will also include continuation of previously initiated and front-funded awards from the Innovative Manufacturing Initiative Funding Opportunity Announcement (FOA), which targeted advancements in manufacturing technologies and materials. No additional funding is required in FY 2015 for the multi-year projects awarded under this previous FOA to continue forward.

Individual High-impact Foundational Technology Area FOAs ($70 million)

In FY 2015, three or four new individual competitive funding opportunities of approximately $20 million each will be released in specific innovative manufacturing technology areas. These foundational technology areas will be selected from the results of technology analyses and a series of workshops held beginning in 2012; future workshops planned by the program and CEMI; and by soliciting input from stakeholders through targeted requests for information (RFI) workshops prior to planning of the FOAs. Candidate topics will be selected based on the consideration of potential energy, environmental, and economic impacts (including reducing the energy intensity of production and producing items which reduce life cycle energy use); Additionality relative to existing public and private sector investments; degree of technical uncertainty and risk which limit potential private sector investment; potential for catalyzing influence of public sector investment; and opportunity for long range impact on domestic manufacturing. In addition to the wide bandgap semiconductors for power conversion applications topic area FOA expected in FY 2014, examples of candidate topics include cross-cutting microwave and radio frequency process technologies which could reduce heating requirements in numerous energy intensive industries; innovative membranes which could reduce separation energy requirements in industries including desalination, food processing, helium extraction, and chemicals production; and advanced low cost composites. Additional topics to be considered include next generation industrial thermal management technologies including advanced insulation and materials, waste heat recovery, high performance computer simulation of energy intensive manufacturing process, advanced sensors and controls, smart manufacturing (end-to-end integration of IT and knowledge technologies into manufacturing), and other emerging technologies with strong potential for dramatic improvement in energy efficiency and manufacturing competitiveness. Projects will be evaluated for selection through the competitive FOA process. In cases where R&D project opportunities are identified in topical areas complimentary to an existing manufacturing institute, the programs will be coordinated to ensure leveraging of existing support without overlap.

Advanced Manufacturing Incubator for High-Impact Foundational Technology ($14 million)

The Advanced Manufacturing Incubator activity will make competitively selected investments in a broad range of the technologies that can meet the goals of the Advanced Manufacturing program with no predetermination about specific technological pathways to allow the business community to propose ideas that may revolutionize the field of advanced manufacturing. These R&D projects will focus on the most fundamental of applied R&D projects that could have significant energy, environmental, and economic gains. This activity provides the incentive for small- and medium-size manufacturing companies to pursue emerging high-risk, high-impact technology developments that they otherwise would not pursue.

Life-Cycle Energy Analysis ($2 million)

In 2015, the program will accelerate its efforts to develop a life-cycle energy framework and methodology for determining the cross-sector impacts of process and materials improvements of potential program investments, providing the foundation for a robust R&D prioritization tool.

Next Generation Manufacturing R&D Projects

Activities and Explanation of Changes

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs FY 2014 Enacted
Next Generation Manufacturing R&D Projects		
• In FY 2014, the Advanced Manufacturing program will have completed funding for all competitively selected R&D projects under the broad Innovative Manufacturing Initiative FOA that closed in Dec. 2011. Additional funding supports one or more targeted Advanced Manufacturing Project funding opportunities to support projects in different foundational technology areas, including steel and combined heat and power. This activity addresses core technical issues for foundational technologies in manufacturing materials and processes that enable U.S. manufacturers to realize significant gains in energy productivity, environmental performance, product yield, and economic growth. .	• Through competitively selected R&D projects, the 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. Three or four targeted High-impact Foundational Technology Area FOAs will be supported in FY 2015. Each FOA will invest in different or complementary foundational technology solutions to manufacturing challenges and will provide approximately $20 million to support R&D projects in that area. In addition, an Advanced Manufacturing Incubator for High-Impact Foundational Technology FOA will supplement the individual targeted FOAs and is planned at approximately $14 million. This represents a strategy focused on high priority foundational technologies through targeted investments based on analyses of impact and alignment with U.S. competitive advantages.	• With R&D project award funding completed in FY 2014 for the previous Innovative Manufacturing Initiative FOA, the increased funding enabled three to four new R&D project FOAs at approximately $20 million each. Moreover, the amount of funding available for the Advanced Manufacturing Incubator activity will be increased substantially to more broadly seek potentially revolutionary manufacturing advances.

Advanced Manufacturing
Advanced Manufacturing R&D Facilities

Description

The Advanced Manufacturing R&D Facilities subprogram supports public-private partnership facilities for foundational manufacturing research and development. The subprogram also supports the transition of innovative, next generation material processes and production technologies to American manufacturing firms, including the most energy-intensive industries. The program's facilities, including Clean Energy Manufacturing Innovation Institutes, the Critical Materials Hub, and the Manufacturing Demonstration Facility, are designed to accelerate the development and implementation of cutting-edge technologies and help the United States position itself as a world leader in manufacturing by bringing together manufacturers, research institutions, suppliers, and universities. The benefits from these Clean Energy Manufacturing Innovation Institutes and other advanced manufacturing R&D facilities will be spread broadly across multiple industries and improve U.S. competitive advantage, especially for small- and medium-sized enterprises (SMEs). Further, the investments with universities and SMEs contribute to developing national capabilities that enable future global leadership.

Clean Energy Manufacturing Innovation Institutes ($155.5 million)

The FY 2015 funding will support up to $70 million for the creation and forward funding of at least one new Clean Energy Manufacturing Innovation Institute and will also provide annual and forward-funded support for two existing Institutes. These Institutes are consistent with the President's vision for a larger multi-agency National Network for Manufacturing Innovation (NNMI). The NNMI model[7] will induce collaboration and spread risk,[8] complement university research, and support innovation to increase competitiveness of U.S. manufacturers. The Clean Energy Manufacturing Innovation Institutes are designed to focus on foundational technologies that are broadly applicable and pervasive in multiple industries and markets with potentially transformational technical and manufacturing productivity impact. Institutes will be partnerships between government, industry, and academia, supported with cost-share funding from Federal and non-Federal sources. Within 5 to 7 years of its launch, each Institute is expected to be financially sustainable from private-sector and other sources without further direct funding from the Advanced Manufacturing program, and the multi-year award funding profiles for the Institutes will reflect this expectation.

The new Institute will be competitively selected, through a Funding Opportunities Announcement (FOA) focused on a foundational technology area, such as those identified for consideration at the Design for Impact workshops.[9] Candidate topics for this new Institute include scale-up of applied materials genome approaches and nanomaterials for energy; next generation electric machines; process intensification for chemical processes; bio-manufacturing scale-up; smart manufacturing for energy intense processes; and cross-cutting emergent topics in advanced manufacturing for clean energy.. Workshops with industry, academia, and other government organizations will be held on each of these topics to determine their suitability for an Institute FOA. Candidate topics will be selected based on the consideration of potential energy, environmental, and economic impacts of technology (including reducing the energy intensity of production and producing items which reduce life cycle energy use); Additionality relative to existing public and private sector investments in such facilities; technical uncertainty and risk which limit potential private sector investment; potential for catalyzing influence of public sector investment; and opportunity for long range impact on domestic manufacturing.

This activity will also support the Next Generation Power Electronics Manufacturing Innovation Institute, focused on wide bandgap semiconductor technology and selected through a FOA issued in FY 2013, and an Advanced Composites Manufacturing Innovation Institute selected through a FOA issued in FY 2014. The technical topic for the Wide Bandgap Semiconductor Technology institute is the next generation of energy-efficient, high-power electronic chips and devices. This technology will make power electronic devices like motors, consumer electronics, and devices that support our power grid faster, smaller, and more efficient. The institute will provide shared facilities, equipment, and testing and modeling capabilities to companies across the power electronics supply chain, particularly small and medium-size manufacturers, to help invent, design and manufacture new wide-bandgap semiconductor chips and devices. The technical topic area for an Advanced Composites institute is low cost, energy efficient manufacturing of fiber reinforced polymer composites. The Institute will target continuous or discontinuous, primarily carbon and glass, fiber systems, with thermoset or thermoplastic resin materials. These types of composites are foundational technologies that are broadly applicable and pervasive in

[7] Executive Office of the President National Science and Technology Council Advanced Manufacturing National Program Office, "National Network for Manufacturing Innovation: A Preliminary Design", March 2013.
[8] Massachusetts Institute of Technology, "A Preview of the MIT Production in the Innovation Economy Report", February 2013.
[9] http://www1.eere.energy.gov/manufacturing/resources/workshops.html.

multiple industries and markets with potentially transformational technical and economic impact. In coordination with the Office of Science, the program will implement a technical training program focused on wide bandgap power electronics which will consist of a mixture of classroom and project based practical experience.

The subprogram will track and assess the impact of all Clean Energy Manufacturing Innovation Institutes and – in cooperation with Department of Defense – of the National Additive Manufacturing Innovation Institute (America Makes), to ensure that supported facilities and activities contribute significantly to the program's clean energy, energy productivity, and manufacturing competitiveness goals. The final installment of planned funding for America Makes is also incorporated within the overall amount. These institutes will be actively managed as public-private partnerships through cooperative agreements, to ensure timely achievement of all technical, operational, organizational and partnership goals. This active management will explicitly include inputs and reviews from public and private sector experts to ensure the institutes are of high value to both public and private sector interests.

The Critical Materials Hub ($25 million)

In FY 2015, the Critical Material Hub, competitively awarded in FY 2013 to a team led by the Ames National Laboratory, will focus on technologies that will enable American manufacturers to make better use of the critical materials we have access to as well as 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 industry and other strategic industries like defense. This fourth year of funding for the Hub will enable it to continue to integrate scientific research, engineering innovation, and manufacturing and process improvements to provide holistic solutions to critical materials challenges facing the Nation.

Manufacturing Demonstration Facility ($10 million)

In FY 2015, the subprogram will continue to fund the Oak Ridge National Laboratory (ORNL) Manufacturing Demonstration Facility (MDF) with an additional $10 million in FY 2015 for the fourth year of its intended five-year funding profile. The MDF is a facility for industrial research partnerships related to additive manufacturing. Its work is supported through a combination of cost-shared cooperative research and development agreements focusing on specific manufacturing challenges, as well as competitively awarded research and development projects. The activities of the MDF are managed as an overall facility to ensure highly leveraged research and developments efforts consistent with the Advanced Manufacturing mission, without duplication or overlap with facilities elsewhere such as America Makes. The subprogram will develop assessment criteria for a full review at the end of five years. The subprogram is in a unique position to leverage and apply experience with the ORNL MDF to help ensure success in future centers in support of the President's vision for NNMI.

Advanced Manufacturing R&D Facilities

Activities and Explanation of Changes

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs FY 2014 Enacted
Advanced Manufacturing R&D Facilities		
• Supported the creation of at least two new Clean Energy Manufacturing Innovation Institutes, consistent with the President's vision for a larger, multi-agency National Network of Manufacturing Innovation (NNMI). These Institutes are intended to provide researchers – from small- and medium-sized enterprises (SMEs) and large businesses and from universities and other research organizations – timely, affordable access to cutting-edge physical and virtual manufacturing capabilities and to facilitate the development and transition of these technologies into the U.S. manufacturing sector to bolster its global competitiveness. DOE is planning to invest $70 million into each of these Institutes to be expended over the next 5 years with a forward-weighted funding profile. Supported $25 million of investment in the Critical Materials Hub, for its sustained, multi-year multidisciplinary effort to develop solutions across the lifecycle of critical materials.	• Supports the creation of at least one new Clean Energy Manufacturing Innovation Institute, consistent with the President's vision for a larger, multi-agency National Network of Manufacturing Innovation (NNMI). Provides annual and forward-funded support for the existing Institutes. DOE is planning to invest $70 million into each Institute to be expended over the next 5 years with a forward-weighted funding profile. Supports $25 million of investment in the Critical Materials Hub.	• The increase in funding will allow the program to award and fully fund at least one additional Institute, as well as provide support for significant pay down of commitments to the existing Institutes that were awarded in previous years. In addition, this funding level will maintain support for the Critical Materials Hub.

Advanced Manufacturing
Industrial Technical Assistance

Description

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

Industrial Technical Assistance ($28.5 million)

The subprogram is critical to the deployment of existing and future advanced energy efficiency technologies and practices. It has delivered technical assistance to thousands of industrial plants which have saved industry billions of dollars and cut carbon emissions by millions of tons. Advanced Manufacturing's CHP efforts support Executive Order 13624 which sets a national goal of 40 GW of new CHP by 2020. The cornerstone of the program's efforts are the CHP Technical Assistance Partnerships (CHP TAPs), which promote and assist in transforming the market for CHP, waste heat to power, and district energy with CHP technologies and concepts throughout the U.S. CHP TAP services include: market assessments for CHP, such as critical infrastructure; education and outreach that provides information on the benefits and applications of CHP to state and local policy makers, regulators, energy end-users, trade associations, and others; and technical assistance to energy end-users and others to help them consider CHP as a viable technical and economic opportunity for them. FY 2015 funding for these activities provides both ongoing support for the existing CHP TAP awards and $10.0 million for competitively awarded technical assistance to help States and regions to increase CHP deployment, including through the design of regulations, policies, or other actionable strategies informed by best practices.

The Better Buildings Better Plants program offers technical assistance and informational resources to manufacturers to help them identify and pursue opportunities to implement cost-effective energy efficiency improvements that save money, create jobs, and strengthen their competitiveness. The program will continue efforts to add more companies and members of their supply chains to the Better Plants program as industrial partners. These manufacturers establish energy savings targets, and some partners are investing in strategic energy management for greater energy savings -- strategic energy management is a long-term approach to efficiency that includes goals, tracking, and reporting. The program is advancing strategic energy management through Superior Energy Performance (SEP), an industry-led certification program that provides industrial facilities with a transparent, globally accepted system for verifying energy performance improvements and management practices. A central element of SEP is implementation of the global energy management standard, ISO 50001, with additional requirements to achieve and document energy performance improvements. DOE provided support for the development of this standard. Now that standards development is complete, DOE is coordinating the ANSI-accredited SEP certification bodies; recruiting and recognizing the early adopter facilities to build the SEP market; and integrating the facility-level SEP certification process with Better Plants corporate partner's efforts to drive continual energy performance improvement using the ISO 50001 energy management standard.

FY 2015 funding supports Industrial Assessment Centers (IACs), which conduct energy efficiency, productivity improvement, and waste reduction assessments for small- and medium-sized manufacturer at no cost to them. The IACs utilize engineering students for the assessments and teach them hands on skills and knowledge of industrial process systems, plant systems, energy systems, and energy management practices. DOE will also work with the IACs on the development and launch of an ABET accredited undergraduate energy engineer degree offering. Finally, the IACs coordinate with the nation's Manufacturing Extension Partnerships, state energy offices, and electric, natural gas and water utilities to maximize the savings potential for the small- and medium-sized clients. FY 2015 funding of $6.0 million completes the five-year funding cycle for the IACs, and it includes funds to assess the performance, nationwide impact, and overall benefit of the program.

Industrial Technical Assistance

Activities and Explanation of Changes

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs FY 2014 Enacted
Industrial Technical Assistance		
• The program will focus in four areas: Combined Heat and Power (CHP) deployment activities including the CHP Technical Assistance Partnerships; the Better Buildings Better Plants Program; Industrial Assessment Centers (IACs); and the Superior Energy Performance ISO/ANSI Certification. These efforts work together to drive a corporate culture of continuous improvement and wide-scale adoption of technologies, such as CHP, to reduce energy use and costs in the industrial sector.	• The program will continue to support Combined Heat and Power (CHP) deployment activities including the CHP Technical Assistance Partnerships and competitively awarded technical assistance to States and regions; the Better Buildings Better Plants Program; Industrial Assessment Centers (IACs); and the Superior Energy Performance ISO/ANSI Certification. These efforts work together to drive a corporate culture of continuous improvement and wide-scale adoption of technologies, such as CHP, to reduce energy use and costs in the industrial sector.	• The program plans to maintain support for the IACs and SEP at levels similar to FY 2014 funding. The increase in funding reflects an intensified investment in CHP deployment activities.

Advanced Manufacturing
NREL Site-Wide Facility Support

Description

In FY 2015, EERE will continue to 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. This practice is consistent with other National Laboratories. EERE began this practice in FY 2014 to reduce NREL's labor rate multiplier, thereby reducing the cost barrier to accessing unique NREL capabilities (such as facilities and staff expertise) by industry and academia. This practice also makes site operating costs more transparent in order to facilitate cost control and planning. In FY 2014, this practice resulted in a reduction in the Lab-wide direct labor multiplier of approximately 15% compared to FY 2013. Within the proposed FY 2015 budget continues this approach. The site-wide facility support funds cover maintenance and engineering support; fire, emergency, and custodial services; general utilities; network infrastructure and licenses; environment, safety, and health support; and sustainability. By moving these costs from laboratory overhead to direct funding, EERE accelerates technology transfer and mission impact by making it easier for companies and external researchers to access NREL capabilities and expertise.

This funding supports research programs by providing basic site services, functions, and infrastructure for Site Operations, which includes: management, building operations, building & grounds maintenance, fire & emergency response, engineering & construction support, minor construction projects, electrical safety program, utilities, and facilities planning support; and activities within the Sustainability and Environmental Health and Safety (EHS) portfolios. These activities and their costs are relatively fixed and only vary significantly based upon variations in commodities, construction activity, emergencies, weather patterns, etc. They are considered to be the core functions for site operations, safety, environmental compliance, and sustainability at NREL. In FY 2015, this funding will support more than 60 full time equivalents that manage and provide support for these core functions. It will also fund site-wide subcontracts such as janitorial services, refuse and recycling, and subcontracts for minor construction. Additionally, this funding will support site-wide costs associated with maintaining NREL's leadership position, such as: maintaining International Organization for Standardization (ISO), American Association for Laboratory Accreditation (A2LA), and other lab-wide accreditations, managing facilities to enable mission goals, improving sustainability, pollution prevention, waste minimization, improving energy efficiency, reducing water use, and maintaining an effective emergency management system.

The FY 2015 contribution from each program differs from the FY 2014 allocation, because EERE has developed a more precise, equitable, and economically neutral method that ensures a net-zero impact on programs' funding. For each program, the contribution to direct funding for site-wide facility support is equivalent to the estimated contribution the program otherwise would have made through overhead charges. This method is based upon each program's level of funding to NREL, adjusted to account for anomalies from capital expenditures and major subcontracts.

NREL Site-Wide Facility Support

Activities and Explanation of Changes

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs. FY 2014 Enacted
NREL Site-Wide Facility Support		
• No NREL site-wide facility support directly funded through the Advanced Manufacturing Office.	• Direct 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.	• The delta is the result in a change in methodology used to allocate site-wide facility support contributions amongst programs. The FY 2015 value enables and directly equates to the program's estimated savings gained from the reduced labor multiplier.

Advanced Manufacturing

Performance Measures

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

	FY 2013	FY 2014	FY 2015
Performance Goal (Measure)	**Next Generation Manufacturing R&D Projects - Demonstrate new manufacturing process technologies with the potential to improve manufacturing productivity through a measureable (> 25%) increase in energy efficiency**		
Target	2 Manufacturing Processes	2 Manufacturing Processes	2 Manufacturing Processes
Result	Met – 2	N/A	N/A
Endpoint Target	Demonstrate 10 manufacturing processes on an industrially relevant scale by 2024, leading to energy savings and increased U.S. competitiveness.		

Federal Energy Management Program

Overview

The U.S. Department of Energy's (DOE) Federal Energy Management Program (FEMP) assists and enables Federal agencies to meet energy-related and other sustainability goals as established through statute and Administrative action to provide Federal energy leadership to the Nation. FEMP works with key individuals in Federal agencies to accomplish energy, water, and greenhouse gas improvements within their organizations by providing expertise in Federal energy project and policy implementation and coordination and collaboration with non-Federal entities to enhance national efforts in energy management. By increasing its use of energy efficiency and renewable energy, the Federal sector leads by example, saving taxpayer dollars, meeting key Federal energy and greenhouse gas emission reduction goals, and spurring innovation and commercialization of clean energy technologies.

FEMP enables Federal agencies to use their funds more effectively to meet Federal and agency-specific energy management and other sustainability objectives. Working with our partners at the National Laboratories, FEMP offers technical expertise needed by other Federal agencies. FEMP provides guidance on best practices in energy management that it disseminates to all agencies, expertise on and management of government-wide performance contracting and the use of alternative fuels in the Federal vehicle fleet, and centralized reporting, data collection, and strategic government-wide communication. FEMP also provides technical guidance and assistance to all Federal agencies and reports to Congress on Federal Energy Efficiency, Federal Fleet Performance, Federal Use of Renewable Electric Power, and Federal compliance with relevant public law and Executive Order (E.O.) requirements.

The Sustainability Performance Office (SPO), funded within the DOE Specific Investments subprogram line, is DOE's internal lead for sustainability and directly supports the Department's Senior Sustainability Officer. SPO also coordinates data collection, reporting, and analysis of DOE's sustainability data, including energy, water, and resource use; manages and implements DOE's Strategic Sustainability Performance Plan; and provides oversight of energy, water, and resource assessments at DOE sites and National Laboratories. These activities, coupled with the implementation of energy conservation measures and efficiency improvements, promote DOE achievement of sustainability goals and reduce DOE's operating expenses, overall energy use, and greenhouse gas (GHG) emissions.

Highlights of the FY 2015 Budget Request

The overall FEMP budget in FY 2015 increases by approximately $8 million compared to FY 2014.

FEMP is increasing funding for Technical Guidance and Assistance by $6.2 million to support the establishment of a center of expertise focused on Federal Data Center Energy Efficiency and Optimization, increased project tracking, energy-efficient and sustainable building practices, technology deployment networks, and expanded renewable energy technical assistance. FEMP's broad range of assistance includes analytical support to Federal agencies for implementation of new technologies, development of Federal agency efficiency standards, specification of energy-efficient products for agency procurement, energy assessments, and assistance to help other agencies develop comprehensive planning and internal processes to reduce their energy use and to achieve Federal water consumption reduction goals.

FEMP is increasing funding for Project Financing by $1.9 million to support expanded development and implementation of critical tools for enhancing the effective use of project financing mechanisms, including: tools for streamlining ESPCs through the strategic sourcing initiative, expansion of the General Services Administration (GSA) schedule use for equipment replacements, and an updated protocol for measurement and verification of ESPCs. Federal agency use of ESPCs was authorized by Congress to provide a supplement to direct appropriations for funding energy-efficient improvements in Federal facilities. By using ESPCs and UESCs, agencies can take advantage of private sector expertise and pay for the investment through energy cost savings achieved over the life of the project.

FEMP is decreasing funding for Planning, Reporting, and Evaluation by $1.5 million. This decrease in funding will streamline activities related to program planning.

Other subprograms within the FEMP are being changed by less than $1 million.

Key Challenges

The program assists DOE and other Federal agencies achieve their energy efficiency and sustainability goals by optimizing their use of appropriated funding, and through increased use of performance contracting including energy saving

performance contracts (ESPCs), utility energy service contracts (UESCs), and power purchase agreements, as authorized. Performance contracting is an important mechanism to help Federal agencies achieve energy conservation and sustainability goals. FEMP has established an impressive track record, assisting multiple agencies since 1998 to establish contracts with guaranteed energy savings of more than 351 trillion Btu over the life of the agencies' projects. This savings is approximately equal to the energy consumption for all Federal facilities in fiscal year 2012.

Federal Energy Management Program
Funding ($K)

	FY 2013 Current[1]	FY 2014 Enacted	FY 2014 Current	FY 2015 Request	FY 2015 vs FY 2014 Enacted
Federal Energy Management Program					
Project Financing	9,501	9,558	9,558	11,433	+1,875
Technical Guidance and Assistance	9,126	6,224	6,224	12,433	+6,209
Planning, Reporting and Evaluation	4,324	5,569	5,569	4,073	-1,496
Federal Fleet	1,540	1,388	1,388	1,634	+246
Federal Energy Efficiency Fund	0	3,000	3,000	3,000	0
DOE Specific Investments	3,774	2,509	2,509	2,927	+418
NREL Site-Wide Facility Support	0	0	0	700	+700
Total, Federal Energy Management Program	**28,265**	**28,248**	**28,248**	**36,200**	**+7,952**

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

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

	FY 2015 vs FY 2014 Enacted
Project Financing: Increase supports expanded marketing and outreach and the development and implementation of tools for streamlining ESPC, expansion of the GSA schedule use for equipment replacements, and an updated protocol for measurement and verification of ESPCs.	**+1,875**
Technical Guidance and Assistance: Increase supports the establishment of a center of expertise focused on Federal Data Center Energy Efficiency and Optimization, project tracking energy-efficient and sustainable building practices, technology deployment networks; and expanded renewable energy technical assistance.	**+6,209**
Planning, Reporting and Evaluation: Decrease in funding reflects the streamlining of activities in this subprogram.	**-1,496**
Federal Fleet: No significant change.	**+246**
Federal Energy Efficiency Fund: No change.	**0**
DOE Specific Investments: No significant change.	**+418**
NREL Site-Wide Facility Support: Delta is the result in a change in methodology used to allocate site-wide facility support contributions among programs. The FY 2015 value enables and directly equates to the program's estimated savings gained from the reduced labor multiplier.	**+700**
Total, Federal Energy Management Program	**+7,952**

Federal Energy Management Program
Project Financing

Description

Congress authorized Federal agency use of ESPCs to help Federal agencies achieve energy conservation and sustainability goals through energy efficiency improvements in Federal facilities. By using ESPCs and UESCs, the Government pays back the third-party investment through energy, and operations and maintenance savings achieved over the project's life. ESPC and UESC projects can include energy and water-efficiency improvements, renewable energy technologies, renewable alternative fuel (biomass/landfill), combined heat and power, advanced metering, and power management. These projects must improve site or system-wide energy efficiency and be life-cycle cost effective.

From FY 2005 to FY 2012, this subprogram facilitated $3.6 billion of private-sector efficiency investments in Federal Government facilities from performance-based contracts, which will result in energy cost savings of approximately $9.8 billion over the life of the energy-saving measures, without any up-front investments from the American taxpayer. The savings on utility bills and operation and maintenance created through these facility upgrades are used to pay the private contractor for the project over the term of the contract, and in most cases, the agencies continue to save money and energy after the contract term ends.

With requested funding, FEMP will continue to leverage its Federal financing expertise to assist site staff and management with initial decision making on the scope of performance contracts, project facilitators to guide agencies through ESPC project development and implementation, beginning and advanced training for Federal personnel in project financing, and tracking of project implementation and performance.

The subprogram's assistance includes the management of the DOE Indefinite Delivery, Indefinite Quantity (IDIQ) contracts for ESPCs. DOE intends to solicit Energy Savings Performance Contracts (ESPCs) by way of DOE Indefinite Delivery Indefinite Quantity (IDIQ) contracts under the authority of 42 USC 8287. DOE anticipates posting of a solicitation during approximately mid-2014 with anticipated awards in approximately mid-2015. The IDIQ contracts will allow for task orders to be placed between Federal agencies and Energy Service Companies (ESCOs) that are competitively awarded contracts.

Project Financing

Activities and Explanation of Changes

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs FY 2014 Enacted
Project Financing		
Support Federal agencies in identifying and implementing energy projects using performance contracting.	Support Federal agencies in identifying and implementing energy projects using performance contracting and expand marketing, streamline processes, expansion of the GSA schedule use for equipment replacements, and create a new protocol for measurement and verification of ESPCs.	Increase will support expanded marketing and outreach and the development and implementation of: tools for streamlining ESPC, expansion of the GSA schedule use for equipment replacements, and a new protocol for measurement and verification of ESPCs.

Federal Energy Management Program
Technical Guidance and Assistance

Description
The Technical Guidance and Assistance subprogram supports the program's mission by helping agencies implement projects and practices that reduce energy bills and promote the use of water conservation, energy efficiency, and renewable energy. The program's technical assistance on energy efficiency and renewable energy technologies results in accelerated Federal sector adoption of these technologies.

The subprogram's assistance helps agencies reach the goals set forth by the EPAct 2005, E.O. 13423, the EISA 2007, and E.O. 13514. Current government-wide goals include the following:

- Improve energy efficiency and reduce GHG emissions of each agency, through the reduction of energy intensity by 3 percent annually, or 30 percent by the end of FY 2015, relative to the baseline of the agency's energy use in FY 2003 (EISA 2007);
- Ensure that at least 7.5 percent of Federal electricity consumption is generated from renewable sources in FY 2014 and 20 percent by 2020 (EPAct 2005, President's Climate Action Plan);
- Ensure that at least half of the statutorily required renewable energy consumed by the agency in a fiscal year comes from new renewable sources (after 1999) and, to the extent feasible, the agency implements renewable energy generation projects on Federal or Indian property for agency use (E.O. 13423); and
- Reduce water consumption intensity by 2 percent annually, or 26 percent by the end of FY 2020 as compared to the FY 2007 base year (E.O. 13514).

The subprogram's broad range of assistance includes the following:

- Analytical support from National Laboratories;
- New technology deployment;
- Direct technical assistance on capital projects;
- Development of Federal agency efficiency standards;
- Specification of energy-efficient products for agency procurement;
- Energy assessments; and
- Other assistance to help other agencies develop comprehensive planning and internal processes to reduce their energy use and to achieve Federal water consumption goals.

Specifically, the subprogram supports data center efficiency and optimization initiatives by encouraging Federal agencies to adopt best practices, construct and manage energy-efficient core data centers, and educate energy managers and information technology professionals. To accelerate progress in this area and the development of relevant technical knowledge, FY 2015 funding supports the establishment of a center of expertise focused on Federal Data Center Energy Efficiency and Optimization. For energy-intensive Federal laboratories, the subprogram develops tools designed to help Federal agencies optimize laboratory energy and environmental performance, provides best practices in laboratory energy and environmental management, and conducts case studies on Federal laboratory energy and environmental projects exemplifying whole-building guiding principles. For renewable energy, the subprogram 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 FY 2013, this subprogram provided web-based training on the latest Federal energy requirements, best practices, and technologies to more than 5,500 individuals/participants.

Technical Guidance and Assistance

Activities and Explanation of Changes

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs FY 2014 Enacted
Technical Guidance and Assistance		
Technical assistance on energy efficiency and renewable energy technologies that results in accelerated Federal sector acceptance of these technologies.	Support technical assistance on energy efficiency and renewable energy technologies results in accelerated Federal sector acceptance of these technologies along with increased support for data centers, energy-efficient and sustainable building practices; technology deployment networks; and expanded renewable energy technical assistance.	Increase will support the establishment of a center of expertise focused on Federal Data Center Energy Efficiency ; project tracking; energy-efficient and sustainable building practices; technology deployment networks; and expanded renewable energy technical assistance.

Federal Energy Management Program
Planning, Reporting and Evaluation

Description

The Planning, Reporting, and Evaluation subprogram effectively tracks the Government's progress and status in energy and related goals' achievement; ensures the program's capabilities are a known resource for energy management; and coordinates the program's strategic planning, budgeting, and evaluation. Specifically, the program compiles annual reports from all Federal agencies on energy consumption and management within Federal facilities, prepares an annual report to Congress, and conducts interagency collaboration. In addition, this subprogram coordinates data collection to track Federal facility compliance with energy and water evaluations, project implementation measures, and benchmarking requirements per Section 432 of the EISA 2007. Furthermore, through communications and interagency coordination, this subprogram shares the program's technical resources with both the public and private sector. Finally, this subprogram also supports the program's strategic planning activities—ensuring that funding supports strategic goals.

NECPA (as amended by EISA 2007) requires DOE to collect, verify and report on Federal agencies' progress (including DOE) toward their goals to address energy efficiency in facilities. As it does every year, in FY 2015, the program will 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 subprogram recognizes energy efficiency and renewable energy champions at Federal agencies.

Planning, Reporting and Evaluation

Activities and Explanation of Changes

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs FY 2014 Enacted
Planning, Reporting and Evaluation		
Tracking the Government's record in energy achievement; ensuring the program's capabilities are a known resource for energy management; and coordinating the program's strategic planning, budgeting, and evaluation.	Continue tracking the Government's record in energy achievement; ensuring the program's capabilities are a known resource for energy management; coordinating the program's strategic planning, budgeting, and evaluation; and supporting public access to Federal energy data.	Decrease in funding reflects the streamlining of activities.

Federal Energy Management Program
Federal Fleet

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

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

The subprogram provides guidance and assistance to help implement Federal legislative and regulatory requirements that mandate reduced petroleum consumption and increased alternative fuel use for the Federal fleet. EISA 2007 requires agencies operating a fleet of at least 20 motor vehicles to reduce the fleet's total consumption of petroleum products by 2 percent annually through the end of FY 2015, relative to their approved baselines from FY 2005.

The subprogram's efforts include assisting agencies with implementing and managing energy-efficient and alternative fuel vehicles, facilitating a coordinated effort to reduce petroleum consumption and increase alternative fuel use, and tracking and reporting Federal progress annually. The subprogram provides information and resources for Federal requirements, technology resources, technical assistance on infrastructure development, and data analysis and trends, as well as coordination of INTERFUEL (an interagency working group for vehicle fleets). The subprogram also provides resources for Federal fleet management, including publications, online tools, and related links on vehicles, alternative fuels, and fleet management deployment strategies. Federal agencies must report vehicle acquisitions and alternative fuel consumption annually. The program outlines reporting requirements and processes, including regulations, timelines, and tools to help Federal agencies meet annual requirements.

Federal Fleet

Activities and Explanation of Changes

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs FY 2014 Enacted
Federal Fleet		
Assisting agencies with meeting or exceeding requirements for reducing fleet petroleum consumption.	Continue assisting agencies with meeting or exceeding requirements for reducing fleet petroleum consumption.	Increase and improve assistance for agencies in meeting or exceeding requirements for reducing fleet petroleum consumption.

Federal Energy Management Program
Federal Energy Efficiency Fund

Description

Through the Federal Energy Efficiency Fund (FEEF) subprogram, FEMP provides direct funding to leverage cost sharing at Federal agencies for capital improvement projects and other initiatives to increase energy efficiency, water conservation, and renewable energy investments at Federal agency facilities. Grants from FEEF will be awarded after a competitive assessment of the technical and economic effectiveness of each agency proposal, which will consider a cost benefit analysis of the life-cycle cost-effectiveness of the project, the amount of energy and cost savings anticipated to the Federal Government, 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. Examples of the type of projects that will be encouraged include combined heat and power and onsite renewables. Because upfront investment of appropriated funding enables the higher long-term savings from a project, grant selection will place greater weight on the amount of funding committed to the project by the proposing agency than on the extent that a proposal leverages financing from other non-Federal sources.

Section 152(f) of the Energy Policy Act of 1992, Public Law 102-486, authorizes the Secretary of Energy to establish a Federal Energy Efficiency Fund with the stated purpose of providing grants to Federal agencies to assist them in meeting the energy management requirements of the National Energy Conservation Policy Act (42 U.S.C. 8256(b)). The FEEF was provided with $2.5 million of FY 2013 and $3 million of FY 2014 funds to support competitively selected projects.

This high-impact subprogram can dramatically increase the Federal pipeline of energy efficiency, water conservation, and renewable energy projects through direct financial incentives provided by appropriations. In FY 2015, $3 million of the program's FEEF funding is estimated to leverage $30 million of project investment and result in 3 trillion Btu and over $76 million in savings over the life of the projects.

Federal Energy Efficiency Fund

Activities and Explanation of Changes

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs FY 2014 Enacted
Federal Energy Efficiency Fund		
Six awards of direct funding to leverage cost-sharing at Federal agencies for capital improvement projects and other initiatives to increase energy efficiency and renewable energy investments at agency facilities. The FEEF was funded with $3 million of FY 2014 funds.	Six awards of direct funding to leverage cost-sharing at Federal agencies for capital improvement projects and other initiatives to increase energy efficiency and renewable energy investments at agency facilities.	No significant changes.

Federal Energy Management Program
DOE Specific Investments

Description
The DOE Specific Investments subprogram supports activities that help ensure achievement of Federal and Departmental sustainability goals within DOE. These goals are driven by mandates from statutes, including EPAct 2005 and EISA 2007, and related E.O., including E.O. 13514 and 13423.

DOE is committed to meeting its sustainability goals and requirements, including reducing scope 1 and 2 GHG emissions by 28 percent and scope 3 emissions by 13 percent by 2020. DOE will strive to achieve this goal through its efforts to reduce energy intensity by 30 percent from FY 2003 by FY 2015; reduce water use intensity by 26 percent from FY 2007 through FY 2020; use at least 20 percent of electricity from renewable sources by FY 2020; and ensure 15 percent of facilities meet the Guiding Principles for Federal Leadership in High-Performance Sustainable Buildings by FY 2015 working toward 100 percent in the out years. In FY 2012, DOE reduced scope 1 and 2 (direct) GHG emissions by 34 percent relative to an FY 2008 baseline—placing DOE on track to meet its FY 2020 scope 1 and 2 GHG reduction goals (28 percent reduction).

The DOE Sustainability Performance Office (SPO) manages the DOE Specific Investments subprogram in collaboration with DOE's Under Secretaries, Program Secretarial Offices, corporate offices, and DOE sites and National Laboratories. The SPO serves as the lead for sustainability at DOE and is responsible for data collection, analysis, and the reporting of Departmental progress. The SPO completes required reporting on behalf of the Department to Congress and OMB, including the Strategic Sustainability Performance Plan, the Annual Energy Report, the Greenhouse Gas Inventory, and the OMB Energy/Sustainability scorecard.

The SPO also uses annualized site-level sustainability data to identify strengths, weaknesses, and to target technical assistance. The SPO will continue to oversee and execute site-level energy, water, and resource assessments to determine where DOE should focus future improvements. SPO will also provide direct funding to leverage cost-sharing at DOE facilities for capital improvement projects and other initiatives to increase energy efficiency and renewable energy investments. All potential improvements will be assessed based on practicability and life-cycle benefits and cost-effectiveness. SPO will leverage gains at DOE sites by sharing best practices and resources throughout the DOE community.

DOE Specific Investments

Activities and Explanation of Changes

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs FY 2014 Enacted
DOE Specific Investments		
Provides technical assistance and support to DOE sites and National Laboratories to meet Departmental sustainability requirements	Continue to provide technical assistance and support to DOE sites and National Laboratory to meet Departmental sustainability requirements.	No significant changes.

Federal Energy Management Program
NREL Site-Wide Facility Support

Description
In FY 2015, EERE will continue to 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. This practice is consistent with other National Laboratories. EERE began this practice in FY 2014 to reduce NREL's labor rate multiplier, thereby reducing the cost barrier to accessing unique NREL capabilities (such as facilities and staff expertise) by industry and academia. This practice also makes site operating costs more transparent in order to facilitate cost control and planning. In FY 2014, this practice resulted in a reduction in the Lab-wide direct labor multiplier of approximately 15 percent compared to FY 2013. The proposed FY 2015 budget continues this approach. The site-wide facility support funds cover maintenance and engineering support; fire, emergency, and custodial services; general utilities; network infrastructure and licenses; environment, safety, and health support; and sustainability. By moving these costs from laboratory overhead to direct funding, EERE accelerates technology transfer and mission impact by making it easier for companies and external researchers to access NREL capabilities and expertise.

This funding supports research programs by providing basic site services, functions, and infrastructure for site operations, which includes: management, building operations, building and grounds maintenance, fire and emergency response, engineering and construction support, minor construction projects, Electrical Safety Program, utilities, and facilities planning support; and activities within the Sustainability and Environmental Health and Safety (EHS) portfolios. These activities and their costs are relatively fixed and only vary significantly based upon variations in commodities, construction activity, emergencies, weather patterns, etc. They are considered to be the core functions for site operations, safety, environmental compliance, and sustainability at NREL. In FY 2015, this funding will support more than 60 full time equivalents that manage and provide support for these core functions. It will also fund site-wide subcontracts such as janitorial services, refuse and recycling, and subcontracts for minor construction. Additionally, this funding will support site-wide costs associated with maintaining NREL's leadership position, such as: maintaining International Organization for Standardization (ISO), American Association for Laboratory Accreditation (A2LA), and other lab-wide accreditations, managing facilities to enable mission goals, improving sustainability, pollution prevention, waste minimization, improving energy efficiency, reducing water use, and maintaining an effective emergency management system.

The FY 2015 contribution from each program differs from the FY 2014 allocation, because EERE has developed a more precise, equitable, and economically neutral method that ensures a net-zero impact on programs' funding. For each program, the contribution to direct funding for site-wide facility support is equivalent to the estimated contribution the program otherwise would have made through overhead charges. This method is based upon each program's level of funding to NREL, adjusted to account for anomalies from capital expenditures and major subcontracts.

NREL Site-Wide Facility Support
Activities and Explanation of Changes

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs FY 2014 Enacted
NREL Site-Wide Facility Support		
No NREL site-wide facility support directly funded through FEMP.	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.	The delta is the result in a change in methodology used to allocate site-wide facility support contributions amongst programs. The FY 2015 value enables and directly equates to the program's estimated savings gained from the reduced labor multiplier.

Federal Energy Management Program
Performance Measures

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

	FY 2013	FY 2014	FY 2015
Performance Goal (Measure)	**Investment - Total Federal Investment in Facilities Energy Conservation Measures Government-Wide**		
Target	N/A	N/A	$750 Million
Result	N/A	N/A	N/A
Endpoint Target	$4.5 Billion of total investment in Federal Facilities Energy Conservation Measures by 2020 ($750 Million annually through FY2020)		

Building Technologies

Overview

In the United States, residential homes and commercial buildings consume 40 percent of the Nation's total energy with an annual energy bill of more than $400 billion.[1] Buildings use more than 70 percent of the electrical energy in the U.S. These energy bills can be cost-effectively reduced by 20-50 percent or more through various energy efficiency technologies and techniques. The Building Technologies program will continue to develop and demonstrate advanced building efficiency technologies and practices to make buildings in the United States more efficient, affordable, and comfortable. The program will utilize a three-pronged strategy: 1) High Impact Technologies: target the greatest opportunities for energy efficiency products and solutions (i.e., the highest potential market and energy efficiency impact); 2) Technology-to-Market: validate and drive these technology products and solutions to market by verifying performance and cost, providing improved data and information, and partnering with manufacturers and users; and 3) Lock In Savings: where a government role is appropriate and justified, lock in the savings through market based (e.g., Energy Star) and regulatory efforts that provide clear public and net economic benefit (i.e., codes and standards). The program's three-pronged strategy will specifically involve:

- High Impact: support research, development, and demonstration (RD&D) of technologies that have the potential to achieve significant improvements in building efficiency that will help accomplish the program's goal. The program will do so by improving both the performance of and the cost to manufacture/install building components (solid-state lighting (SSL); windows; heating, ventilation and cooling; building envelope; and transactive controls) through ground-breaking research and development and integration of those technologies; and develop whole-building energy system solutions that engineers, architects, and researchers can use to model energy consumption/performance in buildings.
- Technology-to-Market: support market-priming measures to help technologies overcome the market barriers to widespread adoption, such as first cost, building trades' limited acceptance and adoption of new technology and practices, and insufficient availability of consumer information. This will be accomplished by increasing market pull from building developers, owners, and tenants through cooperation with stakeholders to develop and share validated data and best practices, improvement of building design and audit tools, and the creation of reliable efficiency benchmarks and databases to facilitate energy efficiency financing and to define efficiency's value-add to consumers.
- Lock in the Savings: support the widespread adoption of building efficiency technologies through the development of national energy efficiency standards for products and technologies that are promulgated by the Equipment Standards subprogram and ensure reductions in energy use and resulting household cost savings. This will be accomplished by raising the standards for energy-consuming equipment and model building codes based on cost-effective, higher-performing technology that private-sector manufacturers have successfully proven and commercialized.

In order to develop and deploy energy efficient technologies and techniques that can make a sizeable reduction in building energy use and greenhouse gas emissions, building system components and transactions must be improved and become cost effective to building owners. Collectively, program activities will focus on the following high level goal that is in alignment with the President's Climate Action Plan and all-of-the-above approach to energy: the program will develop and promote the adoption of technologies and practices, that when fully deployed, would reduce U.S. building-related energy use by 50 percent from the 2010 Annual Energy Outlook baseline. Achieving this goal would decrease annual energy use by approximately 20 quads, which is equivalent to approximately 1 billion metric tons of CO_2, and save consumers and businesses roughly $200 billion in annual energy costs.

The program invests in a balanced portfolio of activities in pursuit of its energy efficiency goals. This investment portfolio is established based on assessments of current market barriers, determination of the technologies that would most contribute to national goals when adopted, and assessing what technology development pathways are well suited to concurrently fulfill the demands of the market in both the near term and into the future.

The program uses analytically-based tools, field measurement and verification, and cost-effectiveness analysis to balance its portfolio. For example, the program's Prioritization Tool is used to assess and compare the potential impact of over 500 different building technologies and measures at various stages of development. Factors such as primary energy savings, costs of conserved energy, market size, lifetime, and market penetration are considered.

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[1] *Buildings Energy Data Book*, U.S. Department of Energy. March 2012, http://buildingsdatabook.eren.doe.gov/TableView.aspx?table=1.2.3.

Highlights of the FY 2015 Budget Request

Major changes for FY 2015 are increases within the program's Emerging Technologies (ET) subprogram and its Equipment and Appliance Standards subprogram. In the ET subprogram, the program will continue its research efforts in its five key technology areas, targeting savings of more than 50 percent over the 2030 buildings energy consumption projected by the 2010 AEO. Technology areas include: SSL; heating, ventilation, & air-conditioning (HVAC), including water heating and appliances; windows and building envelope; whole-building energy modeling; and sensors and controls (including transactive controls). In FY 2015, the program will pursue an approximately $8 million early-stage research and development (R&D) Incubator Funding Opportunity Announcement (FOA) for off-roadmap technologies. This Incubator FOA will include an "open" topic that allows applications for all relevant building energy efficiency technologies and solutions that reduce the costs or improve information flow to better manage buildings. The program will also pursue an Innovations FOA that will include roadmap-driven topics, such as advanced controls, envelope & windows, and AC/DC converters for miscellaneous electric loads–all of which offer the possibility of significant energy savings.

The ET subprogram will pursue non-vapor compression technologies capable of being used in HVAC applications through an approximately $10 million Future of Air Conditioning Technologies (FACTs) FOA. Non-vapor compression air conditioning technologies have the potential to replace or be integrated with conventional vapor compression technologies to provide up to 50 percent reductions in energy consumption. Furthermore, the program will continue efforts to develop more efficient and cost-effective heat exchangers. Heat exchangers are a critical cross-cutting technology platform used not only in air conditioning, heating, water heating, and refrigeration; but also in nearly every application that generates waste heat, a target rich environment for future energy savings.

In FY 2015, the program will also invest in R&D on transactive controls, which support smart buildings, buildings with technologies and control systems that cannot only optimize energy performance and comfort, but also support energy-related transactions outside the building envelope. The program's sensors and controls development work will enable improved building energy management and enable key elements for a more transactive energy market, in which building systems could better respond to price signals to reduce energy transaction costs and ensure more competitive pricing.

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

Residential and Commercial Buildings Integration efforts will focus on identifying energy efficient solutions and partnering with market leaders to accelerate adoption through continued development of tools and databases that reduce uncertainty associated with energy savings related investments (e.g., Building America Solution Center; Building Performance Database). In FY 2015, Commercial Buildings Integration (CBI) will demonstrate and evaluate the impact of three promising new technologies in commercial buildings; broaden the use of the Commercial Energy Asset Score by demonstrating its use in utility energy efficiency programs; and demonstrate 2 percent per year portfolio-wide energy savings in Better Buildings Alliance industry partner organizations. Residential Buildings Integration (RBI) will encourage construction of 5,000 highly efficient new homes through Challenge Home, and 100,000 retrofits through Home Performance with ENERGY STAR, as well as demonstrate program models to enhance private sector participation in offering these programs and services.

The Residential Buildings Integration subprogram is in the process of making improvements to the successful Building America (BA) initiative to significantly increase its applicability and its reach into the market. BA will continue to develop new, cost-effective energy efficient technical solutions for existing and new construction; however, rather than only focusing on whole house approaches, actionable solutions will be developed around typical systems that are retrofitted individually. While whole house retrofits are the most cost effective and comprehensive opportunity for a homeowner, few homeowners are able to implement this approach. Instead, systems (HVAC, windows, roofs, etc.) are typically retrofitted individually, either due to end of life function, the desire to increase home health and comfort, or even aesthetics, and are replaced as finances and priorities allow. This new, more granular approach will provide feasible and cost effective solutions to a wider range of companies working to improve residential homes.

The Equipment and Buildings Standards subprogram will be increased and will generate cost-effective energy savings through the development of national appliance and equipment standards. The additional funding supports increased rulemakings and standards certification and enforcement in both commercial and industrial products, as well as increased emphasis on assisting state and local jurisdictions to improve building energy code compliance. Because minimum standards effectively eliminate low-efficiency products from the marketplace, the program saves consumers money and energy by ensuring that products purchased, installed, and operated are energy-efficient, while updated codes, adopted by state and local jurisdictions, provide a minimum energy efficiency performance for homes and businesses. Energy conservation standards and test procedures directly support national energy policy objectives, such as increasing energy savings and energy productivity, and reducing carbon emissions.

Building Technologies
Funding ($K)

	FY 2013 Current[2]	FY 2014 Enacted[3]	FY 2014 Current	FY 2015 Request	FY 2015 vs. FY 2014 Enacted
Building Technologies					
Emerging Technologies (ET)	58,599	55,862	55,862	79,000	+23,138
Commercial Buildings Integration (CBI)	33,956	30,782	30,782	28,000	-2,782
PSU Consortium for Building Energy Innovation	22,843	9,994	9,994	10,000	+6
Residential Buildings Integration (RBI)	27,678	24,390	24,390	23,000	-1,390
Equipment and Buildings Standards	61,525	55,840	55,840	69,000	+13,160
NREL Site-Wide Facility Support	0	1,000	1,000	2,700	+1,700
Total, Building Technologies	**204,601**	**177,868**	**177,868**	**211,700**	**+33,832**

SBIR/STTR:

- FY 2013 Transferred : SBIR: $2,366,000; STTR $307,000
- FY 2014 Projected: SBIR: $1,932,000; STTR: $276,000
- FY 2015 Request: SBIR: $2,732,000; STTR: $377,000

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

Building Technologies
Explanation of Major Changes ($K)

	FY 2015 vs. FY 2014 Enacted
Emerging Technologies (ET): The funding increase for emerging technologies is primarily associated with increased R&D investments in high-impact areas. Specifically, ET will invest in FOAs to pursue non-vapor-compression air conditioning technologies and to modernize the EnergyPlus whole building energy modeling "engine;" will support a full "Incubator" FOA; and will increase investments in transactive controls and EERE's Grid Integration Initiative, all of which offer significant opportunities to increase energy savings and reduce greenhouse gas emissions.	**+23,138**
Commercial Buildings Integration (CBI): CBI will reduce funding for several activities which require less investment as the projects move from development to deployment. This includes several core tools and platforms, including the Commercial Building Asset Score and the Standard Energy Efficiency Data platform (SEED).	**-2,782**
PSU Consortium for Building Energy Innovation: No significant change.	**+6**
Residential Buildings Integration (RBI): RBI will slightly scale back investments in developing and deploying energy efficient technologies for new and existing homes, in order to focus efforts on the subprogram's high-impact activities.	**-1,390**
Equipment and Buildings Standards: The additional funding supports increased rulemakings and standards certification and enforcement in both commercial and industrial products, as well as increased emphasis on assisting state and local jurisdictions to improve building energy code compliance.	**+13,160**
NREL Site-Wide Facility Support: The delta is the result in a change in methodology used to allocate site-wide facility support contributions amongst programs. The FY 2015 value enables and directly equates to the program's estimated savings gained from the reduced labor multiplier.	**+1,700**
Total, Building Technologies	**+33,832**

Building Technologies
Emerging Technologies

Description

The Emerging Technologies (ET) subprogram supports a broad array of technologies that impact building energy consumption. These technologies include HVAC, water heating, building envelope, windows, solid-state lighting, sensors & controls (including transactive controls), appliances like clothes washers and dryers, and building energy modeling. Emerging Technologies investments will support the goal to develop technologies enabling a 70 percent reduction in lighting energy use, 60 percent savings in water heating, 20 percent savings in HVAC, 20 percent savings in building envelope & windows, 20 percent savings in appliances, and 30 percent savings enabled by sensors & controls from the 2010 AEO baseline.

FY 2015 activities include: achieving >10 percent improvement in the manufacturing cost of warm-white Light-Emitting Diode (LED) packages, to 144 lumens per dollar; initiating field tests for multi-function fuel-fired heat pumps; establishing the Fenestration Attachments Rating & Certification Organization; enhancing EnergyPlus energy modeling software speed so that it can execute in 4 hours (currently 7.5 hours); and delivering an Open Energy Information System (EIS) beta platform for commercial buildings, all of which will contribute to the goal of enabling a 50 percent energy reduction in U.S. residential and commercial building stock (new and existing) to the "business-as-usual" projection by the 2010 Annual Energy Outlook.

HVAC/Water Heating Appliance R&D focuses on cost-effective technologies that improve system energy consumption. Collectively, these end uses consumed 23.4 quads of primary energy, or 58 percent of building energy use in 2010.[4] These efforts support the program's goal of enabling an overall 50 percent building energy savings through: 20 percent energy savings in HVAC, 60 percent energy savings in water heating, and 20 percent energy savings in appliances. Analysis has shown that heat pumps have the technical potential to save up to 50 percent of the energy used by conventional HVAC technologies in residential buildings. The program's focus is on the introduction of new heat pump technologies, heat exchanger technologies, and advanced appliances, e.g., refrigerators, clothes dryers, etc. A competitive FOA supporting research and development of non-vapor compression air conditioning technologies will be issued in FY 2015. These technologies have the potential to replace or be integrated with conventional vapor compression technologies to provide 50 percent reductions in energy consumption, and therefore will be a focus in FY 2015 as existing vapor-compression-based heat pump projects are completed. In FY 2015, $15 million will be invested in these activities.

Next-generation windows and building envelope technologies have substantial technical potential to reduce energy consumption in buildings. However, to make significant progress toward the program goal, any next-generation technologies must be developed with a specific emphasis on achieving a market-acceptable installed cost to facilitate mass-market adoption. Activities in windows and building envelope will focus on technologies such as highly insulating materials and systems, and methodologies and analysis tools for measurement and validation of building envelope performance.

Windows and envelope activities have been significantly restructured to focus on reducing the cost of high impact, next-generation energy-efficiency products to enable mass-market adoption. Some previous efforts were not continued because it was determined that the potential energy savings were insufficient to achieve program goals, including projects focused on cool roof coatings, attic/roof insulation, and dynamic windows. Other efforts were not continued because there was no viable path to necessary cost reductions, including dynamic windows and highly insulating windows. In FY 2015, $3 million will be invested in window and envelope to develop air sealing and infiltration systems focused on controlling heat, moisture and air flow in buildings. The ultimate program target in this area is to develop technologies with a <2-year payback period by 2025. The program will also continue to provide national labs with $2 million to support projects aligned with core capabilities in windows and building envelope technologies.

The Solid-State Lighting (SSL) initiative is furthering the technical capabilities and market acceptance of light emitting diodes (both organic and inorganic) that will enable the reduction of lighting energy consumption by about 50 percent , thus playing a major part in enabling a 50 percent reduction in energy consumption in the entire building sector.. The SSL program is investing $25 million to improve performance and lower cost. In FY 2015, SSL activities will pivot back from a specific manufacturing cost reduction focus to a broader R&D program that includes other high-priority research topics

[4] *2011 Buildings Energy Data Book*; sum of space heating, space cooling, water heating, refrigeration, cooking, and wet cleaning end uses.

such as LED emitter materials, Organic Light-Emitting Diode (OLED) light extraction techniques, LED new-form-factor luminaires, and OLED electrode structures. In FY 2015, SSL will target >10 percent improvement (relative to 2014) in manufacturing cost of warm-white LED packages, to 144 lumens per dollar by the end of the fiscal year.

A comprehensive, open source open architecture building control system solution would provide capabilities that enable a variety of applications implemented by multiple vendors that interoperate with other systems and present a consistent style of interaction with the user. The opportunity for open source building control systems and affiliated low cost sensors is the largest, untapped need facing the building management sector. In FY 2015, the program will invest $8 million to develop common, shareable components and tools that improve the ability of building operators and owners to achieve projected savings at the lowest possible cost to their businesses.

Highly automated buildings will need additional sensors and metering; some for energy systems (plug load, lighting, HVAC), others for air quality, building occupancy, external lighting conditions, water consumption, security, etc. A key issue that impedes broad scale deployment of even existing sensors is the relatively high total cost (both device and installation). To address this need, the program will focus on opportunities that will develop and take to market new sensors and sensor configurations that allow easy implementation into building operation, in a secure and cost effective way. The program will also fund building applications and whole-home pilots to develop sensor and control system materials (manuals, tools, software installation support) so that industry can replicate at scale. The program will commit up to $2 million in competitively selected matching research funds for companies that want to engage in innovative buildings-related sensors, controls, and associated systems research that helps meet these goals. The program also requires that 100 percent of the research paid for by these funds remain non-proprietary, for the public good, and in keeping with (and not replacing) industry developed/developing standards.

Transactive controls, a core component to DOE's grid integration activities, are control solutions that allow operational decisions to be based on market signals (i.e., commodity, service, retrofits, etc.) whether it is a direct (i.e. time of day electricity price) or indirect (i.e. price given the fuel and carbon impact of the existing electricity mix) financially based indicator of the energy system. In some installations, as demonstrated by OE with utility partners, these systems have been proven to be a more economically efficient method of managing a complex energy system because electronically controlling end uses in a dynamic fashion is a less expensive method than to deploy traditional stationary storage (i.e. electric or thermal storage) or other ancillary service solutions.

To date, utilities and other market participants have been slow to integrate transactive controls in a holistic way – either behind the meter or across the meter (i.e., in lighting/HVAC systems in a building, virtually aggregated water heaters in a utility service territory, or roof top unitary air conditioning equipment across big box retailers) even though it is a proven alternative to stationary storage. Many of the existing deployments of transactive energy built upon smart meter installations.

To better enable building-level technologies to interact with each other and with the grid, the program will invest $10 million to support development of transactive controls as described above and an additional $7 million in EERE's Grid Integration Initiative to support complementary cross-cutting work. Customer-owned electric vehicles, distributed renewable generation, and building equipment can be integrated to optimize their overall performance and designed to interact with the utility grid and better meet grid requirements as the concentration of these technologies on the grid increases. To enable customer options that address these integration issues in a comprehensive manner, EERE will implement a joint $19 million FOA sponsored by the Solar Energy Technologies program ($7 million), Building Technologies program ($7 million), and Vehicle Technologies program ($5 million) to solicit technology and tool development and demonstration activities. Work within the Building Technologies program will specifically focus in the following areas:

- Standardization of Data – within the building complex, increasing levels of information are needed to optimize efficiency and behind the meter coordination of information prior to interactions with the grid. This work will explore common data interfaces within the building and provide an information basis for NIST to develop standards. This effort will be coordinated for handoff with NIST and OE.
- High Resolution Data – Building-wide data will not be sufficient for a highly automated building. The metrics are too broad and vague. To optimize building performance and to more effectively transact with the grid, successful solutions require building energy data that is relevant to the product or service that the building is designed to provide (e.g., a refrigerated distribution center for foods vs. a multi-family housing unit). This work will develop tools that provide

higher resolution information from the buildings and validate what information is most useful for optimization within the building and with the grid.

- Data Analytics/Tools – Data 'mining' to improve building energy performance or forecast the value of transactions is necessary to support a fluid and vibrant building-to-grid (B2G) data sharing network. A critical component of any solution in building automation is predictive analytics that identifies trends in how the building is performing or being used, inferring relationships between variables and creating rules to predict how the building performs under different scenarios.

Whole-Building Energy Modeling (BEM) — physics-based software calculations of a building's annual energy consumption from a description of its assets and operations—is a key enabler of building energy efficiency. BEM supports integrated, performance-driven design in new construction and major retrofits, which yields lower energy use in buildings. BEM forms the basis of whole-building energy-efficiency standards like ASHRAE 90.1 and IECC, energy-efficiency rating systems like LEED and GreenGlobes, and Federal and utility incentive programs. Emerging uses of BEM include design, optimization, and implementation of control systems for energy minimization in addition to occupant comfort, ongoing commissioning and fault-detection and diagnosis for building HVAC systems, and dynamic building control and demand-response.

EnergyPlus is Building Technologies' state-of-the-art open-source whole-building energy modeling engine. The program develops and deploys EnergyPlus to address the various energy simulation use cases. For instance, EnergyPlus is the simulation engine inside a number of commercial and free design tools including Building Technologies' own OpenStudio. EnergyPlus is inside compliance tools like California's CBECC-Com for Title24. It is also inside rating tools like Building Technologies' own Asset Score.

In FY 2015, the program will invest $3 million to modernize EnergyPlus, which utilizes a significantly out-of-date programming language. This includes upgrading EnergyPlus to use: a modern software platform that better meshes with existing software ecosystems and supports performance optimization; modern algorithms that support building physics calculations for lighting and heat transfer; and updated and optimized equipment-sizing strategies. The FY 2015 goal is to execute Energy Plus (in a standard test) in 4 hour versus the current 7.5 hour timeframe. This investment is supplemented by in-kind contributions from several private entities that use this tool to support their businesses.

Specifically, a large software company is supporting work on modernization and speedup with an eye towards including EnergyPlus as the analysis engine behind their popular suite of architectural design tools. In addition, a large HVAC company is supporting the equipment sizing work as a step towards using EnergyPlus as the analysis engine within their popular energy-simulation and equipment-sizing software

Recent ET accomplishments include:

- SSL-funded R&D produced an efficacy of 161 lumen per Watt in a laboratory device with quality warm white lights (CRI of 88, R9 of 29, and CCT of 3078 K), thus exceeding the expected efficacy for 2013 by 25 percent. Further, DOE R&D helped improve manufacturing cost to 115 lumen per dollar, which slightly exceeded the goal of 111 lm/$. Overall, SSL products on the market and installed in buildings for CY 2012 were estimated to save consumers 70 trillion Btu (0.70 quads) annually in source energy.[5]
- Oak Ridge National Lab (ORNL) with a private-sector partner won an R&D 100 Award for a ground source integrated heat pump (GS-IHP) unit. This revolutionary unit uses variable speed technology to save up to 60 percent of annual energy use and cost for residential heating and cooling over conventional systems, and is up to 30 percent more efficient than other ground source heat pumps. The product will be manufactured in Oklahoma.
- Another private-sector company, with support from the Lawrence Berkeley National Laboratory (LBNL), received a 2013 R&D 100 Award for their Universal Smart Window (USW) Coating. This first-of-its-kind technology enables dynamic control over how much of the sun's heat enters a building through its windows, thereby lowering energy consumption and improving occupant comfort. Unlike competing smart window technologies, the USW Coating can block heat-producing, near-infrared solar radiation without blocking visible light.
- The most recent release of the Modelica Buildings Library now includes more than 200 open-source models for room and zone heat and mass transfer, airside equipment, plant equipment, and control primitives. This free library is seeing growing use in prototyping and demonstration projects including an optimized chiller control project in the

[5] "Adoption of Light-Emitting Diodes in Common Lighting Applications." Navigant, May 2013, available at: http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/led-adoption-report_2013.pdf.

Washington, DC, Navy Yard. In addition, the latest release of EnergyPlus is the first multi-core enabled release of EnergyPlus.

In addition, these funds may be used to support efforts such as peer reviews; data collection and dissemination; and technical, market, and economic studies and other analyses.

Emerging Technologies

Activities and Explanation of Changes

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs. FY 2014 Enacted
Emerging Technologies		
Lighting R&D ($25,785,000) • Support will be continued to both improve performance and to lower costs for LEDs and OLEDs. With direction from well-established technology roadmaps setting a target for LED manufacturing cost (128 lumens/$), a competitive FOA will be released to pursue innovations in LED and OLED core technologies (i.e., LED emitter materials, OLED light extraction techniques), product development (i.e., novel LED luminaires, improved OLED light extraction), and manufacturing (i.e., LED luminaire manufacturing, OLED deposition equipment).	*Lighting R&D ($25,800,000)* • Continue support to improve performance and costs for LEDs and OLEDs. The roadmap-driven LED cost target is 144 lumens/$ for FY 2015. A competitive FOA will again be released to keep driving innovations in LED and OLED core technologies (i.e., down converters, stable white OLEDs), product development (i.e., LED package development, low-cost OLED electrodes), and manufacturing (i.e., LED test equipment, OLED materials manufacturing).	*Lighting R&D (+$15,000)* • No significant changes.
Space Conditioning and Refrigeration R&D ($6,696,000) • Continue support to complete early-stage research and development of the radial air bearing heat exchanger, and its application to HVAC systems. Continue development of more efficient, vapor-compression heat pump systems, including cold-climate heat pumps and CO2 heat pump water heaters. Continue development of natural-gas-fired HVAC technologies, including a multifunction natural-gas heat pump and an absorption heat pump water heater. Complete computational effort to help develop next-generation, low-global-warming-potential refrigerants.	*Space Conditioning and Refrigeration R&D ($15,200,000)* • Continue development of heat-pump technologies, especially integrated heat pumps (IHPs) that combined space heating and cooling with water heating. A key project is development of a fully variable-speed version of an air-source IHP for the US market with a 50-55 percent energy savings potential. A significant effort will be devoted to a competitive FOA to pursue non-vapor-compression air conditioning technologies that offer improved efficiency, reduced global warming potential, improved part-load performance, and building system integration capability.	*Space Conditioning and Refrigeration R&D (+$8,504,000)* • The substantial increase in funding will allow the pursuit of a competitive FOA on non-vapor-compression air conditioning technologies which have the potential of “leapfrogging” existing HVAC technologies by pursuing entirely new approaches that offer better performance with reduced environmental burden.

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs. FY 2014 Enacted
Transactive Controls ($5,389,000) • Core funding is provided to support the introduction of self-configuring, self-commissioning, and self-diagnosing building systems that ensure continuous peak operating efficiency and can be introduced into building stocks quicker and at lower cost than traditional approaches based on disseminating information in an attempt to change behavior.	*Transactive Controls ($10,000,000)* • Invest in the development of an open-source open-architecture transactive software platform for building energy management. This will standardize the development and application of control strategies for existing and new buildings, especially small to medium sized buildings <200k square feet. This work will build on the program's efforts to increase the operating efficiency of building energy systems, ensure persistence of operations through improved maintenance and make buildings more grid-responsive. Additional tasks will address issues such as: standardized communication linkages between lighting and HVAC equipment, between buildings, and between utility DR programs. These linkages will align with the protocols and standards under development by the Office of Electricity and others to ensure interoperability across the distribution system.	*Transactive Controls (+$4,611,000)* • Increased funding supports development of an open-source open-architectures transactive software platform for building energy management.
Building Envelope R&D ($9,994,000) • Core funding is continued to support the ongoing development of software design tools for energy-efficient windows (WINDOW and THERM), residential attics (AtticSim), and heat/moisture transfer in building insulation (WUFI), including experimental testing required for model validation. A competitive FOA will be released to support establishing a Fenestration Attachments Rating & Certification Agency (FARCA). A FOA topic will also be released on highly-insulating, cost-effective building envelope components.	*Building Envelope R&D ($6,000,000)* • Core funding (building envelope and roofs at ORNL and windows at LBNL) will continue to support the development of the software design tools and the accompanying experimental testing. A FOA topic will be released to support air sealing and infiltration control systems-level R&D focused on controlling heat, moisture and air flow in buildings.	*Building Envelope R&D (-$3,994,000)* • The decrease in funding is associated with a fully funded FY 2014 four-year FOA to establish the Certification and Rating of Attachments for Fenestration Technologies (CRAFT). Funding for window attachments related projects declines as it is deprioritized. Additionally, some previous efforts are not being continued because the program determined that the potential energy savings are insufficient to achieve program goals and/or because there was no viable path to necessary cost reductions – including projects on cool roof coatings, attic/roof insulation, dynamic windows, and highly insulating windows.

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs. FY 2014 Enacted
Analysis Tools ($2,998,000) • Core funding is provided for continued support of the EnergyPlus whole building energy modeling (BEM) "engine". Crucial updates to EnergyPlus will be carried out by lab performers and Year 3 (of 5) of the competitively awarded EnergyPlus maintenance agreement, such as improved equipment sizing, and handling of general space geometries for heat transfer and lighting. Preparations will also be made for the FY 2015 FOA on EnergyPlus Modernization via a collaborative effort with Autodesk Inc. that will transition EnergyPlus from a FORTRAN to a C++ platform. Core funding is also provided for the Radiance lighting engine for speedups and tighter integration with EnergyPlus, for the Modelica Buildings Library for the development of component and controls models for EnergyPlus, and for the BESTEST suite of energy simulation validation tests for updated thermal shell tests.	*Analysis Tools ($7,000,000)* • Core funding will continue to maintain and upgrade EnergyPlus with a focus on supporting generalized equipment control strategies. Significant effort will be devoted to modernizing EnergyPlus through a competitive FOA which will target a refactoring of EnergyPlus and a re-engineering of its envelope and loads subsystem to exploit high-performance physics algorithms and their implementations on modern hardware like graphics processing units. Core funding will be provided for Radiance for additional speedup work and refactoring to support simulation for the Modelica Buildings Library for component and controls models for the re-engineered EnergyPlus, and for the BESTEST suite of simulation validation tests for airside equipment tests.	*Analysis Tools (+$4,002,000)* • Funding increase supports a competitive FOA to modernize EnergyPlus.
Grid Integration Initiative ($0) • This activity was not funded in FY 2014.	*Grid Integration Initiative ($7,000,000)* • The program will solicit technology and tool development and demonstration activities to ensure customer-owned electric vehicles, distributed renewable generation, and building equipment can be integrated to optimize their overall performance and designed to interact with the utility grid and better meet grid requirements as the concentration of these technologies on the grid increases.	*Grid Integration Initiative (+$7,000,000)* • Supports building-related investments in EERE-wide Grid Integration Initiative.

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs. FY 2014 Enacted
High-Impact Technology R&D ($5,000,000) • The program is issuing an "Incubator" FOA to support innovative technologies and solutions that could help meet existing goals but are not represented in a significant way in the program's existing Multi-Year Program Plans (MYPPs) or current portfolios. The Incubator program allows EERE to assess new technologies for their potential to be "on ramped" to future MYPPs. Successful incubator projects will reduce the risk associated with potentially breakthrough approaches and technologies so that they could be viable candidates for inclusion in future program roadmaps.	*High-Impact Technology R&D ($8,000,000)* • Similar to FY 2014, the program is issuing an "Incubator" FOA to support innovative technologies and solutions that could help meet existing goals but are not represented in a significant way in the program's existing MYPPs or current portfolios. The Incubator program allows EERE to assess new technologies for their potential to be "on ramped" to future MYPPs. Successful incubator projects will reduce the risk associated with potentially breakthrough approaches and technologies so that they could be viable candidates for inclusion in future program roadmaps.	*High-Impact Technology R&D (+$3,000,000)* • Increase in funding ramps up the "Incubator" activity to provide a greater range of additional opportunities to surface innovative solutions associated with the reduction of building energy consumption.

Building Technologies
Commercial Buildings Integration

Description

The Commercial Buildings Integration (CBI) subprogram accelerates energy performance improvements in existing and new commercial buildings by developing, demonstrating, and releasing a suite of cost-effective technologies, technical specifications, tools, and solutions, as well as analyzing their ability to deliver the intended energy savings. The subprogram also promotes voluntary activities to prime and support improved energy efficiency in the commercial building sector, with an emphasis on high-potential products for commercial building investment, in all climate zones and in building types representing 80 percent of building energy use. The goals for these activities are to demonstrate that it is cost effective to reduce the energy required to operate commercial buildings by 20 percent by 2020 and, in all climate zones and in building types representing 80 percent of building energy use, by 50 percent by 2013 from a Commercial Building Energy Consumption Survey (CBECS) 2003/2012 baseline.

CBI has had success in three areas: demonstrating actual energy and cost savings that can be achieved with high efficiency equipment; partnering with market leaders to prove energy conservation strategies; and developing databases capturing building improvement information that reduce uncertainty associated with investment (i.e., Buildings Performance Database). CBI has increased the square footage of Better Buildings commercial partners implementing energy saving technologies and practices to over 10 billion square feet of buildings; published the first twelve implementation models for commercial building owners and operators describing successful pathways used to overcome common barriers to energy efficiency; and conducted pilot testing of the commercial building energy asset score with hundreds of buildings across several building types, to help the market develop a standard approach to recognizing efficient building assets.

In FY 2015 CBI will invest $5 million to advance the adoption of newly commercialized or underused advanced technologies and methods to facilitate integrated low-energy building design and operation through technologies demonstrations, industry challenges, and focused investigations that establish how these technologies can be properly applied in commercial buildings throughout all climate zones in the U.S.

CBI also will invest $15 million to build the common data structures, tools and processes to support and drive greater investment in energy efficiency across all commercial market sectors. CBI is focused on several key areas that represent significant barriers to greater commercial investment in energy efficiency. These include:

- Energy performance data access and utilization (see below);
- Design and decision support tools that incorporate energy performance into organizational culture and real estate transaction points (lower-cost, higher-value energy modeling for design and construction; energy-aware appraisal, leasing and financing; organization-wide energy management) and that inform cost-effective organizational and business models; and
- Preparing the clean energy workforce to design, build and operate buildings more efficiently, including common workforce guidelines to streamline and improve the value of the credentialing process, and training content where specific gaps are identified.

CBI will continue its efforts to improve access to decision-grade information on building energy performance and make building energy performance information interoperable, accurate and readily available at all levels of granularity. This builds on successful program areas to ensure that owners, operators, tenants, and investors can use data effectively to create value in buildings through improved energy efficiency and that state and local decision makers can better assess the results of efficiency projects and programs. CBI's work in this area will include several components:

- Common data exchange standards—Work with the energy efficiency industry to develop and deploy voluntary data standards (such as the Building Energy Data Exchange Specification (BEDES)) and tools that improve interoperability, reduce the cost of doing business, and unlock new business opportunities;
- Efficient data collection –Increase the depth and breadth of nationally available data (through the Buildings Performance Database (BPD)) while lowering the costs of data collection and management (through the Standard Energy Efficiency Data Platform (SEED));
- Improved & standardized EM&V – develop, demonstrate and release improved methods of evaluation, measurement and verification (EM&V) of energy efficiency impacts that increase market trust in energy savings and reduce the cost of doing business; and

- Automation of data collection – 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. CBI will coordinate efforts with the State Energy Program and DOE's broader State and local activities, and will coordinate with the EIA on the Commercial Building Energy Consumption (CBECS) survey.

CBI will invest $8 million in market partnerships to accelerate the adoption of advanced technologies and energy-saving strategies for new and existing buildings. Through industry partnerships (such as our Retail Partnership with Wal-Mart, Target, Yum! Brands, and McDonald's), as well as federal, state and local government owners and operators of buildings, CBI convenes industry partners to develop and deploy solutions for their peers, including advanced technical specifications that drive efficiency in a range of building technologies, research and tools that can advance efficiency leasing, valuation and financing, platforms that can be used to advance and implement energy efficiency strategies, and replicable business and organizational models. Examples include the advanced rooftop air conditioner and parking and garage lighting specifications, both of which would significantly reduce energy use. CBI will encourage whole-building energy performance improvement via market partnerships leading to portfolio-wide energy savings of 2 percent per year for participating organizations (currently CBI has about 200 Better Buildings Alliance members across multiple commercial sectors). In addition, CBI is working with a diverse set of industry and non-governmental organizations to drive these solutions and tools further and faster through joint campaigns, new incentives and other strategic activities. These strategic partnerships with end-users and key stakeholders focus on market barriers and catalyze action to enable the widespread use of energy efficiency technologies and techniques across the commercial building sector.

Specifically, in FY 2015 CBI will:

- Launch one new product "challenge specification" with the potential to reduce energy use by 1 quad.
- Demonstrate and evaluate impact of several promising new technologies in commercial buildings with the potential to with the total potential to reduce energy use by up to 1 quad.
- Broaden the use of the Commercial Energy Asset Score to help people identify cost-effective building technology retrofit opportunities to improve their building's energy performance. Increase adoption by demonstrating its use in 2 utility energy efficiency programs.
- Assist over 200 organizations representing 10 billion sq. ft. of commercial building space or more to demonstrate 2 percent per year portfolio-wide energy savings.

In addition, these funds may be used to support efforts such as impact analysis; peer reviews; data collection and dissemination; and technical, market, economic, and other analyses.

Commercial Buildings Integration

Activities and Explanation of Changes

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs. FY 2014 Enacted
Commercial Buildings Integration		
• CBI will demonstrate promising new energy efficient technologies in commercial buildings. These demonstrations become the "real-world examples" that encourage early adopters to install new technologies. • CBI will maintain and grow its successful market partnerships to accelerate adoption of energy efficiency technologies and practices. In 2014 CBI will assist over 200 organizations representing 10 billion square feet of commercial building space to demonstrate 2 percent per year portfolio-wide energy savings. • CBI will work with industry to develop common metrics and tools that help decision makers evaluate the cost and benefits of energy efficiency improvements. For example, CBI will work with industry to develop a standard data format for commercial building energy information that can be used to improve interoperability and project management across the buildings industry. • CBI will continue to encourage the deployment of energy modeling to reduce the cost of implementing energy efficiency measures in buildings. CBI will build on the adoption by two utilities of DOE-developed energy modeling platform Energy Plus in their energy efficiency programs, encouraging other utilities to use this platform to lower their program costs and increase energy savings. • CBI will continue to develop and demonstrate a training curriculum encouraging energy efficient practices in the operation of existing buildings. By the end of 2014 CBI expects more than 50	• CBI is charged with demonstrating and increasing adoption of promising new energy efficient technologies in commercial buildings. • CBI will continue its focus on building a national approach to making building energy data available and usable. Through the Energy Data Accelerator started in 2014, CBI will support at least 19 city-utility pairs to meet their commitments to provide whole building energy data to building owners in their areas. • CBI develops common data structures, tools, and processes that help decision makers evaluate the cost and benefits of energy efficiency improvements and identify cost-effective opportunities to improve building energy performance. In FY 2015, the program will partner with industry stakeholders to demonstrate and broaden the use of several tools, including the Commercial Building Asset Score to help people understand the efficiency of the equipment and systems in their buildings, the Standard Energy Efficiency Data platform to help cities and other entities standardize large amounts of building performance data. CBI will maintain market partnerships to accelerate adoption of energy efficiency technologies and practices that integrate these technologies to achieve maximum savings. • In 2015, CBI will launch one new product "challenge specification" 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.	• In 2015, CBI funding for several activities will decline as they move from development to deployment. This includes several core tools and platforms, including the Commercial Building Asset Score and the Standard Energy Efficiency Data platform (SEED). • The Energy Data Accelerator, started in 2014, will be provided additional funding as CBI provides support to 19 city-utility partner pairs that are developing and testing solutions for whole-building data access for building owners.

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs. FY 2014 Enacted
organizations to be training their building operators using this curriculum. • CBI will continue and complete its activities to develop and demonstrate energy efficiency solutions for small buildings sector; develop and demonstrate energy efficient practices in the design of new and existing buildings; and support industry development of workforce guidelines for key job categories that support American workers for implementing energy efficiency.	In 2015, CBI will continue to assist over 200 organizations representing 10 billion sq. ft. of commercial building space or more to demonstrate 2 percent per year portfolio-wide energy savings.	

Building Technologies
Pennsylvania State University (PSU) Consortium for Building Energy Innovation

Description
The mission of the PSU Consortium for Building Energy Innovation (formerly the Energy Efficiency Buildings HUB) is to help transform the energy efficiency market for existing small- and medium-sized buildings, and develop the tools and strategies to support vibrant ecosystems of workforce and service providers to identify and apply integrative technologies and innovative practices in existing buildings. This refocusing of Penn State's efforts followed a rigorous technical review that identified high-value activities complementary to the work of other subprograms and examined the best approaches to adapting those activities to the unique and complex challenges of energy efficiency in commercial buildings. With a more integrated approach, and increased collaboration with the program's broader portfolio of performers across the U.S., the PSU Consortium will improve its ability to expand from a regional focus to a national audience and accelerate its national impact in the building retrofit market.

The PSU Consortium will "go deep" in areas where local expertise and the ability to customize the program's national approaches are required to achieve and validate lasting energy savings. In particular, the work at PSU complements the program by:

- Serving as a local test bed for DOE-produced solutions;
- Testing real-world integration of technologies and processes;
- Producing replicable solutions that require a local origin but can be applied nationally; and
- Collaborating with the program to advance research, development and integration of needed technologies.

The PSU Consortium is focused in three areas: (1) To develop market-tested pathways to 50 percent energy reduction in existing small and medium commercial buildings, (2) identify and overcome market barriers in implementing energy efficiency in existing small and medium commercial buildings, and (3) accelerate adoption of energy efficient retrofit solutions at local and national scales.
Key activities include:

- Developing and demonstrating packages of existing emerging technologies focused on integration of systems;
- Testing, verifying and demonstrating low-cost building operations solutions (e.g., sensors, controls, diagnostics);
- Developing and refining retrofit strategies and tools, tailored to Small/Medium Sized Commercial Buildings (SMSCB);
- Demonstrating strategies that can be applied at a regional level in collaboration with retrofit enablers (e.g., regulators, program administrators, service providers, the finance sector);
- Developing and demonstrating strategies to improve capacity for retrofits in the SMSCB market; and
- Packaging regional successes for application on a national scale.

In FY 2015, the PSU work will develop new technologies and solutions not currently available in the market that are needed to reduce energy use in small- and medium size commercial buildings, and demonstrate new paths to market for real energy savings. PSU will continue to deploy their work and other energy saving solutions in small- and medium-sized commercial buildings in Greater Philadelphia, while working with other regions for national deployment.

In addition, these funds may be used to support efforts such as impact analysis; peer reviews; data collection and dissemination; and technical, market, and economic studies and other analyses.

Pennsylvania State University (PSU) Consortium for Building Energy Innovation

Activities and Explanation of Changes

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs. FY 2014 Enacted
PSU Consortium for Building Energy Innovation		
• The mission of this work is to help transform the energy efficiency market for existing small-medium sized buildings, and develop the tools and strategies to support vibrant ecosystems of workforce and service providers to identify and apply integrative technologies and innovative practices in existing buildings. The work at PSU is complementary to that of the program's other subprograms, with the ability to "go deep" in areas where local expertise and the ability to customize the program's national approaches are required to achieve and validate lasting energy savings. In particular, the work at PSU complements the program by: ▪ Serving as a local test bed for DOE-produced solutions; ▪ Testing real-world integration of technologies and processes; ▪ Producing replicable solutions that require a local origin but can be applied nationally; and ▪ Collaborating with the program to advance research, development and integration of needed technologies.	• In FY 2015, the PSU work will develop new technologies and solutions not currently available in the market that are needed to reduce energy use in small- and medium-size commercial buildings, and demonstrate new paths to market for real energy savings. PSU will continue to deploy their work and other energy saving solutions in small- and medium-sized commercial buildings in Greater Philadelphia, while working with other regions for national deployment.	• No significant changes.

Building Technologies
Residential Buildings Integration

Description
The Residential Buildings Integration (RBI) subprogram is focused on reducing energy use in residential buildings. RBI investments will support the goal to demonstrate and promote adoption of energy efficient technologies and techniques that, when fully deployed, would reduce building-related energy use by 30 percent and 25 percent, respectively, in new and existing residential building stock by 2020, and 50 percent and 40 percent by 2030.

To achieve this goal, RBI will conduct applied research, increase builder and homeowner awareness, facilitate and promote energy efficiency in both new construction and in home retrofits, and provide clear guidance on how to ensure the safety and comfort of homes in concert with energy saving improvements. As part of this effort, RBI will increase its focus on barriers to the adoption of technologies and building practices that are available today, but which are not readily accepted by builders, contractors or homeowners. To facilitate adoption of these available technologies, RBI will pursue cost reduction strategies and provide solutions to barriers that prevent technology adoption. Many of these solutions may focus on single energy efficiency measures independent of any whole house review. Lastly, RBI will work to bring to market technologies developed and tested through the Emerging Technologies subprogram, while demonstrating technologies that lead to net-zero energy ready homes or are ready for incorporation into building energy codes.

Recent accomplishments include:

- Ten new Building America Top Innovations were selected based on Building America partnership research and demonstration activities and announced at the Housing Innovation Awards at the 2013 Solar Decathlon. Past Building America innovations have been incorporated as energy-efficient building features within the ENERGY STAR Homes program, enabling the certified homes to save approximately 20 percent in energy (over codes). They also have helped accelerate adoption of efficient residential building model energy codes (IECC 2009 and IECC 2012), which are approximately 15 percent to 30 percent more energy efficient than prior energy codes.
- The Building America Program released the Building America Solution Center, a dynamic new tool that allows residential building professionals full and simple access to the wealth of building science and energy efficiency information produced through applied R&D funded by the Building America program.
- The Residential Buildings Integration subprogram (RBI) completed pilot testing of the Home Energy Score in nine States, and partnered with 30 organizations to implement the Home Energy Score in over 6,000 homes in 19 States to date. DOE program partners promote the Home Energy Score to homeowners without direct DOE funding, including several state-funded partner programs. Connecticut, Florida, and Missouri are actively pursuing statewide adoption of the Home Energy Score.
- The DOE Challenge Home Program was launched as an ambitious successor to the Builders Challenge home labeling program. Challenge Home works with builders, verifiers, and industry experts to promote a whole new level of new home performance, with rigorous requirements that ensure outstanding levels of energy savings, comfort, health, and durability. The program has grown its partnerships by 60 percent since FY 2012, far exceeding program goals.
- Over 100,000 homes were retrofitted under the Home Performance with ENERGY STAR Program and the Better Buildings Neighborhood Program demonstrating a range of program models in numerous communities across the country offering home energy savings of 15 percent or more.

In FY 2015, RBI will invest $14 million in the Building America initiative. RBI will direct approximately one-third of this spending toward achieving the long-term goal of providing solutions that support 50 percent savings in new homes, and 30 percent savings for home upgrades. Such projects include developing high performance high-R wall systems for use in cold climates, and low-load HVAC systems that ensure dehumidification in temperate climates. Another third will address indoor air quality and moisture/water management, which are critical health, durability, and comfort issues which are the secondary effects related to high performing homes. In conjunction with the Codes subprogram, the remaining third will examine code compliance issues to develop solutions as well as available retrofit technologies to reduce costs associated with code compliance. As part of the overall Building America effort, this initiative will investigate various homeowner transaction processes (e.g., home sales, home equipment replacements such as HVAC, etc.) to identify and reduce impediments to greater adoption of technologies beneficial to the homeowner. To gain a broader market reach in FY 2015, rather than only focusing on whole house approaches, actionable solutions will be developed around typical individual systems, known as incremental measure packages. This more granular approach will provide feasible and cost effective

solutions to a wider range of companies working to improve residential homes, which in turn will provide the larger set of home owner's access to energy efficiency improvements without undertaking a whole house retrofits.

Under the Building America Program, RBI will continue to expand its Building America Solution Center. The Solution Center provides the proven results of the Building America Research Program in a web-based electronic platform that builders and contractors may readily access from the field. Through the Building America Solution Center builders can see and understand various aspects of installation of these high efficiency technologies and state-of-the-art building practices and processes.

The Building America Solution Center also supports retrofit contractors by providing the home improvement trades with the latest Building America information on the installation of energy efficiency technologies and practices in the field.

To highlight emerging new technologies within the housing market, the program funds a "Challenge Home" program, which is a labeling program that highlights 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 even the typical ENERGY STAR home. The Challenge Home Program provides an avenue for builders to promote their high performing homes through DOE recognition, using many of the technologies emerging from the Building America Research Program, and demonstrating the value of net-zero energy ready homes to homeowners. In addition, once demonstrated through these leading builders, these high efficiency technologies and practices will be more readily adopted by other market players and can be validated for potential future inclusion in the ENERGY STAR Homes Program and, ultimately, model building codes. In 2015, RBI will invest $0.5 million in the Challenge Home Program.

In FY 2015, RBI will implement an improved Solar Decathlon, an activity that challenges collegiate teams to design, build, and operate integrated energy efficient, solar-powered houses that are functional, cost-effective, and attractive. RBI will enhance the impact of the Solar Decathlon while still providing the essential components that make it a signature DOE activity. The program will fund the Solar Decathlon at $3 million in FY 2015, while increasing the participation and investments of stakeholders.

The retrofit or home improvement market is a critical sector to address national energy consumption, yet it is highly fragmented and therefore the most difficult buildings market to reach. Many of the technologies and retrofit practices to achieve 20 percent to 30 percent energy savings are already known. However, moving these technologies and practices into the mass market has proven difficult. In FY 2015, RBI will focus on enhancing the Better Buildings Residential activities which serve as the platform to promote energy efficiency in existing homes. These activities develop a suite of informational, retrofit program design, and best-practice sharing tools covering energy efficiency technologies and techniques to better serve the local program sponsors such as NGOs, utilities and state energy offices implementing energy efficiency programs at the local level. The Better Buildings Residential activities are the outgrowth of the Better Buildings Neighborhood Program, a half-billion dollar Recovery Act grant program, and are intended to provide technical assistance that will allow regional and local efficiency programs and their partners to more comprehensively address barriers to adoption of retrofits and to continually improve their programmatic approaches.

As an important component of the Better Buildings Residential activities, the program will continue to expand its Better Buildings Solution Center, a counterpart to the Building America Solution Center, to provide regional and local program sponsors and administrators implementing existing home retrofits with the best practices and lessons learned from the Better Buildings Neighborhood Program. Information and lessons learned from over 41 grantees over the last three years are invaluable to many programs, and this web-based electronic tool provides this information. These lessons include financing, work force development, demand-driver, quality assurance, and benchmarking characteristics of successful programs. In addition to Better Buildings Solution Center, DOE will continue to convene program administrators and allies through conference calls and webinars to foster a community of program administrators sharing their successes as well as problems facing their programs. In FY 2015, these Better Buildings Residential activities are funded at $2.8 million.

The program will continue to support Home Performance with ENERGY STAR as a model whole-house retrofit program, at $1.2 million in FY 2015. This whole-house upgrade program works with local sponsors, such as utilities and state energy programs, to promote energy efficiency upgrades through a qualified workforce through outreach support, contractor recognition, approved analytical techniques, workforce development, and information on financing through HUD's Power Saver Loan Program. The work is backed by rigorous quality assurance by a third party. Over 300,000 homes have been upgraded under this program to date. Additional changes to program design to facilitate quality assurance, improved

labeling of homes, and alternative deployment structures that do not require a local sponsor will help expand the program nationally. In addition, DOE is expanding its efforts into promoting incremental measure retrofit programs to help homeowners more affordably and easily make upgrades and to thereby increase the national energy savings in the existing homes market.

In addition, DOE will expand the Home Energy Score for use by retrofit contractors through extensive outreach through our Better Buildings Residential Network. The Home Energy Score is similar to a vehicles mile-per-gallon rating. It allows homeowners to compare the energy performance of their homes nationwide by using a 1-10 scale, with 10 being the most efficient. FY 2015 funding for Home Energy Score activities will be $1.2 million.

Specifically, in FY 2015 RBI will:

- Building America: demonstrate 10 new innovations from Building America research across new homes, existing homes, and individual efficiency measures;
- Building America: document 1 proven high performance new home solution package per climate, and 1 retrofit whole house solution package per climate;
- Building America Solution Center: add 40 new guidance documents and at least 200 new registered users;
- Challenge Home: 5,000 highly efficient new homes constructed by building partners;
- Solar Decathlon: Architectural plans submitted by teams for review by DOE;
- Better Buildings Residential: recruit 75 member organizations committed to increasing the number of retrofitted; homes in their locality and receive benchmarking data from 15 programs;
- Better Buildings Residential: launch single incremental measure programs with 5 program partners by providing training, outreach materials, and quality control mechanisms; and
- Home Energy Score: 25,000 homes scored by local sponsors such as utilities, NGOs and state energy offices;
- Home Performance with ENERGY STAR: 125,000 retrofits in FY 2015.

In addition, these funds may be used to support efforts such as peer reviews; data collection and dissemination; and technical, market, economic, and other analyses.

Residential Buildings Integration

Activities and Explanation of Changes

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs. FY 2014 Enacted
Residential Buildings Integration		
• RBI will focus on building system R&D and expansion of partnerships with market leaders to develop actionable cost effective options for whole home or systems energy efficient retrofits, while developing databases and tools that reduce uncertainty associated with investment (e.g., Building America Solution Center and Home Energy Score). • RBI will demonstrate top innovations from applied research across new homes, existing homes, and individual efficiency measures. • RBI will demonstrate market-based cases for net-zero energy ready homes to builders and homeowners, and will expand the network of private sector trainers to provide technical assistance to builders and to translate building science knowledge into educational materials for use by builders. • RBI will develop a plan for an improved Solar Decathlon that enhances the impact of the event while still providing the essential components that make it a signature DOE activity. • Through Better Buildings Residential activities, RBI will enhance a suite of resources including expansion of access to best practices and lessons learned. RBI will provide options for increasing lower-cost, high-volume single measure activities that increase efficiency in homes. RBI will provide informational resources to help state and local decision makers in their support of residential efficiency programs. • Through the Home Energy Score, RBI will provide clear information to homeowners and help enable state and local decision makers in their	• RBI will focus on building system R&D and partnering with market leaders to accelerate adoption of energy efficient solutions in the residential building sector, while developing databases and tools that reduce uncertainty associated with investment (i.e. Building America Solution Center and Home Energy Score). • RBI will continue supporting development of innovations through applied research and industry partnership demonstrations, with strategic refinements to increase impact and accelerate adoption. RBI will expand capability to address secondary effects related to high performing homes such as indoor air quality, moisture/water management (for durability). RBI will examine and address technical code compliance issues and available retrofit technologies to reduce implementation costs. Investigate market transaction processes to identify and reduce impediments to technology adoption of technologies beneficial to the homeowner. • RBI will continue to demonstrate market-based cases for net-zero energy ready homes to builders and homeowners. • RBI will expand the network of private sector trainers for the Challenge Home Program under Building America to provide technical assistance to builders and to translate building science knowledge into educational materials for use by builders. • Through Better Buildings Residential activities, RBI will continue to enhance a suite of resources including expansion of access to best practices	• RBI will slightly scale back investments in developing and deploying energy efficient technologies for new and existing homes, in order to focus efforts on the subprogram's high-impact activities.

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs. FY 2014 Enacted
support of residential efficiency programs (WBS Categories: Design and Decision Support, Market Engagement-Channel Development, and Program Planning). • Through the Home Performance with ENERGY STAR Program, RBI will help efficiency programs and their partners to more comprehensively address barriers to adoption of retrofits. RBI will offer innovative implementation options for deploying building science best practices for retrofitting homes.	and lessons learned. RBI will provide options for increasing lower-cost, high-volume single measure activities that increase efficiency in homes. RBI will provide informational resources to help state and local decision makers in their support of residential efficiency programs. • Through the Home Energy Score, RBI will provide clear information to homeowners and help enable state and local decision makers in their support of residential efficiency. • Through the Home Performance with ENERGY STAR program, RBI will help efficiency programs and their partners to more comprehensively address barriers to adoption of retrofits. RBI will offer innovative implementation options for deploying building science best practices for retrofitting homes.	

Buildings Technologies
Equipment and Buildings Standards

Description

The Equipment and Buildings Standards subprogram supports market-based and 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. Since minimum standards effectively eliminate low-efficiency products from the marketplace, the program saves energy by ensuring that products purchased, installed, and operated are energy-efficient. Test procedures and energy conservation standards developed by this program support national energy policy objectives, such as increasing energy savings and energy productivity, and reducing carbon emissions.

DOE remains committed to meeting all of its legislatively mandated deadlines for covered appliances and equipment and 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 in the adoption of energy efficient technologies primarily through support to Energy Star, regulatory activities, and model building code activities. The vast majority of the subprogram's test procedure and standards rulemaking activities are legislatively mandated by the Energy Policy and Conservation Act (as amended). The rulemaking schedule, and thus the level of program activity, is largely determined by existing legislation. Since 2009, 21 new or updated standards, covering more than 30 products, have been issued and will ensure annual energy savings over the coming years. Cumulative consumer utility bill savings associated with these recently enacted standards are projected to be hundreds of billions of dollars (undiscounted) through 2030. The Equipment and Building Standards subprogram will support the goal of reducing building source energy use and will establish efficiency standards that cut greenhouse gas emissions by at least 3 billion metric tons through 2030.[6]

DOE will build upon prior year activities by initiating new energy conservation standards and test procedures for certain types of consumer products and commercial equipment and by issuing Notices of Proposed Rulemaking and Final Rules for standards and test procedures.

In FY 2015, the proposed funding of $62.5 million for appliance and equipment standards activities will enable DOE to continue to take all necessary and feasible steps to finalize legally required efficiency standards consistent with all applicable judicial and statutory deadlines. DOE will build upon prior-year new product coverage activities by completing those rulemakings that deliver a high level of benefits beyond statutorily mandated rules. DOE will also maintain its activities in certification and enforcement to increase the effectiveness of existing energy conservation standards. The frequency and scope of product testing to verify compliance with DOE standards will reflect the compliance experience from previous years. The additional funding targeted for certification and enforcement will allow DOE to test increased volumes of commercial and industrial products, which tend to cost more to purchase and test than home appliances, but also use more energy per unit. With certification requirements for certain commercial products coming into play in mid to late 2014, DOE will have many more products to test for compliance to minimum efficiency standards.

State and local building codes regulate 70 percent of building energy and represent the baseline for building energy efficiency. Building energy codes are an existing solution that can provide between 20-30 percent whole building energy savings. The Building Energy Code Program is a legislatively authorized program with a mandate to develop Federal determinations based upon model codes that address all new construction and major renovations in residential and commercial buildings. As directed by law, the Building Energy Codes Program (BECP) activities include:

- Code Development—Supporting and participating in the codes development processes by providing cost-effective technical proposals and building consensus between stakeholders for technologically feasible and economically justifiable energy efficiency measures. In FY 2015, the program will review the technical and economic basis of the national model building energy codes and participate in the industry processes for review and modification (42 U.S.C. 6836).
- Code Related Rulemakings—Exercising statutory authority to make determinations on the IECC and Standard 90.1 (42 U.S.C. 6833) and to develop and promulgate rules regulating building energy efficiency s, including those governing Federal buildings (42 U.S.C. 6834 and 6835) and manufactured housing (42 U.S.C. 17071). In FY 2015, activities will

[6] At least three billion tons of carbon dioxide emissions will be avoided due to appliance and federal building standards finalized during the Obama Administration's first and second terms.

focus on: ASHRAE Standard 90.1-2013 Determination (42 U.S.C. 6833), IECC 2015 Determination (42 U.S.C. 6833), Manufactured Housing (42 U.S.C. 17071), Federal Buildings (42 U.S.C. 6834), Fossil Fuel and Sustainable Design (42 USC 6835).

- Code Adoption, Compliance and Market Engagement—Providing financial and technical assistance to States, territories and regional and national organizations to upgrade, implement, and increase compliance with their building energy codes (42 U.S.C. 6836, 42 U.S.C. 6833). The Building Energy Codes subprogram also provides financial support to the Regional Energy Efficiency Organizations and National Association of State Energy Officials to assist with state code adoption and compliance activities. FY 2015, the program will increase the number of States (by at least 5) that have adopted versions of model building energy codes, increase compliance activities in at least 5 States that have building energy codes. At this time 8 states and territories have not adopted a statewide building code.

The Building Energy Codes subprogram is a highly impactful program. All activities are cyclical by nature and are scalable based upon desired impact. The associated cumulative energy savings through 2020, since program inception in 1992, is estimated to be approximately 11.6 quads.[7] The program's nearer-term goals are to assist States and localities in adopting, complying with, and enforcing the model energy codes for residential and commercial buildings, resulting in higher-performing buildings that maximize cost-effective energy savings. In FY 2015, proposed funding of $6.5 million will expand the program's focus on compliance support and compliance measurement, with the goal of enhancing consumer benefits that are intended to accrue to owners and occupants of newly built and retrofit buildings. Specific activities will include:

- Collaboration with regional and state entities to create the institutional capacity to increase code compliance on an on-going basis;
- Development and deployment of education and training activities;
- Establishing the case and providing materials for utilities interested in supporting activities which will lead to increased code compliance;
- Updating the DOE compliance measurement protocols developed in 2009-10;
- Conducting statistically reliable residential compliance baselines;
- Analyzing residential compliance results to determine which code requirements combine low compliance and high potential energy savings. Using this information to inform education curricula; and
- Piloting commercial compliance studies with the intent of establishing a generally-accepted methodology for commercial buildings.

Increases in efficient building energy code development and adoption by States and localities, paired with rigorous compliance verification, will provide significant reductions in building energy use, which is an essential aspect of EERE goals. DOE's current goals for more efficient code development, coupled with increased adoption and compliance rates would result in significant energy savings over current practices.

Specifically, in FY 2015 the Equipment and Building Standards subprogram will:

- Publish standards NOPRs for 16 products (13 rulemakings);
- Publish test procedure NOPRs for 3 products (3 rulemakings);
- Publish test procedure final rules and publish standards final rules as technical feasibility and economic justification are firmly established;
- Initiate new standards rulemakings for 6 products (4 rulemakings);
- Initiate new test procedure rulemakings 3 products (3 rulemakings);
- Support development of ASHRAE 90.1-2016 and IECC 2018;
- Increase the number of states (by at least 5) that have adopted updated versions of model building energy codes (Adoption); and
- Increase compliance activities in at least 5 states that have building energy codes (Compliance).

In addition, these funds may be used to support efforts such as peer reviews; data collection and dissemination; and technical, market, and economic studies and other analyses.

[7] Building Energy Codes Program: National Benefits Assessment, 1992-2040, available at: www.energycodes.gov/sites/default/files/documents/BenefitsReport_October2013.pdf.

Equipment and Buildings Standards

Activities and Explanation of Changes

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs. FY 2014 Enacted
Equipment and Buildings Standards		
• Program will meet all statutory obligations and continue to work on all active rulemakings. Rulemakings will be started for those rules with statutory obligations. Enforcement and ENERGY STAR verification activities will be maintained at reduced levels compared to FY 2013. • The Building Energy Codes Program will meet all statutory obligations, including participation in national model code development and implementation. The program will also release a Funding Opportunity Announcement (FOA) targeting increased compliance activities,	• Program will accelerate appliance efficiency standards rulemakings and actively enforce Federal minimum efficiency levels. The new product coverage determinations will be continued further into the rulemaking process. • The Building Energy Codes Program will continue to meet statutory obligations to participate in national model code development activities, and seek to increase the number of states (by at least 5) that have adopted and are complying with updated codes.	• The additional funding supports increased rulemakings and certification and enforcement in both commercial and industrial products. • Additional funds will allow an s increased emphasis on code compliance.

Building Technologies
NREL Site-Wide Facility Support

Description

In FY 2015, EERE will continue to 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. This practice is consistent with other National Laboratories. EERE began this practice in FY 2014 to reduce NREL's labor rate multiplier, thereby reducing the cost barrier to accessing unique NREL capabilities (such as facilities and staff expertise) by industry and academia. This practice also makes site operating costs more transparent in order to facilitate cost control and planning. In FY 2014, this practice resulted in a reduction in the Lab-wide direct labor multiplier of approximately 15 percent compared to FY 2013. The proposed FY 2015 budget continues this approach. The site-wide facility support funds cover maintenance and engineering support; fire, emergency, and custodial services; general utilities; network infrastructure and licenses; environment, safety, and health support; and sustainability. By moving these costs from laboratory overhead to direct funding, EERE accelerates technology transfer and mission impact by making it easier for companies and external researchers to access NREL capabilities and expertise.

This funding supports research programs by providing basic site services, functions, and infrastructure for Site Operations, which includes: Management, Building Operations, Building & Grounds Maintenance, Fire & Emergency Response, Engineering & Construction support, Minor Construction projects, Electrical Safety Program, Utilities, and Facilities Planning Support; and activities within the Sustainability and Environmental Health and Safety (EHS) portfolios. These activities and their costs are relatively fixed and only vary significantly based upon variations in commodities, construction activity, emergencies, weather patterns, etc. They are considered to be the core functions for site operations, safety, environmental compliance, and sustainability at NREL. In FY 2015, this funding will support more than 60 full time equivalents that manage and provide support for these core functions. It will also fund site-wide subcontracts such as janitorial services, refuse and recycling, and subcontracts for minor construction. Additionally, this funding will support site-wide costs associated with maintaining NREL's leadership position, such as: maintaining International Organization for Standardization (ISO), American Association for Laboratory Accreditation (A2LA), and other lab-wide accreditations, managing facilities to enable mission goals, improving sustainability, pollution prevention, waste minimization, improving energy efficiency, reducing water use, and maintaining an effective emergency management system.

The FY 2015 contribution from each program differs from the FY 2014 allocation, because EERE has developed a more precise, equitable, and economically neutral method that ensures a net-zero impact on programs' funding. For each program, the contribution to direct funding for site-wide facility support is equivalent to the estimated contribution the program otherwise would have made through overhead charges. This method is based upon each program's level of funding to NREL, adjusted to account for anomalies from capital expenditures and major subcontracts.

NREL Site-Wide Facility Support

Activities and Explanation of Changes

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs. FY 2014 Enacted
NREL Site-Wide Facility Support		
• 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.	• 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.	• The delta is the result in a change in methodology used to allocate site-wide facility support contributions amongst programs. The FY 2015 value enables and directly equates to the program's estimated savings gained from the reduced labor multiplier.

Building 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. For more information, refer to the Department's FY 2013 Annual Performance Report.

	FY 2013	FY 2014	FY 2015
Performance Goal (Measure)	**Lighting - Decrease the manufacturing cost of a warm white LED package. (Lumens / $)** 2013: Increase lighting efficacy of "warm white light" solid-state lighting in a lab device.		
Target	148 lumens per watt of "warm white light"	128 lm/$	144 lm/$
Result	Exceeded – 168	N/A	N/A
Endpoint Target	217 lm/$ by 2020		

Weatherization and Intergovernmental Program

Overview

The mission of the Weatherization and Intergovernmental Program (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 and to improve energy security.

Aligning with the President's Climate Action Plan and the Administration's all-of-the-above approach to American energy, the program addresses both the demand and supply sides of energy by facilitating investments in energy efficiency and clean energy generation. In FY 2015 WIP's mission is supported by three programs: the Weatherization Assistance Program (WAP), the State Energy Program (SEP), and the Clean Energy and Economic Development Partnerships (CEED Partnerships). The Tribal Energy Program (TEP) is being consolidated within DOE's Office of Indian Energy Policy and Programs.

The program and its national network of state and local government agencies provide strategic leadership, resource leveraging, and market expertise to accelerate deployment of energy efficiency and clean energy products and technologies which improve America's energy security and economic prosperity. For decades, States have demonstrated leadership through exercising 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 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 executive orders, legislation and local ordinances, management of retrofit programs, and land use plans. Figure 1 identifies Federal leadership and partnership activities that result in positive economic impacts at the state and local level.

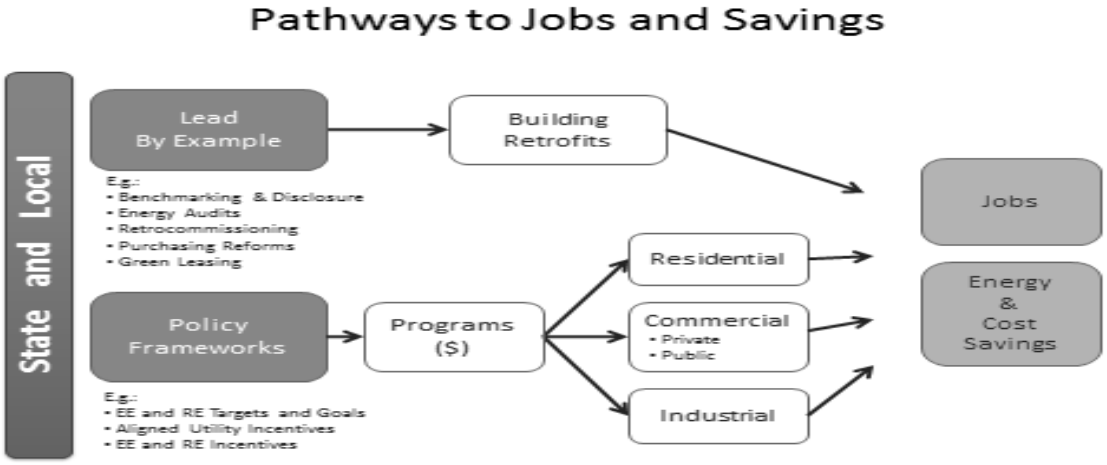


Figure 1: Federal leadership and partnership activities that result in positive economic impacts at state and local level

WIP is part of EERE's balanced research, development, demonstration, and deployment approach to accelerate America's transition to a clean energy economy. Key program characteristics include the ability to do the following:

- Utilize state energy and weatherization networks, which play a crucial role in energy program and policy implementation; and
- Address market, planning, implementation, and financing challenges to encourage the deployment of clean energy policies and technologies.

The program uses an integrated approach consisting of the following strategies/pathways:

- Formula grants to support the core capabilities of state energy and weatherization offices;
- Competitive awards to support innovative state and local high-impact and self-sustaining clean energy projects;
- Technical assistance to facilitate clean 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, communication, and provision of technical assistance.

Highlights of the FY 2015 Budget Request

The program's budget request supports several key initiatives that contribute to achieving high-level objectives:

- The FY 2015 funding request for the WAP seeks to restore program funding to pre-Recovery Act levels to maintain access to these services in jurisdictions across the country. WAP is the largest nationwide residential retrofit program and provides a foundation in many communities for related services. It helps eligible households reduce the comparatively large percentage of available income that they spend on energy, and is estimated to provide savings of $300 million over the life of installed measures in the homes weatherized. The FY 2015 request supports:
  - Anticipated completion of 33,100 low-income residential energy retrofits, with per unit average annual energy cost savings of $250 to $480 per year between 2015 and 2035;
  - Continued improvements in workforce training and quality standards; and
  - Competitively selected and managed high-impact projects on financing models for the retrofit of low-income multi-family buildings.
- The SEP will continue support for core capacity and innovation in the States through formula and competitive grants as well as direct technical assistance and dissemination of best practices to:
  - Assist in reducing government facilities and operations energy use by 2 percent per year by 2020;
  - Accelerate investment in public sector use of energy service performance contracts by $1-2 billion by 2016;
  - Maintain the viability of the state energy office network and capacity to develop, improve, and implement state energy plans;
  - Support transformative projects focused on development and implementation of state policies addressing barriers limiting investment in energy efficiency and renewable energy, including the self-sustaining financing models; and
  - Facilitate self-sustaining markets for energy efficient residential, commercial and industrial building upgrades.
- The Clean Energy Economic Development Partnerships provide technical assistance to States and local communities to create economic development roadmaps that leverage the current shale gas boom to support sustained economic development and growth, as well as to assist local governments in their efforts to diversify their economies by attracting advanced manufacturing and clean energy industries. Technical assistance to local governments will enable them to pursue high impact local models for advancing clean energy.
- A key budget change is the transfer of the Tribal Energy Program to the Office of Indian Energy Policy and Programs. This transfer is described in the "Explanation of Major Changes".

Key Challenges

WIP's subnational partners utilize these resources to enable them to perform residential energy efficiency retrofits for low income households, energy planning, emergency energy management, development and financing of clean energy projects, and sustainable energy policy and program development. WIP also designs and manages a broad portfolio of state and local technical assistance programs and initiatives. The objective is to equip leaders with the knowledge, skills, and tools they need to promote clean energy investments in their jurisdictions through focused support in the following priority areas: energy efficiency and renewable energy technologies, strategic energy planning, policy and program design and implementation, energy data management and evaluation, and financing solutions.

Weatherization and Intergovernmental Program
Funding ($K)

	FY 2013 Current	FY 2014 Enacted[1]	FY 2014 Current	FY 2015 Request	FY 2015 vs FY 2014 Enacted
Weatherization and Intergovernmental Program					
Weatherization Assistance Program					
Weatherization Assistance	128,879	170,898	170,898	224,600	+53,702
Training and Technical Assistance	2,826	2,998	2,998	3,000	+2
Total, Weatherization Assistance Program	**131,705**	**173,896**	**173,896**	**227,600**	**+53,704**
State Energy Program	47,108	49,970	49,970	63,100	+13,130
Clean Energy and Economic Development Partnerships	0	0	0	14,000	+14,000
Tribal Energy Program	9,421	6,996	6,996	0	-6,996
Total, Weatherization and Intergovernmental Program	**188,234**	**230,862**	**230,862**	**304,700**	**+73,838**

[1] FY 2014 Enacted funding reflects the contractor foreign travel rescission of $137,798.

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

	FY 2015 vs FY 2014 Enacted
Weatherization Assistance: The $209 million for Weatherization Assistance formula grants (an increase of $38 million) will support program operations and assist approximately 33,100 low-income families across the country. This funding level allows for the implementation of standard work specifications, the training and certification of specific job classifications and the retention of highly skilled workers. The $53.7 million increase in the Weatherization Assistance Program also includes an additional $15 million for weatherization competitive awards to develop and test out a number of financing models to support energy-efficiency retrofits in the underserved multi-family sector. There is an additional $0.6 million included for NREL Site-Wide Facility Support.	**+53,702**
Training and Technical Assistance: No significant changes.	**+2**
State Energy Program: The State Energy Program request increases by $13.13 million, primarily in support of a variety of multi-jurisdictional competitive energy projects that will have high impact/high-visibility and replicability to other state and local entities.	**+13,130**
Clean Energy and Economic Development Partnerships: The $14 million increase for the Clean Energy and Economic Development Partnerships will provide technical assistance for economic development roadmapping in regional sustainable shale gas growth zones. A separate portion of the funding will be used for technical assistance partnerships with local communities to enable them to develop and implement strategies to achieve their local clean energy goals.	**+14,000**
Tribal Energy Program: The decrease for the Tribal Energy Program (TEP) is due to the proposed budget transfer of TEP from EERE to the Office of Indian Energy Policy and Programs (Office of Indian Energy). The basis for the change is that EPAct 2005 established the Office of Indian Energy, provided a funding authorization through FY 2016, and identified specific activities that are similar to those currently (through FY 2014) conducted by EERE/TEP. The transfer would include all funding, functions, and 1 FTE. There are no anticipated impacts on DOE facilities, National Laboratories, and Federal staff. The $6.9 million reduction for tribal activities in the WIP budget request is offset by a matching increase in the budget request for the Office of Indian Energy.	**-6,996**
Total, Weatherization and Intergovernmental Program	**+73,838**

Weatherization and Intergovernmental Program
Weatherization Assistance Program
Weatherization Assistance

Description

Weatherization Assistance Grants ($224 million)

Low-income weatherization assistance activities reduce the cost of residential household energy bills, which are significantly disproportionate to higher income households. Up to 40 million low-income households in the U.S. are eligible for low-income housing energy assistance.

Weatherization formula grants support the largest (and one of the most technically advanced) network of residential energy retrofit providers in the country. Funds are allocated on a statutory formula basis and awarded to States, U.S. territories, and Washington, D.C. governments to increase the energy efficiency of homes occupied by low-income families. These agencies, in turn, contract with approximately 800 Community Action Agencies, local governmental and nonprofit agencies to deliver weatherization services to low-income clients 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; improve hot water production and use; and reducing electric base load consumption. The consistent delivery of quality services is addressed through active Federal, regional and state training and technical assistance programs.

Funding at the $209 million request level provides sufficient funding for the deployment of formula grants that will support the nationwide delivery of services, a skilled professional weatherization workforce, and related training programs. This funding level would sustain the provider networks, resulting in thousands of homes receiving weatherization services and allowing eligible low income families to apply retrofit savings to purchase other essential basic needs (like food, medicine, etc). The program leverages both Federal and non-Federal funding sources to expand the array of services available for each home or increase the number of homes weatherized, which would be supported by programmatic funding.

Of the total WAP funding, $15 million will be used to fund competitively selected projects to demonstrate the viability of a variety of financing programs for replicability across the country. The financing models that prove successful will support expansion of weatherization activities in the underserved residential multi-family sector. Currently, more than 50 percent of low-income residents reside in multi-family housing stock. The expansion of multi-family financing programs is the most practical means to dramatically increase the impact of federal funds utilized in the weatherization of low-income households. In FY 2015, the program will competitively select and manage high-impact projects that would enable recipients to establish financing and loan models for the retrofit of low-income multi-family buildings. Competitive assistance activities will incorporate data collection and share the project results including best practices.

NREL Site-Wide Facility Support ($0.6 million)

In FY 2015, EERE will continue to 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. This practice is consistent with other National Laboratories.

This funding supports research programs by providing basic site services, functions, and infrastructure for Site Operations, which includes: Management, Building Operations, Building & Grounds Maintenance, Fire & Emergency Response, Engineering & Construction support, Minor Construction projects, Electrical Safety Program, Utilities, and Facilities Planning Support; and activities within the Sustainability and Environmental Health and Safety (EHS) portfolios. These activities and their costs are relatively fixed and only vary significantly based upon variations in commodities, construction activity, emergencies, weather patterns, etc. They are considered to be the core functions for site operations, safety, environmental compliance, and sustainability at NREL. In FY 2015, this funding will support more than 60 full time equivalents that manage and provide support for these core functions. It will also fund site-wide subcontracts such as janitorial services, refuse and recycling, and subcontracts for minor construction. Additionally, this funding will support site-wide costs associated with maintaining NREL's leadership position, such as: maintaining International Organization for Standardization (ISO), American Association for Laboratory Accreditation (A2LA), and other lab-wide accreditations,

managing facilities to enable mission goals, improving sustainability, pollution prevention, waste minimization, improving energy efficiency, reducing water use, and maintaining an effective emergency management system.

Program Benefits

- Reduced national energy consumption and lowered energy costs (in a range of $250 to $480) for low-income households;
- Expanded clean energy training and employment opportunities;
- Senior citizens with special needs or individuals with disabilities occupy approximately 49 percent of the homes weatherized annually;
- Improved health and safety of homes occupied by low income families;
- Average leveraging of one dollar in non-Federal contributions for each weatherization assistance grant dollar; and
- Models of financing mechanisms that have potential for expanding the scope and impact of weatherization activities in residential multi-family housing.

The WAP FY 2015 goals that follow are complementary to the objectives identified in the budget highlights section:

- Achieve or exceed target for 33,100 home energy upgrades nationwide, restore capacity throughout the national weatherization network, and expand worker training opportunities.
- Continue to upgrade technical capabilities within the weatherization network and facilitate adoption of these infrastructure-building approaches and methods to strengthen the national energy retrofit market.

Weatherization Assistance

Activities and Explanation of Changes

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs FY 2014 Enacted
Weatherization Assistance		
Weatherization Assistance Grants ($170,898,000) • Supports energy upgrades in the homes of low income families; • Award and actively manage 59 weatherization formula grants ($171 million); and • Weatherize more than 24,000 homes.	*Weatherization Assistance Grants ($224,000,000)* • Supports energy upgrades in the homes of low income families; • Award and actively manage 59 weatherization formula grantees which will support over 33,000 comprehensive energy audits and residential energy retrofits ($209 million); and • Competitively select and manage more than 20 high-impact projects on financing models for the retrofit of low-income multi-family buildings ($15 million).	*Weatherization Assistance Grants (+$53,104,000)* • Formula funding at the request level supports critical infrastructure and operations to serve low-income families across the country; and • Increases competitive assistance efforts which improve energy-efficient retrofit processes in the underserved multi-family sector.
NREL Site-Wide Facility Support ($0) • No funding requested.	*NREL Site-Wide Facility Support ($600,000)* • 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 (+$600,000)* • The delta is the result in a change in methodology used to allocate site-wide facility support contributions amongst programs. The FY 2015 value directly equates to the estimated savings gained from the reduced labor multiplier.

Weatherization and Intergovernmental Program
Weatherization Assistance Program
Training and Technical Assistance

Description

Training and Technical Assistance ($3.0 million)

Program-directed weatherization training and technical assistance activities improve program effectiveness, service delivery, and efficiency. Requested resources support the expansion of certified training programs for a network of workers in residential energy retrofits and other energy-related fields. Other activities include: strategic planning and analysis; program performance measurement and documentation; and facilitation of advanced techniques and collaborative strategies (e.g., through pilot programs, publications, training programs, workshops and peer exchange).

Program Benefit

- Upgraded technical capabilities within the weatherization network through improved worker training curriculums, work standards, and audit processes; and
- Facilitation and coordination with other federal agencies to implement Healthy Homes improvements throughout the network.

Training and Technical Assistance

Activities and Explanation of Changes

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs FY 2014 Enacted
Training and Technical Assistance		
• Improves technical capabilities and overall program effectiveness; • Continue development and implementation of work standards, audit tools, and financial initiatives to facilitate energy-efficient retrofits in multi-family housing; • Implement enhancements to the National Weatherization Training Platform (NTER) to allow state and local weatherization professionals to access certification training on-line through DOE; and • Cooperate with other Federal agencies in the Federal Healthy Homes Work Group (HUD, EPA, Centers for Disease Control and Prevention, Department of Labor), and local non-profit organizations to establish strong effective partnerships between programs. Implement certifications of select workforce through job task analysis.	• Improves technical capabilities and overall program effectiveness; • Continue upgrade of weatherization provider network technical capabilities and management; • Review and implement changes based on the findings of the National Weatherization Evaluation; • In coordination with the Healthy Homes Initiative expand national network of trained and certified weatherization service providers who have the skills to assess health issues along with conservation needs; and • Continue to cooperate with other Federal agencies involved in the Federal Healthy Homes initiative (HUD, EPA, Centers for Disease Control and Prevention, Department of Labor), and local non-profit organizations to ensure strong effective partnerships between programs and complete implementation of certifications of select workforce through job task analysis.	• No significant changes.

Weatherization and Intergovernmental Program
State Energy Program

Description

State Energy Program ($63.1 million)

The SEP assists States in establishing and implementing clean energy plans, policies, and programs to reduce energy costs, increase competitiveness, enhance economic development, 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 associated suite of economic and environmental benefits. SEP provides States with capacity building resources, technical assistance, and best practice sharing networks to facilitate the adoption of plans, policies, and programs that are appropriate based on state and regional circumstances.

SEP funding in the amount of $39.0 million is targeted to formula-based grants that allow 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 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.

FY 2015 SEP funds will also provide for an increased scope of competitive projects and technical assistance targeted to transformational projects within state energy offices that will create more public-private partnerships initiated by states within and outside of their borders to address critical clean energy challenges. Awards would include individual state projects as well as multi-jurisdictional approaches where state energy offices partner with other states and/or local government energy or economic development agencies to develop and implement initiatives aimed at creating and/or transforming markets to enable scaled-up adoption of energy efficiency and clean energy technologies. 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 economy goals. These awards will be focused on facilitating the efforts of participating jurisdictions to take proven models and adapt them to enable their replication across the State and/or region. Awardees will receive support to help them adopt effective new policies and use regional best practices that have been applied successfully in areas that have similar energy needs, priorities and market situations to develop and carry out clean energy measures.

Through competitive financial assistance awards, states are able to join together on sector, regional and/or nationally focused initiatives aimed at finding solutions to barriers states face in meeting their clean energy economy goals. These competitive projects also provide opportunities for the states to submit innovative proposals addressing issues specific to their situations and to leverage other funding to create sustainable, high-impact solutions in clean energy development. The primary objective is for awardees to develop public-private partnerships to deploy policies and technologies that have the best opportunity for local geographic and economic impact. In FY 2015, DOE will utilize the experience and capabilities of at least 10 - 20 awardees to advance transformative best practices, benchmarking, and lead-by-example policy strategies.

In FY 2015, SEP funds will also provide direct technical assistance to state energy offices, including “on request” assistance provided via regional and other real-time channels, and through use of other appropriate mechanisms for providing effective and efficient support to states. Technical assistance is an interdependent component to the financial assistance activities—making technology deployment more efficient and effective and enhancing the likelihood of program success. Technical assistance resources are integral to (1) tools development, decisional information, and other technical assistance to grantees and sub-recipients; (2) national energy initiatives and strategic partnerships focused on deployment and best practices; (3) improvement of web-based reporting and monitoring systems; and (4) metrics and evaluation of state planning, analysis, and evaluation activities.

In addition to the work outlined above, SEP has made significant progress toward market transformations through the following initiatives and activities, several of which will continue in FY 2015:

- SEP leads the public sector section in EERE's Better Buildings Challenge and Better Buildings Alliance and other cooperative initiatives. Between FY 2010 and FY 2013 the program established partnerships with:
  - 71 public-sector partners to reduce their energy intensity by 20 percent or more by 2020; and
  - 29 States to develop replicable approaches for improving public buildings, including through the use of energy savings performance contracts.
- The program utilizes partnerships with national and regional organizations that represent key decision-makers in order to improve the pace of efficiency and clean 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.
- SEP will complete its major national evaluation in FY 2014, which will identify successful project efforts and provide future opportunities for grantees to select higher-value clean energy policies and programs. Key metrics include energy usage reduction, renewable energy production, carbon emissions reductions, and employment impacts.

Program Benefits

State energy activities occupy a unique position in its capacity to greatly leverage private sector investments to create sustainable jobs in a new clean energy economy at a time when prospects in other sectors are shrinking. State energy offices play a crucial role in the set up or reform of policy and market infrastructures — often the last critical step to successful technology adoption. Additional benefits include:

- Reduced energy use and increase renewable energy generation capacity;
- Local jobs and economic development through clean energy services and retrofits spurred by state programs and policies;
- Leverage $11 in non-Federal contributions for each dollar in state energy grants; and
- Funding flexibility allows States to select highest priorities for capacity building efforts.

The SEP FY 2015 goals that follow are complementary to the objectives identified in the budget highlights section:

- The overall objective is to bring markets to scale for cost-competitive clean energy technologies through leveraging best practice approaches and voluntary commitment-driven partnerships.
- Develop and deploy assessment, planning, and decision-making tools for the adoption of policy infrastructures to facilitate clean energy technology deployment, including self-sustaining financial models.
- Strengthen partnerships with national and regional organizations that represent key decision-makers to improve the pace of efficiency and clean energy project implementation.

State Energy Program

Activities and Explanation of Changes

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs FY 2014 Enacted
State Energy Program		
• Advance deployment of energy efficiency and renewable energy policies and technologies by state governments; • Award and actively manage $39 million in 56 formula grants; • Competitively select and manage 10-15 transformational energy projects that address barriers and provide assistance on developing policies and programs; • Complete a major national evaluation of the program; • Develop and deliver a portfolio of strategic technical assistance offerings to state and local governments; and • Complete a strategic plan that identifies desired long-range technical assistance outcomes and the sequence of actions for successful implementation.	• Advance deployment of energy efficiency and renewable energy policies and technologies by state governments; • Award and actively manage $39 million in 56 formula grants; • Competitively select and manage at least 10-20 energy efficiency and clean energy technology projects; • Review and implement changes based on the findings of the major national evaluation of the program; and • Develop and deliver a portfolio of strategic technical assistance offerings to state energy offices, including “on request” assistance through regional and other real-time channels.	• Increases the set of competitive high impact/high-visibility energy projects with the states, as well as, integrated regional, state, and local energy initiatives and additional partnerships.

Weatherization and Intergovernmental Program
Clean Energy and Economic Development Partnerships

Description

Clean Energy and Economic Development Partnerships (CEED Partnerships) ($14 million)

CEED Partnerships are targeted towards joint initiatives created through regional, state and local collaborations to accelerate adoption of clean energy technologies and spur development in areas across the country by leveraging the unique economic resources of the area coupled with energy savings and their co-benefits to help communities create new services and manufacturing opportunities and jobs. Funds will be deployed to foster partnerships regionally among state and local governments with key stakeholders to bring together the necessary knowledge, assets, and tools to put innovative ideas into action to promote clean energy investments in their jurisdictions. Through this effort DOE will provide technical support to assist the partnerships with strategic energy and economic planning, policy and program design and implementation, energy data management and evaluation, and financing solutions.

Sustainable Shale Gas Growth Zones: Domestic unconventional natural gas (shale gas) production has generated rapid economic growth in those regions with large shale gas resources. The rapid rate of development has created near term challenges to infrastructure and services, while over the long-term raises the possibility of a boom-bust cycle. In FY 2015, $10 million would be awarded on a competitive basis, to states, regional organizations and local governments to develop roadmaps for economic development in shale gas growth zones, assisting communities as they come together at the regional level to develop and deploy strategies that increase economic diversification and ensure economic growth over the long-term. This effort will be coordinated tightly with all other DOE state and local efforts and existing DOE Intergovernmental processes.

Local Technical Assistance Program (LTAP): This new effort seeks to develop engagements among local governments that are representative of sizeable geographic areas that, through their combined efforts, will be able to achieve significant scale-up in adoption of energy efficiency and clean energy technologies. In FY 2015, $4 million in funding would provide technical assistance activities to incentivize and enable local governments/communities to work in their own facilities and with local businesses to adopt energy efficiency and clean energy technologies to make dramatic gains toward the clean energy economy. More specifically, DOE will provide local entities with examples of successful models utilized in other jurisdictions of similar size and situation and assist them in developing and implementing strategies to achieve the clean energy technology goals they set for their own operations as well as those developed in partnership with community businesses.

Program Benefits

- Accelerates job creation and investments in technology in regions across the country, using the inherent resources in the region to spur strategic innovation and achieve economic growth.
- Increases the scale of energy efficiency and clean energy technology adoption and associated savings and economic benefits across the country through regional and local approaches among a broad diversity of leaders, with the potential to reduce energy intensity in these areas by 20 percent or more by 2020.

The CEED Partnerships FY 2015 goals include:

- Provide assistance to communities in shale gas growth zones to support community-driven economic development roadmapping.
- An increase in public-sector partners committed to leadership in successfully reducing their local or regional energy intensity by 20 percent or more by 2020 and an acceleration of investment in energy service performance contracts by $1-2 billion by 2016 (shared with SEP target).

Clean Energy and Economic Development Partnerships

Activities and Explanation of Changes

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs FY 2014 Enacted
Clean Energy and Economic Development Partnerships		
• No funding requested.	• Competitively select projects in regional sustainable shale gas growth zones; and • Provide direct technical assistance on energy planning, policy and program development and implementation to regional, state, and local partners.	• The increase in funding provides competitive financial awards and technical assistance in support of high impact regional, state and local energy and economic development initiatives.

Weatherization and Intergovernmental Program
Tribal Energy Program

Description

Tribal Energy Program ($0)

TEP builds partnerships with the 566 federally recognized tribal governments to address residential, commercial, and industrial energy and environmental priorities. The program employs a three-pronged approach, which includes a combination of financial, technical, and information and education assistance.

In FY 2015 DOE proposes to transfer TEP from WIP to the Office of Indian Energy Policy and Programs. The Tribal Energy Program and Office of Indian Energy Policy and Programs have a shared history of working cooperatively on providing resources and tools to tribal governments which spur tribal energy self-sufficiency. The basis for the change is that EPACT 2005 established the Office of Indian Energy Policy and Programs, provided a funding authorization through FY 2016, and identified specific activities that are similar to those currently (through FY 2014) conducted by EERE/TEP.

Program Benefits

- Tribal energy activities provide value by advancing sustainable clean energy development and deployment on tribal lands.
- Average leveraged cost share is approximately $1 in non-Federal contributions for each $1 in tribal energy grants.

Tribal Energy Program

Activities and Explanation of Changes

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs FY 2014 Enacted
Tribal Energy Program		
• Advance sustainable clean energy development and deployment on tribal lands; • Competitively select and fund 15-30 tribal high-impact clean energy projects ($5.0 to $5.6 million); • Continue training, providing internships and direct technical assistance, and monitoring activities; and • Complete strategic plan, which identifies desired long-range outcomes and the sequence of actions for successful implementation (if appropriate).	• No funding requested.	• Reduction in the WIP budget request is offset by a matching increase in the budget request of the Office of Indian Energy.

Weatherization and Intergovernmental 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. For more information, refer to the Department's FY 2013 Annual Performance Report.

	FY 2013	FY 2014	FY 2015
Performance Goal (Measure)	**Retrofits - Weatherize homes of low income families**		
Target	10,300 homes weatherized	24,600 homes weatherized	33,100 homes weatherized
Result	Exceeded – 46,871	N/A	N/A
Endpoint Target	Support 300,000 homes energy retrofits between FY 2013 and FY 2022.		

Program Direction

Overview

The Program Direction budget enables EERE to maintain and support a world-class Federal workforce to accomplish its mission to win the clean energy race in the transportation, renewable power, and energy efficiency sectors. This budget provides necessary resources for program and project management, administrative support, contract administration, human capital management, Headquarters and field site non-laboratory facilities and infrastructure, and contractor support.

The Program Direction budget supports EERE's "Strengthening Operations for Accountability and Results" (SOAR) initiative to transform EERE's organization and operations. Examples of recent SOAR accomplishments include the following:

- EERE is enacting a uniform approach to Active Project Management across its full portfolio of projects, including the creation and enforcement of rigorous "Go-No/Go" milestones, performance of regular in-depth project site visits/reviews, and termination of under-performing projects.
- EERE worked together with the National Renewable Energy Laboratory (NREL) and other national laboratories to establish an EERE-wide uniform process for planning lab projects and monitoring their progress over time.
- EERE completed a voluntary reorganization in order to become a more effective, agile, and transparent organization that maximizes impact on the energy landscape and provides the highest possible return on investment to the American taxpayer. In particular, EERE organized its programs around relevant clean energy sectors (transportation, renewable power, and end use efficiency).
- EERE completed the initial deployment of its Integrated Resource and Information System (IRIS), which will replace dozens of current IT systems with a single, integrated, cloud-based, and mobile-friendly Enterprise IT solution. EERE also completed a beta version of an online map providing the public with detailed information on innovative, EERE-funded projects across the country.
- EERE completed significant reductions in its permanent cost structure. EERE reduced its Program Direction contractor expenditures by over 50 percent from FY 2013 to FY 2014. EERE also reduced its lease costs by approximately $2 million by relocating the Golden Field Office to government-owned space on the NREL campus.
- EERE is partnering with the Department to consolidate support services to EERE personnel. The DOE Chief Information Officer has assumed responsibility for providing EERE with commodity IT services. In addition, EERE realigned its Human Resources personnel to report to the DOE Chief Human Capital Officer.
- EERE convened subject matter experts and Lean Six Sigma practitioners in several Communities of Practice to produce uniform and efficient business processes for managing the development of Funding Opportunity Announcements (FOAs), the merit-based evaluation and selection of applications, the negotiation and execution of financial assistance agreements, and the active management of resulting projects. EERE trained over 400 personnel in the new business processes.

Highlights of the FY 2015 Budget Request

The FY 2015 Program Direction Budget has three primary goals:

- Strengthen EERE's workforce through training and talent management programs, including effective recruitment strategies, career and leadership development, and succession planning;
- Support lean Active Project Management across EERE's full portfolio of projects, including travel to project sites and IT systems 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 2013 Current	FY 2014 Enacted	FY 2014 Current	FY 2015 Request	FY 2015 vs FY 2014 Enacted
Washington Headquarters					
Salaries and Benefits	78,059	81,832	81,832	80,401	-1,431
Travel	3,529	4,255	4,255	4,732	+476
Support Services	14,900	15,430	15,430	15,426	-4
Other Related Expenses	23,300	28,680	28,680	27,718	-962
Total, Washington Headquarters	**119,788**	**130,197**	**130,197**	**128,277**	**-1,920**
Golden Field Office					
Salaries and Benefits	19,945	16,530	16,530	16,241	-289
Travel	200	151	151	259	+108
Support Services	5,600	320	320	324	+4
Other Related Expenses	3,500	2,554	2,554	2,600	+46
Total, Golden Field Office	**29,245**	**19,555**	**19,555**	**19,424**	**-131**
National Energy Technology Laboratory					
Salaries and Benefits	6,922	7,267	7,267	7,140	-127
Travel	200	181	181	259	+78
Support Services	1,900	1,950	1,950	2,000	+50
Other Related Expenses	2,400	2,850	2,850	2,900	+50
Total, National Energy Technology Laboratory	**11,422**	**12,248**	**12,248**	**12,299**	**+51**
Total Program Direction					
Salaries and Benefits	104,926	105,629	105,629	103,782	-1,847
Travel	3,929	4,587	4,587	5,250	+663
Support Services	22,400	17,700	17,700	17,750	+50
Other Related Expenses	29,200	34,084	34,084	33,218	-866
Total, Program Direction	**160,455**	**162,000**	**162,000**	**160,000**	**-2,000**
Total FTEs	**732**	**707**	**707**	**697**	**-10**
	Support Services and Other Related Expenses				
Support Services					
Technical Support	14,985	11,387	11,387	11,437	+50
Management Support	7,415	6,313	6,313	6,313	0
Total, Support Services	**22,400**	**17,700**	**17,700**	**17,750**	**+50**

	FY 2013 Current	FY 2014 Enacted	FY 2014 Current	FY 2015 Request	FY 2015 vs FY 2014 Enacted
Other Related Expenses					
Other Services	14,612	15,560	15,560	14,694	-866
Working Capital Fund	14,588	18,524	18,524	18,524	0
Total, Other Related Expenses	**29,200**	**34,084**	**34,084**	**33,218**	**-866**

Program Direction

Activities and Explanation of Changes

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs FY 2014 Enacted
Salaries and Benefits		
Funding enables EERE to maintain and support a world-class Federal workforce to accomplish its mission to win the clean energy future in the transportation, renewable power, and energy efficiency sectors. Provides necessary resources for program and project management, administrative support, contract administration, and human capital management.	Funding enables EERE to maintain and support a world-class Federal workforce to accomplish its mission to win the clean energy race in the transportation, renewable power, and energy efficiency sectors. Provides necessary resources for program and project management, administrative support, contract administration, and human capital management. EERE workforce will decrease slightly through normal attrition, non-renewal of limited term employees, and the use of early retirement authorities granted by OPM and OMB for FY 2013 and FY 2014.	Change due to the adjustments to EERE staff.
Travel		
EERE's FY 2014 travel budget supports management of projects across the country. EERE reduced travel expenses from prior years in accordance with Administration guidance while providing sufficient funding for government oversight of EERE-funded projects.	Travel increases to support intensified project management.	Change reflects increased emphasis on Active Project Management.
Support Services		
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 will continue to provide EERE with a range of services needed to meet its mission, including IT services, specialized contractual support services and training, education, safety, health support, and safeguards and security.	Service continues at approximately the same level of funding in FY 2015 as in FY 2014.
Other Related Expenses		
Other Related Expenses provides funds for office space and overhead at DOE Headquarters and field sites through EERE's contribution to the Department's Working Capital Fund (WCF) for common administrative services and through direct payments	Requirement continues into FY 2015.	Change is due to reductions in general office supplies and materials, as well as decreased support for conferences, communications and outreach, graphics design, and HR services.

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs FY 2014 Enacted
in the field. Expenses covered include building operations, telecommunications, network connectivity, supplies/equipment, printing/graphics, copying, mail, contract closeout, purchase card surveillance, computer equipment (hardware, software, licenses and support), utilities, postage, administrative expenses, security, and publications.		

Strategic Programs

Overview

The Office of Strategic Programs (OSP) is a core crosscutting EERE corporate office focused on accelerating development, commercialization, and adoption of energy efficiency and renewable energy technologies through strategic EERE planning and corporate-level partnerships to support the transition of EERE technologies to market, communications and engagement with energy stakeholders, development of international markets for U.S. clean energy companies, and analytical support for decision making and management of the EERE portfolio.

OSP performs four critical functions that crosscut EERE programs:

- Leveraging EERE crosscutting capabilities and existing authorities, through collaboration with private-sector, academic, National Laboratory, and other partners; to support technology commercialization, reduce market barriers, and assist pursuit of first market opportunities.
- Providing a portfolio-based analytical foundation to support strategic planning and decision making and evaluation of EERE impacts.
- Catalyzing international markets for U.S. clean energy solutions through technical and policy assistance, analysis, and promoting standards, test procedures, and certification prevalent in the U.S.
- Communicating objectively and transparently in response to a high volume of requests from Members of Congress, the media, multiple stakeholder groups, and the public to improve understanding about EERE's activities and the progress and impacts of clean energy research, development, demonstration, and deployment (RDD&D).

Many of OSP's activities focus on breaking down crosscutting barriers to the successful commercialization of clean energy technologies. OSP also supports the use of information, communication, and online technologies that support the interactivity, transparency, and accessibility of EERE information, projects, data, modeling solutions, and state-of-the-art training. Through robust analysis, OSP provides core support for analysis-based decision making and strategic planning, and performance management in EERE and DOE. OSP's international activities facilitate leveraging of international resources to advance DOE's domestic research and development (R&D) program goals, and promote domestic manufacturing by priming large emerging markets for exports of U.S. clean energy technologies.

Highlights of the FY 2015 Budget Request

- <u>Technology-to-Market</u>
  Execute a small suite of high-value crosscutting commercialization, integrated deployment, and workforce and education activities, in support of innovative and focused investments that prioritize the accelerated adoption of EERE technologies.
- <u>Strategic Priorities and Impact Analysis</u>
  Analysis that EERE previously conducted to support policy assessment functions has been consolidated in DOE's Energy Policy and Systems Analysis office; EERE activities are focused on estimating and verifying EERE impacts, technology characterization and data resources, and understanding markets and systems.
- <u>International</u>
  Focus resources on partnerships with 5 to 7 core partner countries and 1 multilateral organization that have the highest potential to grow the U.S. market for clean energy technology and services exports and to promote the deployment of clean energy technologies globally.
- <u>Communications & Outreach</u>
  Conduct high-priority execution, oversight, and support activities for EERE in focusing its resources on maintaining functions for web/online, media, executive communications, and internal communications.

Strategic Programs
Funding ($K)

	FY 2013 Current	FY 2014 Enacted[1]	FY 2014 Current	FY 2015 Request	FY 2015 vs FY 2014 Enacted
Strategic Programs					
Technology-to-Market	6,504	6,590	6,590	7,700	+1,110
Strategic Priorities and Impact Analysis	7,000	6,400	6,400	6,429	+29
International	4,450	4,550	4,550	2,850	-1,700
Communications and Outreach	5,600	6,000	6,000	4,800	-1,200
Total, Strategic Programs	**23,554**	**23,540**	**23,540**	**21,779**	**-1,761**

[1] FY 2014 Enacted funding reflects the contractor foreign travel rescission of $14,000.

Strategic Programs
Explanation of Major Changes ($K)

	FY 2015 vs FY 2014 Enacted
Technology-to-Market: Maintain commercialization program activities through continuation of Phase II of the National Clean Energy Business Plan Competition and through modest continuation of National Laboratory effort. Complete first phase of EERE-wide evaluation of workforce/education activities, such as competitions (cost share with Strategic Priorities and Impact Analysis). Maintain maintenance support of DOE National Training and Education Resource (NTER) node.	**+1,110**
Strategic Priorities and Impact Analysis: No significant change in subprogram funding level. Reflects reduced funding for analysis that EERE previously conducted to support policy assessment functions, which has been consolidated in DOE's Energy Policy and Systems Analysis office, but increased funding to enhance EERE project data collection, analysis, and evaluation and thereby strengthen program management.	**+29**
International: Support 5-7 core partner countries rather than 12.	**-1,700**
Communications and Outreach: Refocus on high-priority media activities; use aggressive selection criteria in responding to media inquiries; discontinue media planning and execution support for Solar Decathlon. Conduct more targeted management and maintenance of website content, development and analysis of metrics, and in meeting requirements. Concentrate support for public inquiries function, with DOE's Executive Secretariat handling all generic inquiries, and most other inquiries being handled directly by programs. Refocus on only the most effective stakeholder, legislative, and public outreach functions.	**-1,200**
Total, Strategic Programs	**-1,761**

Strategic Programs
Technology-to-Market

Description
The Technology-to-Market subprogram aims to accelerate the commercialization and market adoption of EERE technologies to overcome key barriers to the development and success of commercial enterprises built around EERE technologies and initiatives. Where strategic and impactful, the subprogram works to attract additional private sector interest and investment in clean energy development, to accelerate the movement of innovative technologies to market, and to ensure there is a trained workforce ready to install and maintain EERE technologies.

Commercialization ($4.95 million)
The commercialization portfolio focuses on leveraging innovative approaches and partnerships to attract new players and investors to EERE technologies and to bridge gaps in the U.S. clean energy ecosystem, especially in the areas of entrepreneurship, technology transfer, and finance. Activities include the National Incubator Initiative for Clean Energy (NIICE), the National Clean Energy Business Plan Competition, National Laboratory Technology Transfer and Commercialization activities, oversight of commercialization assistance to EERE-supported Small Business Innovation Research companies that demonstrate market adoption potential and alignment with EERE RD&D, and other activities that accelerate the movement of innovative technologies to market:

- NIICE, started in FY 2014, focuses on three goals: 1) strengthening clean energy business incubator services across the U.S. for domestic economic benefit (including manufacturing); 2) catalyzing early-stage clean energy investment through nonprofit non-governmental organization involvement, corporate venture capital engagement, and crowd funding platforms; and 3) fostering closer relationships between the National Laboratories and clean energy businesses.
- Phase II of the National Clean Energy Business Plan Competition will aim to spur innovations by providing clean energy startup business experience to hundreds of university students each year, and awarding prize funding for winning teams to further develop and implement their business plans. These activities encourage the commercialization of new and cost-effective scientific and engineering solutions to America's energy challenges.
- A focused effort to dramatically improve technology transfer and commercialization activities from our National Laboratories in FY 2015 will help bridge the "commercialization valley of death" at each laboratory. By identifying high-impact laboratory technologies, assessing market opportunities, and linking the most promising technologies to business and investment networks, the effort will leverage Federal investments to increase cooperative R&D, start-up options, licensing, deal flow, and acquisitions. In addition, opportunities for the private sector to develop and deploy technologies based on National Laboratory intellectual property (IP) will continue to be encouraged through the use of Energy I-Portal, which provides searchable information about DOE-stewarded federally owned IP available for licensing, patents, and patent applications.

Integrated Deployment ($1 million)
The integrated deployment portfolio aims to take a comprehensive approach to catalyzing market adoption in high-cost and/or locally motivated markets. Using replicable local deployment strategies that prioritize EERE technologies and practices not only expands consumer confidence in product selection, but allows for better support of Federal, state, and local government partners. Additionally, there are opportunities to work with communities impacted by natural disasters, by providing guidance on comprehensive rebuilding with improved energy efficiency and sustainability; the goals are integrated within DOE and also with outside stakeholders. The subprogram focuses on working directly with a limited number of communities to adopt numerous EERE technologies in an integrated fashion, depending on each community's unique needs and circumstances. There is an initial focus on communities faced with high energy cost/high fossil fuel use and those hit by natural disasters, yet the model is designed to be replicable. The subprogram also works collaboratively with other Federal agencies to support the early deployment of cost-effective EERE technologies.

Workforce and Education ($1.75 million)
The workforce and education portfolio aims to develop improved approaches for, and expand access to, the workforce training needed to ensure the availability of a highly skilled workforce for jobs in clean energy sectors. In late FY 2014 through FY 2015, it will commence an evaluation of EERE competitions and other workforce development activities in order to improve coordination and programmatic structures and best practices. On a very limited basis, it will also continue to publicize and leverage partnerships with external stakeholders to promote the well-established Energy Literacy Framework. The subprogram activities are coordinated with other government agencies and external stakeholders to maximize

effectiveness. The subprogram will continue to utilize foundational tools, such as the NTER training platform, to help individual programs build workforce pipelines as EERE technologies are more widely adopted.

Technology-to-Market's subprogram goals include:

- Partnering with EERE programs, OSP subprograms, and other DOE offices (e.g., Office of Electricity, Office of Fossil Energy, and Office of Indian Energy) to create a unified markets focus across EERE, including for new markets.
- Bringing together partners (e.g., universities, small businesses, non-profits, National Laboratories, venture capital companies, entrepreneurial organizations, and state/local governments) through the use of collaborations, competitive grants and prizes, and partnerships to spark technology innovation and market replication.
- Providing EERE with centralized, state-of-the-art technology market expertise (e.g., finance, workforce) for EERE programs to draw upon as needed in support of their missions.
- In partnership with the Strategic Priorities and Impact Analysis subprogram, enabling assessment, evaluation, and recommendations regarding the structure, goals, and impacts of EERE's competitions and related workforce activities.

The subprogram's FY 2013-FY 2014 accomplishments include:

- From a $7.25 million FY 2012-FY 2013 investment utilizing funds through FY 2014, EERE engaged thousands of participants on cross-cutting commercialization and entrepreneurship initiatives, with outcomes including more than 200 ventures and incorporated startups, 114 patents and disclosures filed, and nearly $138 million in follow-on external funding for successful projects (as of December 2013).
- In FY 2013 through FY 2014, conducted a Peer Review of the Innovation Ecosystems program and used that information to inform the development of the newly launched National Incubator Initiative for Clean Energy.
- In FY 2014, successfully transferred the stewardship of the NTER to an external entity.

Technology-to-Market

Activities and Explanation of Changes

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs FY 2014 Enacted
Technology-to-Market		
Commercialization ($4,590,000) • Launch the National Incubator Initiative for Clean Energy, a two-year program (FY 2013 and FY 2014 funding). • Initiate focused effort on technology transfer and commercialization activities at National Laboratories.	*Commercialization ($4,950,000)* • Launch Phase II of the National Clean Energy Business Plan Competition. • Provide ongoing support for focused effort on Laboratory technology transfer and commercialization activities.	*Commercialization (+$360,000)* • Maintain commercialization program activities through continuation of Phase II of the National Clean Energy Business Plan Competition and through modest continuation of National Laboratory effort.
Integrated Deployment ($1,000,000) • Launch a coordinated deployment initiative for first-to-market technologies with the Department of Defense and the National Science Foundation.	*Integrated Deployment ($1,000,000)* • Scale whole-systems energy approach from one anchor location to another within broader region. • Provide ongoing support to continue activities initiated in FY 2014.	*Integrated Deployment ($0)* • Maintain existing deployment portfolio.
Workforce and Education ($1,000,000) • Begin to transfer stewardship of NTER to an external entity. • Begin EERE-wide evaluation of workforce/education activities, such as competitions. • Translate Energy Literacy Framework into Spanish to further engage with minority and underrepresented populations.	*Workforce and Education ($1,750,000)* • Finalize transfer of NTER stewardship to an external entity. • Complete first phase of EERE-wide evaluation of workforce/education activities, such as competitions. • Outreach on Energy Literacy and Energy 101 frameworks.	*Workforce and Education (+$750,000)* • Complete first phase of EERE-wide evaluation of workforce/education activities, such as competitions (cost share with SPIA, 250 thousand). • Maintain maintenance support of DOE NTER node.

Strategic Programs
Strategic Priorities and Impact Analysis

Description
The Strategic Priorities and Impact Analysis (SPIA) subprogram provides a foundational analytic basis for EERE program implementation and decision-making. By conducting portfolio-wide analyses and collaborating with EERE programs, National Laboratories, and industry experts, the subprogram evaluates investment tradeoff decisions and identifies new opportunities.
The activities of this subprogram provide consistent EERE-wide structures, methodologies, and approaches for impact analysis, performance evaluation, and strategic planning and provide core analytic support for EERE by demonstrating the prospective impacts of different research portfolios and technology policy scenarios. Thus, the subprogram's analyses assist EERE's senior management and programs to select portfolios and pathways that will most effectively and productively advance DOE's economic, environmental, energy security, and management excellence goals.

The subprogram's four areas support major Administration priorities. For instance, each area provides strategic analysis underpinning the Clean Energy Manufacturing Initiative. Market analysis examines the impacts of clean energy manufacturing on the economy and the role of innovation in strengthening different clean energy sectors. Industry-validated techno-economic analysis quantifies the specific factors that drive U.S. competitiveness. Findings provide an understanding of specific cost and policy advantages in other regions, and allow EERE to tailor investments to ensure domestic competitiveness.

<u>Portfolio Impacts Analysis ($2.2 million)</u>
Estimates specific and economy-wide benefits of the EERE portfolio to inform investment tradeoff decisions and assess new opportunities. Impact analysis and methods include both prospective and retrospective work, allowing EERE to plan for the future based on past lessons learned. Where not otherwise available, tools are developed to estimate the business, environmental, and direct employment impacts of different energy futures scenarios. This focus area continues to develop common approaches to evidence-based evaluation and works with EERE programs to apply rigorous evaluations across all aspects of EERE RD&D and program management.

<u>Energy Systems Analysis ($1.6 million)</u>
Informs EERE strategic planning and helps identify long-term pathways for meeting national clean energy goals. These studies examine future markets and technologies for the buildings, transportation, industry, and electricity generation sectors-integrating across the EERE technology programs. The work assesses a range of costs and benefits of EERE technologies under evolving future market and policy environments to ensure that EERE decisions made now have a high likelihood of achieving long-term impact. The work is used to set realistic goals across EERE and provide a foundation for program technology road-mapping.

<u>Market Intelligence ($1.3 million)</u>
Includes analysis of technology financing structures and tools, identification of supply-chain bottlenecks, and implications of market conditions for manufacturing and supporting industries. The subprogram explores the market conditions that would support reaching national objectives, including cost effectiveness of EERE technologies, infrastructure requirements needed for EERE technology deployment at scale, and reduction of non-cost and market barriers achievable through EERE action. This focus area explores the role of private-sector funding to ensure that EERE avoids investing in areas that are highly supported by private companies. It examines factors influencing competitiveness of domestic manufacturing of advanced technologies and provides recommendations to maintain or increase competitiveness.

<u>Data Resources ($1.3 million)</u>
Includes characterizing technologies to provide integrated cost and performance data for EERE technologies, which are foundational data elements for decision-making processes. This focus area provides high-quality, continuously improved, peer-reviewed data on EERE technologies in formats that can be directly accessed by users online. The subprogram will build and maintain 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 provided through www.DSIREusa.org.

SPIA subprogram investments reflect goals that include:

- Conducting analyses that support EERE's senior management in evaluating different technology research and programmatic portfolios and understanding the associated markets and institutions.

- Providing internal and, when appropriate, external corporate and strategic expertise, resources, and integrated information to EERE Programs, in support of the Programs' analysis and road-mapping efforts, particularly those with a crosscutting nature.
- Enabling activities that include retrospective and prospective evaluations of EERE impacts and investigate near-term and long-term strategies to remove barriers and accelerate the market adoption of EERE technologies.

The subprogram's FY 2013-FY 2014 accomplishments include the following:

- Developed an EERE-wide approach to clean energy manufacturing competitiveness analysis applied to a range of strategic technologies, which is now ready for transition to implementation by individual technology programs.
- Released the Transportation Energy Futures study, an assessment of avenues to reach deep cuts in petroleum use and greenhouse gas emissions in the transportation sector.
- Completed a first-of-a-kind study of the value of demand response and energy storage on grids with low and high levels of variable renewable generation, providing comparisons on how generation and non-generation resources contribute to system flexibility.
- Provided EERE-wide standardized evaluation study methodologies for technology R&D and published a second edition of the EERE Peer Review Guide.
- Worked with EERE programs to determine cost and performance targets and associated economic, environmental, and energy impacts, supporting the EERE strategic planning process with quantitative scenarios and goals.

Strategic Priorities and Impact Analysis

Activities and Explanation of Changes

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs FY 2014 Enacted
Strategic Priorities and Impact Analysis		
• Finalize clean energy technology manufacturing analysis methodology, combine with market analysis of private investments, and provide as decision structure for ongoing use across EERE technologies. • Release a completely reworked, public facing version of DSIRE. • Finalize Demand Response and Energy Storage Integration Study and execute communications plan to disseminate analysis findings. • Complete a suite of standardized evaluation study methodologies, including a data tracking system, and conduct a training seminar to EERE staff across the programs in order to facilitate faster, more accurate, and cheaper retrospective impact and return on investment (ROI) studies that inform programmatic decisions.	• Conduct energy systems analysis of futures scenarios, including results from renewable energy, transportation, industry, and buildings work. Results inform long-term DOE strategic planning and are available to the public. • Link retrospective and prospective impacts analysis, standardizing and connecting existing tools and methods. Work will enable benchmarking future investments against successful past investments. • Improve metrics to show how much renewable energy is cost-effective in different regions of the U.S., supporting collaboration with the Energy Information Administration on the levelized avoided cost of energy (LACE) calculation as an alternative and complementary metric to LCOE. • Examine technical and economic valuation of EERE technologies in the electric grid of the future to determine the full costs and benefits of EERE technologies – Energy Efficiency, Photovoltaics, Combined Heat and Power, Hydrogen Fuel Cells, Plug-in Hybrid Electric Vehicles/Electric Vehicles, demand response, transactive building controls, and others – as they increasingly penetrate the distribution system and the grid. • Continue to work with EERE programs to apply standard evaluation approaches and initiate a new evaluation study.	• Reflects reduced funding for analysis that EERE previously conducted to support policy assessment functions, which has been consolidated in DOE's Energy Policy and Systems Analysis office, but increased funding to enhance EERE's project data collection, analysis, and evaluation and thereby strengthen program management. • Continue to build a comprehensive set of EERE technology progress metrics that extend beyond levelized cost (i.e., levelized cost of driving, LACE and levelized cost of conserved energy) to more fully reflect the market competitiveness and market potential of EERE technologies opened up through EERE action. • Initiate at least 1 large-scale stakeholder-driven futures study that outlines a wide range of integrated long-term technology pathways that are capable of achieving national energy, environment, and economic goals. • Complete one new retrospective impact and ROI evaluation study that quantifies EERE impact and guides future EERE program implementation by showing what has worked and what has not.

Strategic Programs
International

Description

The International subprogram accelerates the development and deployment of clean energy technologies through international collaboration, funding U.S.-based technical experts to lead engagement in targeted opportunity spaces to help fulfill DOE's mission. The activities of this subprogram guide sound project investment choices (of both partner countries and topic areas) using analysis and prioritization criteria from its subprogram strategic plan, consultations with EERE programs, and interagency work products of the Renewable Energy and Energy Efficiency Export Initiative, and understanding of partner country interests. The subprogram measures project impacts in terms of U.S. export promotion, clean energy deployed, and favorable renewable energy or energy efficiency policy changes facilitated. In managing its FY 2015 activities, the subprogram will:

- Focus on deployment partnerships with 5 - 7 key countries that provide the best opportunity to accelerate development and deployment of clean energy technologies.
- Continue facilitating EERE technology R&D partnerships with Australia, Canada, European Union, Korea, and Japan.
- In China, spur adoption of EERE International-developed model Energy Saving Performance Contracts in China. Facilitate pilot project highlighting U.S. energy efficiency technologies and services.
- In India, reduce project financing risk and facilitate market access for U.S. providers of EE technologies and services through the provision of technical analysis of third-party compliance regimes for India's Energy Conservation Building Codes.

Subprogram activity areas include:

<u>Priming Markets for U.S. Exports ($1.6 million)</u>

EERE investments in diverse clean energy technologies set the stage for the development of a robust clean energy export market for the U.S. with commensurate employment and related economic effects. Rapidly growing countries like China, India, and Brazil are constructing power plants, commercial buildings, industrial facilities, and housing at an unprecedented rate. Priming markets and building capacity in these countries through technical assistance on policy options—developing codes and standards, as well as evaluating and addressing technology product reliability from different sources—will help this development occur with the cleanest energy profile possible. These activities also generate market pull for energy efficiency and renewable energy technologies, which can be met with U.S. clean energy exports. The activities include technical collaborations that focus on establishing business cases for adopting codes, standards, and advanced EERE technologies in a manner that is within DOE's mission space and expertise. Such activities could lead to U.S. industry tapping the trade promotion tools (e.g., low-cost financing, risk insurance, et cetera) of other Federal agencies to promote exports.

<u>Promoting Global Deployment of Clean Energy Technologies ($1.25 million)</u>

Partnerships with key countries advance the deployment of clean energy technologies and can achieve substantial, measurable reduction of greenhouse gas emissions. This includes, for example, coordinating U.S and Chinese mayors exchanges, which has led to sales of U.S. clean energy goods and services, foreign direct investment creating jobs in U.S cities, and new sustainability policy approaches in U.S. cities, informed by China's experience.

The subprogram goals include the following:

- Accelerating the progress of EERE's domestic R&D programs by leveraging the resources and expertise of major developed partner countries.
- Increasing U.S. exports of clean energy technologies and creating U.S. jobs through collaborative projects focused on testing, analyzing, and deploying U.S. technologies, and on promoting sound technical and policy approaches (building codes and compliance, financing models for energy efficiency retrofits or renewable energy deployment) that facilitate rapid international deployment of energy efficiency and renewable energy technologies.

The subprogram's FY 2013-FY 2014 accomplishments include the following:

- Coordinated the annual U.S.-China Renewable Energy Industries Forum with China's National Energy Administration - facilitating memorandums of understanding between a U.S.-based company likely to be the technology supplier for China's first commercial-scale concentrating solar power project, and prominent Chinese organizations. This agreement could generate more than $100 million in export content.

- Provided technical assistance for Brazil to establish a testing laboratory for energy performance of building envelope components, directly leading to sales of U.S.-manufactured laboratory equipment and Brazil's utilization of standard test methods used and supported by U.S. industry, which reduce barriers to U.S. suppliers in the Brazilian market.
- Helped commercialize a clean energy technology through the U.S.-Israel Binational Industrial Research and Development (BIRD)-Energy Foundation. Specifically, an Israeli company and a U.S.-based company partnered for a $900 thousand advanced biofuels conversion R&D grant; the U.S. company later successfully competed for $9 million from EERE's Bioenergy Technology Program, to launch a pilot plant in the U.S.
- Facilitated leveraging of a multi-million dollar Japanese investment to develop R&D collaborations, including $1.5 million for work at Sandia National Laboratories on advancing hydrogen fuel systems.

International

Activities and Explanation of Changes

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs FY 2014 Enacted
International		
• Continue work with partner countries, such as Argentina, Brazil, Canada, China, India, Indonesia, Mexico, Russia, Saudi Arabia, South Africa, and the United Arab Emirates, negotiating beneficial next steps in annual bilateral action plans as appropriate. • Continue coordinating beneficial R&D collaborations with Australia, Canada, European Union, Israel, Japan, and others.	• Focus on core partner countries (China, India, Brazil, Indonesia, Mexico, and Russia) and 1 multilateral organization (International Partnership for Energy Efficiency and Conservation (IPEEC)) that have the highest potential to grow the U.S. market for clean energy technology and services exports and to promote the deployment of clean energy technologies globally.	• Support 5-7 core partner countries rather than 12.

Strategic Programs
Communications and Outreach

Description
The Communications and Outreach subprogram provides strategic communications leadership, coordination, and support for EERE and in support of the Department through organizing, editing, and disseminating information to media and the public on EERE programs, activities, and technologies, as well as their associated impacts. This information helps promotes and raise awareness, overcome informational barriers to understanding and adopting EERE technologies, and helps encourage the accelerated adoption of EERE technologies and practices.

The subprogram's activities ensure that EERE information is available to the general public, media, and stakeholders in coordination and consultation with EERE's programs. The subprogram's externally facing tools and communications include Web content and services; traditional, social, and multi-media; informational materials and publications; public service announcements; and letters in response to public inquiries. Through these channels, the subprogram communicates with a broad range of EERE stakeholders, the media, and the public. Requests for information from Members of Congress, the media, stakeholders, and the public are considerable; in support of EERE programs, departmental offices, and other entities, Communications and Outreach activities result in the development, processing, editing, and approval of more than 400 different communications items each month. The subprogram also conducts internal communications activities to encourage enhanced coordination and awareness within EERE.

Communications & Outreach activities - Focus on priority areas of activity of Online/Digital Presence, Media Relations, and Executive Communications.

<u>Online/Digital Presence ($2.35 million)</u>
The subprogram manages and updates EERE's website enterprise, EERE's primary broad-based means for providing information for its many stakeholder audiences, with 13.2 million unique visitors in FY 2013. Beginning in late 2012 and through FY 2014, EERE redesigned, transitioned, and streamlined a large majority of its eere.energy.gov website content—at the time representing a presence a few times larger than all of DOE's combined—through migration to energy.gov's information architecture platform. The subprogram will continue to manage and update this presence, developing new content as needs emerge and continuing to reduce content wherever possible. The subprogram will also continue to enable EERE's open data activities, and its modest focus on widgets, mobile applications, and other electronic and online communications technologies to disseminate information to multiple user audiences. This includes discerning what new hardware and web tools are required to best operate and maintain EERE's website enterprise assets that are for specific technical audiences.

<u>Media ($1.3 million)</u>
The subprogram will continue to engage stakeholders, the media, and the public through frequent news updates and program information, in support and coordination with EERE programs and DOE's Office of Public Affairs. This includes issuing press announcements and alerts about key activities such as funding opportunity announcements, responding to media inquiries, emailing bulletins to tens of thousands of subscribers, and when possible, facilitating interviews with media outlets. The subprogram also uses targeted social media to provide updates on EERE project milestones and successes, as well as online multimedia channels to provide information about energy efficiency and renewable energy technologies.

<u>Executive and Internal Communications ($0.4 million)</u>
The subprogram will continue to provide primary support to all EERE senior leaders in terms of developing, maintaining, and updating all presentation materials for frequent speaking engagements. The subprogram helps maintain the overall EERE identity through guidelines and standards to ensure consistency and develops crosscutting informational materials about EERE's activities, project successes, and accomplishments. In addition, the subprogram engages internal audiences through a variety of tactics, such as developing and regularly disseminating relevant information, and planning and executing internal engagements.

<u>Communications Analysis and Outreach ($0.4 million)</u>
The subprogram's FY 2014 activities focused on dialoguing with internal stakeholders on knowledge gaps and identifying low-cost means to disseminate its informational materials through key stakeholder groups, with an emphasis on third party validation with specific entities; large crosscutting groups, including those with hard-to-reach audience members; and congressional engagement. In FY 2015, the subprogram will continue to conduct consumer views analysis and high-value, high-priority outreach.

Public Inquiries and Publication Distribution ($350 thousand)

The subprogram will continue to manage a large public inquiry/letter correspondence function across EERE, responding to and analyzing a wide variety of daily requests, as well as providing informational material distribution services for EERE programs.

The subprogram's goals include the following:

- 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 reflecting online and open data policies. This will include implementing a digital strategy completed in FY 2014 that reduces EERE's print footprint by at least 25 percent by mid-FY 2015, while making its publications more widely available through online publishing and distribution services.

The subprogram's FY 2013-14 accomplishments include the following:

- Achieved significant efficiencies and greater effectiveness in rebalancing its staff and associated portfolios to ensure proper emphasis on media services, online services, and executive communications.
- Worked in collaboration with EERE programs on open data initiatives through supporting activities to identify, target, and amplify valuable EERE resources that encourage innovation, including enabling access to EERE datasets, interfaces, and associated code for external parties to develop broader applications.
- With significant subprogram leadership and investment, completed transitioning EERE's website to energy.gov's information architecture environment. Streamlined EERE's online presence, which was significantly larger than energy.gov, in reducing URLs by 50 percent and redundant and old content by 30 percent since 2013, and improving the online user experience.
- Provided support to technology programs on more than 200 press releases, progress alerts, and high-value social media posts; more than 50 congressional meeting requests and associated follow-up; more than 500 media requests; and more than 150 speaking requests.
- Developed a wide-ranging plan to identify high-value, high-priority media and stakeholder engagement for the year, and set major targets/goals on strategies and tactics to communicate about EERE's portfolio. Results included development and broader dissemination of more than 100 new success stories, 20 keynote-level speaking engagements, EERE-related news items in at least 10 national publications with a cumulative reach of more than five million readers, and other metrics.
- Achieved a 35 percent savings in significantly reducing EERE's publications footprint such as production, printing, and storage through digitizing its approach to publications when possible and securing more cost-effective online services.

Communications and Outreach

Activities and Explanation of Changes

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs FY 2014 Enacted
Communications and Outreach		
• Maintain strong media presence on behalf of EERE and the department through responses to high-value inquiries and editing and coordination of press releases. In coordination with DOE Public Affairs, identify highest value multi-media and social media activities to continue. • In collaboration with EERE technology programs, complete transition of majority of EERE web/online assets to energy.gov. Complete EERE project map and heavily support DOE in improving the architecture, navigation, and contents related to online resources for state and local audiences. • Support development of communications strategies, tactics, and products for high priority initiatives such as Clean Energy Manufacturing Initiative and Workplace Charging Challenge. • Provide stakeholder engagement and legislative affairs support services for EERE. • Execute more cost-effective solution for storage and handling of requested EERE products, including implementing strategy for higher level of online-only publishing. • Complete *Saving Energy Saves You Money* campaign agreement with the Ad Council by May 2014; complete asset divestment of *Anatomy of the House.*	• Maintain high-priority media presence/activities. • Maintain core digital/online presence. • Better enable technology programs and initiatives to conduct high-value communications activities. • Maintain executive communications function with emphasis on digital-only dissemination of materials. • Maintain modest internal communications, stakeholder engagement, and legislative affairs support functions.	• Refocus on high-priority media activities; use aggressive selection criteria in responding to media inquiries; discontinue media planning and execution support for Solar Decathlon. • Conduct more targeted management and maintenance of website content, development and analysis of metrics, and in meeting requirements. • Concentrate support for public inquiries function, with DOE's Executive Secretariat handling all generic inquiries, and most other inquiries being handled directly by programs. • Refocus on only the most effective stakeholder, legislative, and public outreach functions.

Facilities and Infrastructure

Overview

The National Renewable Energy Laboratory (NREL) is the Nation's only National Laboratory with a primary mission dedicated to the research, development, and demonstration (RD&D) of energy efficiency, renewable energy, and related technologies. The Office of Energy Efficiency and Renewable Energy (EERE) is NREL's steward, primary client, and sponsor of NREL's designation as a federally funded research and development center. The Facilities and Infrastructure (F&I) budget line provides funding for NREL's General Plant Projects (GPP), General Purpose Equipment (GPE), Maintenance and Repair (M&R), Construction Line Item projects, Safeguards and Security (S&S), and the operation of the Energy Systems Integration Facility (ESIF). The F&I budget line funds NREL's research and support infrastructure, helping maintain it in good operating condition, ensuring it is available for EERE's use, and ensuring that the workplace is safe and secure for employees and the public.

Over the last five years, EERE has completed important capital investments across the NREL campus to expand the laboratory's capabilities. EERE is not planning significant capital investments in FY 2015 and, while GPP and GPE investments and direct-funded M&R activities have remained approximately the same over the last three years, no significant increases to these investments are planned for FY 2015. Furthermore, during this timeframe, EERE investments in NREL's research and support infrastructure have resulted in tripling DOE-owned space at the campus. These efforts have greatly increased DOE's grid-integration research capabilities and improved overall operational efficiency.

The most prominent of these completed capital investments at NREL is the new Energy Systems Integration Facility (ESIF). Commissioned in September 2013, ESIF is a state-of-the-art user-facility that provides critical research and testing capabilities to DOE and its university and industry partners. ESIF is a unique national resource designed to address the myriad challenges and opportunities associated with integrating high-penetration levels of dynamic energy efficiency and renewable energy technologies into U.S. energy systems.

Facilities and Infrastructure Program

EERE is committed to maintaining and fully utilizing NREL's capabilities as the Nation's premier energy efficiency and renewable energy research facility. EERE's investment in NREL's energy technology research, property, people, and support infrastructure is designed to create and maintain the physical and operational assets required to achieve NREL's assigned mission in a safe, secure, and efficient manner. EERE's investments are guided by DOE investment standards.

The F&I Program Strategy is designed to:

- Provide the laboratory with a safe and secure work environment and protect EERE partners and the public.
- Maintain EERE's science and support infrastructure investments through regular annual reinvestments reflecting age, condition, risk, and DOE and industry standards.
- Renovate research and support infrastructure on a regular schedule to ensure the availability of a world-class RD&D environment and support ongoing EERE mission activities.
- Acquire new mission-critical capabilities, when warranted, to ensure EERE's ability to execute its mission;
- Providing direct operating funding for all appropriate activities, consistent with Generally Accepted Accounting Principles, for both F&I and site-wide investments.
- Develop energy systems integration as a new aspect of energy R&D for the Nation through experiments and development of capabilities at ESIF and at remote locations through high-performance computer models and hardware-in-the-loop modeling and testing.

Facilities and Infrastructure Benefits

The F&I program has dependably delivered the capital construction projects, small site projects, and equipment required to operate NREL in a safe and efficient manner. F&I investments have ensured that EERE's research and support investments are maintained to high standards of mission readiness, as evidenced by superb ratings in the DOE Facilities Condition Index.

The Operations and Maintenance subprogram budget's major funding activities include GPP investments to maintain and enhance the real property portfolio, renovate general science capabilities and buildings, and create a safe and secure work environment; GPE investments to acquire shared science and support equipment; M&R, which provides direct funding for a portion of small-scale, regular M&R of real property and science and support equipment; and S&S investments to provide a safe work environment for staff and the public, protect cyber networks, and protect both physical and intellectual property.

The Facility Management subprogram's major funding activity is ESIF core operations, which is new for FY 2014. These funds support highly educated and internally-trained staffs who design and control hardware and grid integration experiments using renewable electricity, natural gas, petroleum and hydrogen in safe and secure applications. Facility Management subprogram funds also support the baseline operations and maintenance expenses of ESIF, which require special training, environmental and safety procedures, and application of unique experimental tools contained in ESIF.

Facilities and Infrastructure
Funding ($K)

	FY 2013 Current	FY 2014 Enacted[1]	FY 2014 Current	FY 2015 Request	FY 2015 vs. FY 2014 Enacted
Facilities and Infrastructure					
Operations and Maintenance	24,880	25,973	25,973	26,000	+27
Facility Management	0	20,000	20,000	30,000	+10,000
Total, Facilities and Infrastructure	**24,880**	**45,973**	**45,973**	**56,000**	**+10,027**

[1] FY 2014 Enacted funding reflects the contractor foreign travel rescission of $27,440.

Facilities and Infrastructure
Explanation of Major Changes ($K)

	FY 2015 vs. FY 2014 Enacted
Operations and Maintenance: No significant changes.	**+27**
Facility Management: The increase in funding requested will support the ramping-up of operations at NREL's new ESIF. Additional staff will be hired to support increasing R&DD activity at ESIF. Furthermore, as a fully functioning user-facility, Peer reviewed DOE projects will have the first opportunity to use ESIF in FY 2015 for directed annual operating plan experimentation, research, development, and demonstration. ESIF's world-class staff will work with DOE and other NREL staff to develop a user program which annually evaluates available ESIF capabilities and solicits proposals for focused research areas. These proposals will be peer-reviewed by appropriate expert panels with knowledge in energy systems.	**+10,000**
Total, Facilities and Infrastructure	**+10,027**

Facilities and Infrastructure
Operations and Maintenance

Description
The F&I program planning seeks to ensure EERE's research and support infrastructure at NREL is maintained to meet or exceed DOE and applicable industry standards, is refreshed regularly, and is safe and dependable for current and future missions. EERE inventories, assesses, and benchmarks its infrastructure investments at NREL against DOE or industry standards.

The Operations and Maintenance subprogram of EERE's F&I budget line provides funding for GPP, GPE, M&R, Construction Line Item projects, and S&S at NREL. EERE's investments in the Operations and Maintenance subprogram ensure that the science and support infrastructure at NREL is maintained in good condition and readily available for use by EERE and other users. These investments also ensure that the workplace is safe and secure for employees and the public.

EERE identifies new strategic or support capabilities early in the planning cycle. This allows F&I budget requirements to be coordinated internally and fulfill DOE process requirements. These proper planning activities are crucial to ensure funding is available and in alignment with EERE research program goals and budgets. Below are the Operations and Maintenance strategic planning principles to keep NREL ready to meet EERE's research and development goals.

The F&I program's planning principles for GPP are to the following:

- Provide real property investments to accommodate new research activities while ensuring safe operations.
- Inventory and assess all real property against DOE, industry, and manufacturers' operational, safeguards and security, and obsolescence benchmarks. This information is available to NREL and DOE and is the foundation for all stewardship budgeting.
- Fund real property maintenance and repair, general improvements, and/or enhancements to general science capabilities and buildings directly supporting EERE's program research activities.
- In budget requests, reflect specific real property needs based on actual conditions to the extent possible and on specific data assessed against the benchmarks.
- In budget requests, include a contingency subcomponent reflecting undefined but not unanticipated investments based on statistical or other analysis of the data collected through condition assessment.
- In budget requests, include regular renovation of laboratories and supporting capabilities to ensure continued relevance and availability of the science and support infrastructure to EERE's future mission.
- Ensure all new real property acquisitions address a specific EERE mission need and are managed in accordance with DOE Order 413.3B, Program and Project Management for the Acquisition of Capital Assets.

The F&I program's planning principles for GPE management are to:
- Maintain all equipment to standards that ensure safe operations.
- Inventory and assess institutional and program science and support equipment against DOE, industry, and manufacturers' operational, safeguards and security, and obsolesce benchmarks. This information is available to NREL and DOE and is the foundation for all stewardship budgeting.
- In budget requests, reflect specific equipment needs based on actual conditions to the practicable extent possible.
- Fund institutional equipment through the EERE G PE subcomponent of the program's budget, and fund program-specific capital equipment by the appropriate EERE program.

The F&I program's planning principles for M&R are to:
- Direct-fund maintenance and repair for the predictive, preventive, and corrective maintenance of real property that is required to sustain property in a condition suitable for its intended designated purpose.
- Maintain real property equipment, systems, and facilities for their intended functions or design conditions to ensure availability of equipment and facilities for research activities.
- Provide funding for needed recurring day-to-day maintenance activities to preserve plant and capital equipment in a condition suitable for its intended purpose.

The F&I program planning principles for S&S are to:

- Ensure that the physical and property security program provides a safe and secure work environment and protection of EERE's investments, in compliance with DOE security requirements.
- Ensure that the cyber security program provides the availability and protection of NREL cyber resources in compliance with DOE security requirements.

Operations and Maintenance

Activities and Explanation of Changes

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs FY 2014 Enacted
Operations and Maintenance		
• Provides funding for GPP, GPE, M&R, Construction Line Item projects, and S&S at NREL. EERE's investments ensure that the science and support infrastructure at NREL is maintained in good condition and readily available for use by EERE and other users.	• Provides funding for GPP, GPE, M&R, Construction Line Item projects, and S&S at NREL. EERE's investments ensure that the science and support infrastructure at NREL is maintained in good condition and readily available for use by EERE and other users.	• No significant changes.

Facilities and Infrastructure
Facility Management

Description
The Facility Management subprogram provides funding for core operations at EERE's signature Energy Systems Integration Facility (ESIF), ensuring the availability of this important new user-facility to EERE and EERE's other DOE, university, and private sector partners. ESIF, located at the National Renewable Energy Laboratory (NREL), is a unique new national asset that provides the public and private sectors with the ability to conduct critical research and development (RD&D) on multiple technologies and energy sources in integrated energy systems.

NREL's Renewable Electricity Futures Study found that U.S. electricity demand in 2050 could be met with 80% generation from renewable technologies on an hourly basis, but that high levels of renewable sources would create technical issues for grid operation. These issues could potentially inhibit widespread adoption of clean energy unless development and demonstration of new technologies and approaches can show proven success. ESIF can help address these challenges by developing and conducting experiments in a controlled and safe environment rather than risking the equipment and reliability of service in operating energy systems. For example, renewable electricity generation equipment can be combined with fossil electric generators to demonstrate which operational approaches will satisfy the electric system requirements.

ESIF provides utilities and other stakeholders a grid isolated research, development, and demonstration facility to reduce the risk of these integration barriers without jeopardizing current grid operations or reliability. ESIF also combines high-performance computing (HPC) and system component experimentation and testing capabilities to identify and resolve the technical and operational risks of large-scale integration of renewable energy and energy efficiency technologies in today's energy environment. ESIF provides the technical capabilities needed to help advance the Nation's energy system into a cleaner, more intelligent and modernized infrastructure.

ESIF was commissioned on budget and on schedule in September 2013. The 182,500 sq. ft. facility contains 15 state-of-the-art laboratories and several outdoor test areas. These facilities will be used by approximately 200 NREL researchers and support staff and will provide office space for external users as well as access to its unique experimental and testing capabilities. Starting in 2013, after major equipment installation and validation, ESIF was commissioned and open for business for manufacturers, utilities, large energy customers, and other energy stakeholders in industry, government research laboratories, and academia on both a non-proprietary and proprietary basis. RD&D conducted at ESIF will accelerate commercialization and adoption of renewable energy and energy efficiency technologies into contemporary energy systems where they can operate synergistically with other energy resources and technologies.

Facility Management

Activities and Explanation of Changes

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs FY 2014 Enacted
Facility Management		
• 2014 will be the first year of ESIF operations with appropriated F&I funds. NREL will expand staff and develop equipment capabilities for all laboratories. During FY 2014, high-performance computing capability will reach one petaflop and visualization operations will be enhanced. All laboratory equipment to be moved from NREL's campus will be installed and prepared for application. We anticipate that NREL will conduct tens of experiments and demonstrations for DOE and external users with matching funds and project payments. Also during FY 2014, NREL will develop and implement the user-facility procedures and supporting peer review process in preparation for selection of FY 2015 projects.	• The staff of ESIF will be expanded and fully trained to support the research, development and demonstration of external and DOE-supported users. DOE work supported by ten programs will be conducted by NREL and other DOE laboratory staff onsite or through high-speed data connections. Multiple hardware-in-the-loop and simulation projects will be completed on the HPC, some with comprehensive simulation demonstrations. User proposals will be collected, externally reviewed, awardees selected and standard agreements negotiated to conduct User-facility projects. We anticipate ESIF staff will complete approximately $30 million of DOE-supported projects and leverage $30 million of external user projects funds.	• The additional funds will allow the expansion of ESIF staff and equipment and continued training for safe and effective operations. User R&D work will engage all labs at near full capacity. NREL will develop ESIF's unique capabilities and report on facility's demonstrated value through technical literature. The first full year of external user proposals will be chosen 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 demand.

Facilities and Infrastructure
Energy Systems Integration Facility (ESIF)

Purpose of the Facility
The expanding scale of technology applications from individual buildings to communities, and eventually to regional grids, presents the Nation's electricity systems with planning, design, and operational challenges. ESIF will be capable of examining and modeling interactions, which will support reliable grid integration of variable renewable energy generation resources, electric vehicles, and advanced building systems and controls for managing demand response. In the next decades ahead, the increasing diversity of supply, greater demand for electricity, and an aging infrastructure will require different approaches to ensure that all energy infrastructure investments yield safe, resilient, reliable, and sustainable systems. Research and development at ESIF is aimed at overcoming the systemic challenge of integrating new technologies into today's energy infrastructure to support a more reliable, cost-effective, cleaner, and secure system for consumers across the country.

The technological challenges addressed by ESIF span the entire energy system—from generation to transmission, distribution and end-use applications. ESIF has a broad range of capabilities to help address technical and integration challenges facing a variety of systems, including: advanced electrical systems (storage, power electronics, etc.), buildings systems and controls, industrial systems and controls, community power generation and microgrids, utility generation, thermal and hydrogen systems, energy efficient and advanced grid technologies, distributed control architectures, device and system interoperability, demand response, data and control integration, and grids that incorporate distributed and/or variable renewable energy (solar, wind, water, fuel cells, etc.) and advanced vehicles.

Technological Capabilities
ESIF is the Nation's first research facility that can conduct integrated megawatt-scale RD&D of the components and strategies needed to safely and seamlessly combine clean energy technologies into electrical grid infrastructure and utility operations at the speed and scale required to meet national goals. Unique capabilities include the following:

- Megawatt-scale hardware-in-the-loop, which allows researchers and manufacturers to conduct integration tests at full power and actual load levels in real-time simulation, as well as evaluate component and system performance before going to market or risking grid reliability.
- Peta-scale computing at the facility's high performance data center will enable large-scale modeling and simulation of component properties, processes, grid operations, and fully integrated systems that would otherwise be too expensive, too dangerous, or even impossible to study by direct experimentation.
- Research Electrical Distribution Bus, connecting multiple sources of electric, fuel, and thermal energy, interconnecting "plug-and-play" testing components and ensuring interoperability across technologies.
- Supervisory control and data acquisition systems to gather and exchange real-time, high-resolution data for multiple-site collaboration, modeling and visualization.
- Data analysis and grid visualization to create complex system simulations and operations in a virtual environment.

These state-of-the art technologies provide scientists and engineers with the tools necessary to address barriers to modernizing energy systems at all scales, with a major focus on the electricity system.

RD&D Priorities
There are a variety of solutions that need to be investigated and demonstrated. Some solutions to address the integration of variable generation that cut across individual technology areas need to be implemented at a systems level. To address these system-level challenges and opportunities, the following RD&D themes have been identified as priority areas of focus for ESIF capabilities:

- Systems Experimentation, Testing and Validation of Advanced Technologies (e.g., testing and evaluating high-penetration networks of distributed renewable energy systems, controllable loads, and electric vehicles).
- Complex Systems, System Interfaces and Controls Research (e.g., developing standard secure monitoring, information exchange, and control technologies to link the performance and operations of a wide variety of energy technologies and to allow interoperability between devices and systems).
- System Simulation, Design and Data (e.g., developing comprehensive models that include electricity, thermal, and fuel systems as well as data and communications layers and that can scale from building to continental systems).

While the funding request is for core staffing and equipment at ESIF, examples of major challenges which could be tackled at the facility by peer reviewed DOE-sponsored or external users selected for support are worth mention:

- Linking Renewable Energy to Dynamic Load Control - demonstrate technology to control loads dynamically without affecting occupant comfort on various scales (single building, campus, multi-site) to smooth PV variability. Integrate with real-time predictive model of PV generation and loads.
- Linking Renewable Energy to Energy Storage - demonstrate same concept as dynamic load control with energy storage (battery, vehicle-to-grid, compressed air energy storage, large-scale hydrogen). Validate the performance of local energy storage to reduce variability of solar at the distribution level or large-scale hydrogen as storage for wind. Integrate and test using power hardware in the loop to evaluate storage at various distribution locations and feeder types or in simulated larger transmission systems.
- Integrating High Efficiency Building Energy Use - Demonstrate integration of advanced sensors and control technology to modify high efficiency, low energy use building use and campus load shapes.
- Value High Efficiency Energy to Utilities - Demonstrate value to utilities and other key stakeholders of high penetrations of high efficiency, low energy use buildings. High penetrations of these buildings may be able to provide services to utilities based on new load models.
- Integration of Renewable Energy and Natural Gas - Demonstrate the ability to have renewable energy work synergistically with natural gas generators at both the local level where waste heat can be collected and used and at the larger system level to reduce system variability.
- Distributed Control Architectures - Link power system controls that integrate combined heat and power (CHP) applications to wind/solar to demand controls; develop new grid architectures that better allow microgrids for improved reliability and security.
- Transportation - Develop and apply large-scale transportation system simulation scenarios highlighting options for charging, fuel flexibility and response to events affecting availability and cost. Model creation should be supported by integrated system demonstrations of vehicles with autonomous operation and ability to be recharged/refueled in a variety of ways.
- Energy Model Verification - Data mining for advanced model verification; use real-time data to validate energy system models for production and end-use that incorporate system interfaces. Data would come, for example, from utilities, regional transmission operators, and collections of equipment distributed for ESIF experiments.
- Energy Value Streams - Linking economics to energy data from energy system stakeholders to formulate value streams. Techno-economic analysis that links real data and experimental results to models and assumptions and enable exploring the system from multiple perspectives simultaneously (energy user, system operator, regulator, national good).
- Open Energy Information Challenge - Host open access to energy information databases and support research that draws on these data sets to create insights and applications.

ESIF as a Technology User-facility

DOE has designated ESIF as a formal technology user-facility to maximize its benefit as a tool to accelerate system-ready energy technology development and effective system integration of new technologies, meeting the purpose of technology user facilities as identified in the DOE Quadrennial Technology Review. Unlike science user facilities where the research community is the predominant user, ESIF capabilities are intended to attract the commercial sector individually or in partnership with the research community to conduct RD&D that reduces risk and provides solutions to energy system integration challenges. During 2014, DOE and NREL will develop a complete user-facility plan to attract commercial, government, academic, and entrepreneurial users. Through application of that plan with expanded core operations funding in FY 2015, ESIF will become a fully functional user-facility, supported with additional staff and equipment.

The F&I program planning principles for ESIF are to:

- Provide an optimal cost structure for all potential users that maximize the return on core Federal investment.
- Provide annual funding for ESIF core operations.
- Make ESIF capabilities broadly available to all potential users through a user-facility model.
- Develop a multi-year plan across DOE Offices and relevant labs for future application of ESIF capabilities and broader grid integration needs.
- Provide annual funding and peer evaluation to ensure ESIF capabilities remain relevant to the user community.

When fully supported in FY 2015, ESIF will have the necessary staff expertise and equipment capabilities in a constant state of readiness to facilitate all types of users and to conduct many different types of experiments. Throughout the design of the facility and in the development of the user program model, more than 250 technical experts and potential users from across industries, laboratories and universities have been consulted. The capability at ESIF, both human and equipment, provides external stakeholders access to high-value assets that one organization (e.g., business, university, utility, etc.) alone could not afford to build, maintain and operate.

DOE will support the base operating costs of ESIF, consistent with the model at other DOE user facilities to attract the user community and deliver outcomes that enable clean energy to be integrated and operated at scale. This will ensure that the facility is kept operationally ready, state-of-the art equipment is maintained, and operations are conducted safely. By operating in this manner, the facility will leverage the government investment by attracting funding and intellectual assets from external users. Without this model, the availability and value of the capabilities could erode, leading to user attrition, a loss of intellectual value and a decrease in funding from external users. A user program will be initiated in FY 2014 and continue in FY 2015 toward full maturity. A breakdown of ESIF's costs per component for FY 2015 may be found in the table below.

Energy Systems Integration Facility (ESIF)

Activities and Explanation of Changes

FY 2014 Enacted	FY 2015 Request	Explanation of Changes FY 2015 vs FY 2014 Enacted
Energy Systems Integration Facility (ESIF)		
• Core ESIF operating costs including labor, utilities, general operating costs, etc.	• Launch Initial ESIF user program. Investment in expanding capital equipment for full operations. Core ESIF operating costs including full labor force, utilities, general operating costs, maintenance of facility and equipment as warranties end, etc.	• The increase in funding requested will support the ramping-up of operations at NREL's new ESIF. Additional staff will be hired to support increasing R&DD activity at ESIF. Furthermore, as a fully functioning user-facility, Peer reviewed DOE projects will have the first opportunity to use ESIF in FY 2015 for directed annual operating plan experimentation, research, development, and demonstration. ESIF's world-class staff will work with DOE and other NREL staff to develop a user program which annually evaluates available ESIF capabilities and solicits proposals for focused research areas. These proposals will be peer-reviewed by appropriate expert panels with knowledge in energy systems.

FY 2015 ESIF Operating Costs Breakdown

ESIF Costs	Labor[1]	Non-Labor[2]	FY 2015 Request
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.	750	240	990
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.	9,800	0	9,800
Equipment: Recapitalization based on average research and scientific computing equipment life. Initial costs address older equipment that is moved to ESIF in FY 2013, as well as expansion of the high-performance computing capability and equipment to enable testing >1MW power systems.	0	4,000	4,000
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 who are drawn on as needed 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.	1,825	9,985	11,810
Utilities: Power, Water, Natural Gas, Dedicated Exhaust, House Nitrogen, Compressed Air, (utilities billed by service providers).	0	3,400	3,400
Total	**12,375**	**17,625**	**30,000**

Types of Users

The primary users of ESIF are the owners and operators of energy generation, delivery, and consuming systems and the suppliers to these companies. These include utilities, system operators, large campus or community energy system owners/operators, building fleet owners/managers, equipment suppliers, and information system suppliers. Additionally, the research community is also considered a user, inclusive of national laboratories, universities, and private laboratories. NREL research staff (beyond those dedicated to the operation of ESIF) is a part of this user community.

User Access

Users will apply through a formal application process that includes peer review of proposals. Peer reviews will be conducted using a panel of independent experts. Users can access ESIF onsite and remotely by logging onto ESIF's network.

User models will differ depending on the type of user and who derives the value from the use of ESIF capability. Research, development, testing and validation will be conducted under standard DOE proprietary or non-proprietary user agreements that are in use at other user facilities. Even under a non-proprietary agreement, some data may be held proprietary while making some information available to the benefit of the larger user community. The table on the following page summarizes the two major types of user agreements.

[1] Labor includes ESIF-assigned staff as well as labor associated with NREL central services provided to ESIF.
[2] Non-labor costs include materials and supplies, small parts, service contracts, and travel.

Types of User Agreements

Type of Agreement	Value Delivered	Example Users	Cost Model
Non-Proprietary	Data and Published Papers	• Utilities • EV Fleet Owners • National Labs • Universities	User pays labor and materials associated with the specific experiment; Technical support for set up and base operating costs covered within ESIF base cost.
Proprietary	Results Held Privately	• Energy Equipment Developers/Suppliers • System Integrators	User pays cost of the experiment + prorated share of operating cost.

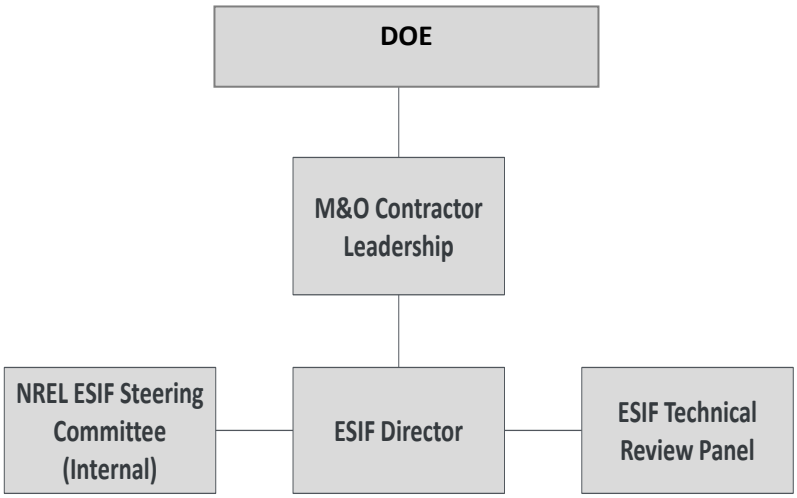
Operations

All aspects of ESIF operations will be detailed in the ESIF Operations Plan, including a discussion of research capabilities and opportunities, the types of users and proposals, the user access process, governance principles and roles, and policies to ensure safe and appropriate operation in compliance with existing requirements.

Governance

ESIF governance model is illustrated in Figure 1. Governance and oversight of ESIF is provided by the DOE Offices of Energy Efficiency and Renewable Energy, Electricity Delivery and Energy Reliability and others, as appropriate through the performance-based management and operating contract for NREL. These DOE offices will participate on the Steering Committee, program reviews, and project planning. Through the prime contract, DOE establishes and implements requirements for mission outcomes and operations. The laboratory management and operations leadership team is responsible for assuring that the objectives of ESIF are accomplished within the DOE prime contract, and the policy and regulatory environment within which NREL operates.

Figure 1: ESIF Governance Model

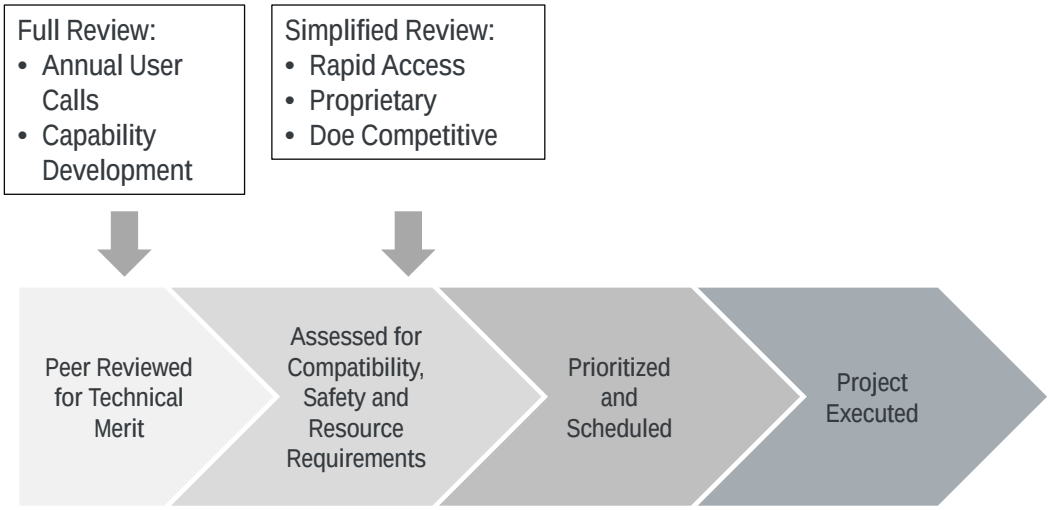


The responsibility for management and operation of ESIF is vested in the ESIF Director and the ESIF management team. The management team is responsible for assuring that the DOE assets in ESIF are appropriately maintained, operated, and protected and that these national assets are made broadly available to the user community to deliver the value for which the facility was constructed. The ESIF director consults with an internal NREL steering committee, comprising ESIF capability experts, regarding appropriate use of capabilities, capital investments, operational matters and success metrics. The ESIF director convenes an expert peer review panel to review the quality and relevance of proposed work in ESIF and to seek advice on ESIF strategy and operational matters.

The ESIF Management Office (EMO), led by the ESIF Director, is responsible for delivering a world-class integrated user program supporting ESIF's vision and mission. From issuing calls for proposals to facilitating the reviews, scheduling training, arranging access, and collecting and reporting results, the EMO works closely with users and management to provide streamlined and safe access to ESIF's unique capabilities for researchers from around the world through a competitive, peer-review process. A variety of different proposal options are available to facilitate researchers' access to the facility based on needs and to confirm that ESIF capabilities are used to address cutting-edge science questions. Figure 2 on the following page shows the general proposal review and approval process.

All proposals that are part of a DOE-funded project will be peer reviewed prior to selection in FY 2015. NREL work-for-others project proposals will be reviewed by NREL staff under a Non-Disclosure agreement to protect business sensitive information. Several other categories of projects identified in Figure 2 undergo a peer review by independent members of the scientific community for scientific quality. All proposals deemed to have met the scientific quality criteria are then reviewed and ranked by the ESIF Review Panel for strategic direction based on criteria annually defined by the ESIF Steering Committee. The Review Panel is appointed by the ESIF Director and will typically be composed of Capability Leads, other ESIF Science Leads, members of the ESIF Steering Committee (SC), members of the ESIF Technical Review Panel (TRP), and/or members of the scientific community. Proposals are rigorously reviewed by the Review Panel to verify that the proposal process provides a fairness of opportunity and resource allocation is justified for the expected scientific impact.

Figure 2: Project Review and Approval Process



User-facility Success Metrics

DOE will work with ESIF management to develop a full set of success metrics with which to measure the return on investment by taxpayers. Preliminary metrics and targets for FY 2015 include are provided in the below table. As operational experience and user engagement grows, the knowledge base to refine these metrics will be developed.

Initial Success Metrics and Targets

Success Metric	FY 2015 Target
Operating Hours	2,300
Number of Users	100
Research Output (papers, patents, awards)	25
Private Sector Leverage (cost share $)	$30 million
Safe Operations	No reportable incidents
Physical Security (Stolen or lost items)	$0 lost or stolen
Cyber Security (computer/IP secure)	Zero successful incidents
Full facility usage (as percent of the total)	70%
Visualization equipment operating and demonstrated	complete
Facility usage in each of the X labs (e.g, smart grid, hydrogen fuel cell, CSP, etc.)	50%

ESIF Benefits

Integrating EERE technologies into the electricity grid and other energy infrastructure is a major component in providing reliable, safe, and cost-effective clean power across the country. The unique, national capability available at ESIF will allow scientists and engineers from the private and public sector to conduct critical research, development, testing and validation that otherwise could not be afforded by one organization. Extending these capabilities to external energy stakeholders through partnerships will create a synergistic intellectual exchange and create a U.S. world-leading knowledge base while

providing the risk mitigation that will aid equipment providers, utilities, public utility commissions, legislative bodies and other entities in making decisions regarding EERE technologies and modernizing the Nation's electricity grid.

Facilities and Infrastructure
Site-Wide Funding Crosscut Contributions

Site-Wide Funding Crosscut Contributions
In FY 2014, EERE programs began funding a portion of site-wide costs directly, consistent with Generally Accepted Accounting Principles and with other DOE National Laboratories, in support of EERE's commitment to making site operating costs more transparent and to facilitating cost control and planning. This site-wide funding is provided through clearly identified "NREL Site-Wide Facility Support" sub-programs within individual EERE programs. NREL Operations and Maintenance were funded through both the F&I budget line in addition to the direct contributions from program funding lines. This combined funding supports basic site services, functions, and infrastructure for Site Operations. Additionally, the site-wide facility funding supports site-wide activities, such as maintaining International Organization for Standardization (ISO) certification.

The FY 2015 contribution from each program differs from the FY 2014 allocation due to a change in methodology for assessing program contributions. The principle used in FY 2014 for the site-wide cost allocation was to assess programs relative to their use of capital research assets. Programs not using capital assets were not assessed in FY 2014. In contrast for FY 2015, EERE now has a new methodology where each program's contribution is a proportional allocation of site-wide offsets calculated based on the actual cost of work performed at NREL for each program. The total costs are adjusted to account for anomalies from capital expenditures and major subcontracts, which have a different labor multiplier applied. The result is a more precise and equitable methodology at the program level and it is ultimately cost-neutral for EERE. The estimated savings gained from the reduced multiplier for each program equal or exceed the program's total allocation of the site-wide funding contribution. The distribution of site-wide contributions across the EERE programs is included below.

Site-Wide Funding Crosscut
(Funding through Program Budgets)
Funding ($K)

	FY 2014 Enacted	FY 2015 Request
Advanced Manufacturing	0	100
Building Technologies	1,000	2,700
Federal Energy Management Program	0	700
Weatherization and Intergovernmental Program	0	600
Geothermal Technologies	0	500
Solar Energy	12,000	9,200
Water Power	0	500
Wind Energy	9,000	4,700
Vehicle Technologies	2,000	3,100
Bioenergy Technologies	5,000	6,200
Hydrogen & Fuel Cell Technologies	1,000	1,700
Total, Site-Wide Funding	**30,000**	**30,000**

Capital Summary ($K)

	Total	Prior Years	FY 2013 Current	FY 2014 Enacted	FY 2014 Current	FY 2015 Request	FY 2015 vs. FY 2014 Enacted
Capital Operating Expenses Summary (including Major Items of Equipment (MIE))							
Capital Equipment > $500K (including MIE)	n/a	n/a	4,399	3,573	3,573	3,600	+27
Plant Projects (GPP) (<$10M)	n/a	n/a	8,773	7,800	7,800	7,800	0
Total, Operations and Maintenance Expenses	**n/a**	**n/a**	**13,172**	**11,373**	**11,373**	**11,400**	**+27**
Capital Equipment > $500K (including MIE)							
Total Non-MIE Capital Equipment (>$500K)[1]	n/a	n/a	4,399	3,573	3, 573	3,600	+27
Total, Capital Equipment (including MIE)	**n/a**	**n/a**	**4,399**	**3,573**	**3, 573**	**3,600**	**+27**
Plant Projects (GPP and IGPP) (Total Estimated Cost (TEC) <$10M)							
Total Plant Projects (GPP/IGPP) (Total Estimated Cost (TEC) <$5M)	n/a	n/a	8,773	7,800	7,800	7,800	0
Total, Plant Projects (GPP/IGPP) (Total Estimated Cost (TEC) <$10M)	**0**	**0**	**8,773**	**7,800**	**7,800**	**7,800**	**0**
Total, Capital Summary	**n/a**	**n/a**	**13,172**	**11,373**	**11,373**	**11,400**	**+27**

[1] Each MIE Total Estimated Cost (TEC) > $2M; Each Plant Project (GPP/IGPP) Total Estimated Cost (TEC) > $5M
[2] Final project selection will be made in FY 2014 for Plant Projects

[1] Final equipment selection will be made during FY 2014.

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. 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 2013 Actual Cost	FY 2013 Planned Cost	FY 2014 Planned Cost	FY 2015 Planned Cost
National Renewable Energy Laboratory	4,939	3,942	13,051	13,000
Total, Direct-Funded Maintenance and Repair	**4,939**	**3,942**	**13,051**	**13,000**

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

	FY 2013 Actual Cost	FY 2013 Planned Cost	FY 2014 Planned Cost	FY 2015 Planned Cost
National Renewable Energy Laboratory	4,826	4,931	0*	0*
Total, Indirect-Funded Maintenance and Repair	**4,826**	**4,931**	**0***	**0***

* NREL transitioned from Indirect to Direct funding for Maintenance in FY2014; therefore, no Indirect costs are planned in FY 2014 or 2015.

Report on FY 2013 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 2013 to the amount planned for FY 2013, including Congressionally directed changes.

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

	FY 2013 Actual Cost	FY 2013 Planned Cost
National Renewable Energy Laboratory	9,765	8,873
Total, Direct-Funded Maintenance and Repair	**9,765**	**8,873**

The Planned Cost is an estimate developed at the beginning of the year and is a minimum target amount. Final FY 2013 actual costs show that NREL was able to invest approximately 10% more than planned on the repair and maintenance of real property assets on the South Table Mountain site (a favorable variance), and remain within funding limits.

Energy Efficiency and Renewable Energy Research and Development
Research and Development ($K)

	FY 2013 Current[1]	FY 2014 Enacted	FY 2015 Request	FY 2015 vs FY 2014 Enacted
Basic	0	0	0	0
Applied	471,680	532,136	635,591	103,455
Development	349,452	314,241	385,624	71,383
Subtotal, R&D	821,132	846,377	1,021,215	174,838
Equipment	4,399	3,600	3,600	0
Construction	0	0	0	0
Total, R&D	**825,531**	**849,977**	**1,024,815**	**174,838**

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

Energy Efficiency and Renewable Energy Research and Development
Small Business Innovative Research/Small Business Technology Transfer (SBIR/STTR) ($K)

	FY 2013 Transferred[1]	FY 2014 Projected	FY 2015 Request	FY 2015 vs FY 2014 Projected
Vehicle Technologies	7,745	7,536	9,430	+1,894
SBIR	6,856	6,594	8,287	+1,693
STTR	889	942	1,143	+201
Bioenergy Technologies	3,239	4,963	4,191	-772
SBIR	2,867	4,343	3,683	-660
STTR	372	620	508	-112
Hydrogen and Fuel Cell Technologies	2,139	2,251	2,302	+51
SBIR	1,893	1,970	2,023	+53
STTR	246	281	279	-2
Solar Energy	3,974	2,043	2,200	+157
SBIR	3,518	1,788	1,933	+145
STTR	456	255	267	+12
Wind Energy	2,050	1,091	1,298	+207
SBIR	1,815	955	1,141	+186
STTR	235	136	157	+21
Water Power	900	731	1,254	+523
SBIR	797	640	1,102	+462
STTR	103	91	152	+61
Geothermal Technologies	777	973	792	-181
SBIR	688	851	696	-155
STTR	89	122	96	-26
Advanced Manufacturing	2,876	5,071	9,125	+4,054
SBIR	2,546	4,437	8,019	+3,582
STTR	330	634	1,106	+472
Building Technologies	2,673	2,208	3,109	+901
SBIR	2,366	1,932	2,732	+800
STTR	307	276	377	+101
Total, SBIR/STTR	**26,373**	**26,867**	**33,701**	**+6,834**

[1] Energy Efficiency and Renewable Energy's FY 2013 transfer included $1,297,380 (in whole dollars) of prior year balances.

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

	FY 2013 Current	FY 2014 Enacted	FY 2014 Current	FY 2015 Request	FY 2015 vs. FY 2014 Enacted
Protective Forces	5,130	5,200	5,200	5,200	0
Physical Security Systems	0	0	0	0	0
Information Security	105	200	200	200	0
Cyber Security	1,985	2,190	2,190	2,190	0
Personnel Security	698	720	720	720	0
Material Control and Accountability	0	0	0	0	0
Program Management	490	490	490	490	0
Security Investigations	0	400	400	400	0
Transportation Security	0	0	0	0	0
Construction	0	0	0	0	0
Total, Safeguards and Security	**8,408**	**9,200**	**9,200**	**9,200**	**0**

Department Of Energy
FY 2015 Congressional Budget
Funding By Appropriation By Site

($K)

Energy Efficiency and Renewable Energy	FY 2013 Current	FY 2014 Enacted	FY 2015 Request
Ames Laboratory			
Energy Efficiency and Renewable Energy			
Vehicle Technologies	2,000	1,700	2,000
Industrial Technologies	9,281	0	0
Advanced Manufacturing	0	9,281	9,281
Total, Energy Efficiency and Renewable Energy	**11,281**	**10,981**	**11,281**
Total, Ames Laboratory	**11,281**	**10,981**	**11,281**
Argonne National Laboratory			
Energy Efficiency and Renewable Energy			
Biomass and Biorefinery Systems R&D	6,060	0	0
Wind Energy	965	541	791
Geothermal Technologies	560	275	136
Hydrogen & Fuel Cell Technologies	7,589	5,400	6,000
Water Power	1,902	567	1,000
Solar Energy	1,275	317	580
Vehicle Technologies	49,865	38,111	35,000
Building Technologies	850	1,255	1,255
Industrial Technologies	1,500	0	0
Federal Energy Management Program	0	200	200
Advanced Manufacturing	0	1,700	2,880
Strategic Programs	70	0	0
Bioenergy Technologies	0	7,000	6,500
Total, Energy Efficiency and Renewable Energy	**70,636**	**55,366**	**54,342**
Total, Argonne National Laboratory	**70,636**	**55,366**	**54,342**
Brookhaven National Laboratory			
Energy Efficiency and Renewable Energy			
Geothermal Technologies	540	100	50
Hydrogen & Fuel Cell Technologies	1,598	900	1,000
Solar Energy	600	0	0
Vehicle Technologies	2,269	1,619	2,000
Strategic Programs	0	0	150
Total, Energy Efficiency and Renewable Energy	**5,007**	**2,619**	**3,200**
Total, Brookhaven National Laboratory	**5,007**	**2,619**	**3,200**
Chicago Operations Office			
Energy Efficiency and Renewable Energy			
Solar Energy	8	0	0
Vehicle Technologies	100	0	0
Total, Energy Efficiency and Renewable Energy	**108**	**0**	**0**
Total, Chicago Operations Office	**108**	**0**	**0**

Department Of Energy
FY 2015 Congressional Budget
Funding By Appropriation By Site

($K)

Energy Efficiency and Renewable Energy	FY 2013 Current	FY 2014 Enacted	FY 2015 Request
Golden Field Office			
Energy Efficiency and Renewable Energy			
Biomass and Biorefinery Systems R&D	75,532	0	0
Wind Energy	12,101	31,851	55,231
Program Direction	29,245	19,555	19,424
Geothermal Technologies	6,358	25,167	23,500
Hydrogen & Fuel Cell Technologies	34,957	58,128	53,483
Water Power	25,421	37,325	35,500
Solar Energy	111,988	162,283	194,309
Vehicle Technologies	100	0	0
Building Technologies	12,267	38,393	51,393
Industrial Technologies	43,343	0	0
Federal Energy Management Program	1,427	3,965	5,126
Weatherization Assistance	914	1,049	16,100
State Energy Program	6,316	7,100	19,670
Tribal Energy Activities	8,681	5,871	0
Advanced Manufacturing	0	112,567	190,691
Strategic Programs	4,308	4,880	4,700
Bioenergy Technologies	0	99,790	135,200
Clean Energy and Economic Development Partnerships	0	0	13,000
Total, Energy Efficiency and Renewable Energy	**372,958**	**607,924**	**817,327**
Total, Golden Field Office	**372,958**	**607,924**	**817,327**
Idaho National Laboratory			
Energy Efficiency and Renewable Energy			
Biomass and Biorefinery Systems R&D	14,405	0	0
Wind Energy	424	530	509
Geothermal Technologies	1,918	550	273
Water Power	300	0	1,000
Solar Energy	1,013	0	0
Vehicle Technologies	8,920	7,520	8,000
Industrial Technologies	1,533	0	0
Federal Energy Management Program	143	375	485
Advanced Manufacturing	0	2,770	4,692
Strategic Programs	0	60	60
Bioenergy Technologies	0	15,000	15,000
Total, Energy Efficiency and Renewable Energy	**28,656**	**26,805**	**30,019**
Total, Idaho National Laboratory	**28,656**	**26,805**	**30,019**

Department Of Energy
FY 2015 Congressional Budget
Funding By Appropriation By Site

($K)

Energy Efficiency and Renewable Energy	FY 2013 Current	FY 2014 Enacted	FY 2015 Request
Lawrence Berkeley National Laboratory			
Energy Efficiency and Renewable Energy			
Biomass and Biorefinery Systems R&D	3,941	0	0
Wind Energy	795	530	572
Geothermal Technologies	5,399	1,350	669
Hydrogen & Fuel Cell Technologies	3,996	1,800	2,000
Solar Energy	2,857	1,390	1,404
Vehicle Technologies	16,132	11,531	12,000
Building Technologies	37,190	27,833	27,833
Industrial Technologies	1,438	0	0
Federal Energy Management Program	3,701	2,760	3,568
Weatherization Assistance	434	250	340
State Energy Program	735	600	700
Advanced Manufacturing	0	2,040	3,456
Strategic Programs	1,430	1,900	1,700
Bioenergy Technologies	0	5,000	4,000
Total, Energy Efficiency and Renewable Energy	**78,048**	**56,984**	**58,242**
Total, Lawrence Berkeley National Laboratory	**78,048**	**56,984**	**58,242**
Lawrence Livermore National Laboratory			
Energy Efficiency and Renewable Energy			
Wind Energy	767	265	500
Geothermal Technologies	1,911	100	50
Hydrogen & Fuel Cell Technologies	1,725	1,200	1,500
Vehicle Technologies	3,081	2,000	2,100
Industrial Technologies	1,325	0	0
Advanced Manufacturing	0	2,475	4,193
Total, Energy Efficiency and Renewable Energy	**8,809**	**6,040**	**8,343**
Total, Lawrence Livermore National Laboratory	**8,809**	**6,040**	**8,343**
Los Alamos National Laboratory			
Energy Efficiency and Renewable Energy			
Biomass and Biorefinery Systems R&D	1,525	0	0
Geothermal Technologies	713	225	112
Hydrogen & Fuel Cell Technologies	9,563	4,800	5,000
Solar Energy	833	271	667
Vehicle Technologies	1,006	1,084	1,000
Industrial Technologies	425	0	0
Bioenergy Technologies	0	2,000	1,900
Total, Energy Efficiency and Renewable Energy	**14,065**	**8,380**	**8,679**
Total, Los Alamos National Laboratory	**14,065**	**8,380**	**8,679**

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Energy Efficiency and Renewable Energy	FY 2013 Current	FY 2014 Enacted	FY 2015 Request
National Energy Technology Lab			
Energy Efficiency and Renewable Energy			
Wind Energy	150	0	0
Program Direction	11,422	12,248	12,299
Geothermal Technologies	0	10,076	29,000
Vehicle Technologies	120,263	134,369	197,423
Building Technologies	33,758	21,850	21,850
Industrial Technologies	3,194	0	0
State Energy Program	100	100	100
Total, Energy Efficiency and Renewable Energy	**168,887**	**178,643**	**260,672**
Total, National Energy Technology Lab	**168,887**	**178,643**	**260,672**
National Renewable Energy Laboratory			
Energy Efficiency and Renewable Energy			
Biomass and Biorefinery Systems R&D	40,392	0	0
Wind Energy	39,879	30,336	32,742
Facilities and Infrastructure	24,880	45,973	56,000
Geothermal Technologies	4,131	2,680	1,329
Hydrogen & Fuel Cell Technologies	17,670	8,600	9,000
Water Power	6,616	3,432	2,500
Solar Energy	96,928	61,747	62,704
Vehicle Technologies	26,149	22,532	25,000
Building Technologies	23,571	19,807	13,507
Industrial Technologies	43	0	0
Federal Energy Management Program	5,121	5,356	6,777
Weatherization Assistance	50	320	930
State Energy Program	163	400	730
Tribal Energy Activities	460	400	0
Advanced Manufacturing	0	760	1,287
Strategic Programs	6,303	6,000	6,770
Bioenergy Technologies	0	50,000	43,000
Total, Energy Efficiency and Renewable Energy	**292,356**	**258,343**	**262,276**
Total, National Renewable Energy Laboratory	**292,356**	**258,343**	**262,276**

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Energy Efficiency and Renewable Energy	FY 2013 Current	FY 2014 Enacted	FY 2015 Request
Oak Ridge Institute for Science & Education			
Energy Efficiency and Renewable Energy			
Geothermal Technologies	326	150	150
Solar Energy	1,040	0	0
Vehicle Technologies	503	150	0
Building Technologies	1,722	0	0
Industrial Technologies	410	0	0
Strategic Programs	523	750	750
Total, Energy Efficiency and Renewable Energy	**4,524**	**1,050**	**900**
Total, Oak Ridge Institute for Science & Education	**4,524**	**1,050**	**900**
Oak Ridge National Laboratory			
Energy Efficiency and Renewable Energy			
Biomass and Biorefinery Systems R&D	12,744	0	0
Wind Energy	307	0	0
Geothermal Technologies	578	0	0
Hydrogen & Fuel Cell Technologies	5,867	3,400	4,000
Water Power	7,650	3,432	6,000
Solar Energy	2,827	0	0
Vehicle Technologies	39,375	35,153	33,000
Building Technologies	15,372	3,985	12,985
Industrial Technologies	23,371	0	0
Federal Energy Management Program	2,285	2,579	3,246
Weatherization Assistance	322	460	430
State Energy Program	634	250	400
Advanced Manufacturing	0	20,727	35,112
Strategic Programs	938	290	290
Bioenergy Technologies	0	14,000	14,000
Total, Energy Efficiency and Renewable Energy	**112,270**	**84,276**	**109,463**
Total, Oak Ridge National Laboratory	**112,270**	**84,276**	**109,463**
Oak Ridge Office			
Energy Efficiency and Renewable Energy			
Wind Energy	510	0	0
Geothermal Technologies	600	600	600
Water Power	360	360	0
Vehicle Technologies	300	0	0
Industrial Technologies	647	0	0
Strategic Programs	108	0	0
Total, Energy Efficiency and Renewable Energy	**2,525**	**960**	**600**
Total, Oak Ridge Office	**2,525**	**960**	**600**

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Energy Efficiency and Renewable Energy	**FY 2013 Current**	**FY 2014 Enacted**	**FY 2015 Request**
Office of Scientific & Technical Information			
Energy Efficiency and Renewable Energy			
Solar Energy	28	0	0
Total, Office of Scientific & Technical Information	**28**	**0**	**0**
Pacific Northwest National Laboratory			
Energy Efficiency and Renewable Energy			
Biomass and Biorefinery Systems R&D	22,500	0	0
Wind Energy	8,880	1,750	1,162
Geothermal Technologies	1,950	325	161
Hydrogen & Fuel Cell Technologies	3,663	2,400	3,000
Water Power	3,553	2,835	5,500
Solar Energy	859	0	0
Vehicle Technologies	11,369	9,251	9,000
Building Technologies	42,999	13,301	21,327
Industrial Technologies	350	0	0
Federal Energy Management Program	2,034	1,272	1,644
Advanced Manufacturing	0	250	424
Strategic Programs	740	475	450
Bioenergy Technologies	0	30,000	25,000
Total, Energy Efficiency and Renewable Energy	**98,897**	**61,859**	**67,668**
Total, Pacific Northwest National Laboratory	**98,897**	**61,859**	**67,668**
Pacific Northwest Site Office			
Energy Efficiency and Renewable Energy			
Federal Energy Management Program	0	300	300
Total, Pacific Northwest Site Office	**0**	**300**	**300**

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Energy Efficiency and Renewable Energy	FY 2013 Current	FY 2014 Enacted	FY 2015 Request
Sandia National Laboratories			
Energy Efficiency and Renewable Energy			
Biomass and Biorefinery Systems R&D	4,141	0	0
Wind Energy	14,112	7,253	8,466
Geothermal Technologies	7,932	2,350	1,165
Hydrogen & Fuel Cell Technologies	4,124	2,000	3,500
Water Power	7,322	3,577	4,000
Solar Energy	22,375	14,678	14,211
Vehicle Technologies	10,870	8,322	8,700
Building Technologies	1,966	400	400
Federal Energy Management Program	110	175	226
Tribal Energy Activities	0	425	0
Strategic Programs	0	200	200
Bioenergy Technologies	0	5,000	4,500
Total, Energy Efficiency and Renewable Energy	**72,952**	**44,380**	**45,368**
Total, Sandia National Laboratories	**72,952**	**44,380**	**45,368**
Savannah River National Laboratory			
Energy Efficiency and Renewable Energy			
Wind Energy	605	292	0
Hydrogen & Fuel Cell Technologies	3,170	2,300	2,500
Solar Energy	1,425	1,680	2,097
Vehicle Technologies	600	0	0
Federal Energy Management Program	12	0	0
Bioenergy Technologies	0	500	600
Total, Energy Efficiency and Renewable Energy	**5,812**	**4,772**	**5,197**
Total, Savannah River National Laboratory	**5,812**	**4,772**	**5,197**
Savannah River Site			
Energy Efficiency and Renewable Energy			
Biomass and Biorefinery Systems R&D	450	0	0
Total, Savannah River Site	**450**	**0**	**0**
SLAC National Accelerator Laboratory			
Energy Efficiency and Renewable Energy			
Solar Energy	1,400	0	0
Building Technologies	69	0	0
Total, Energy Efficiency and Renewable Energy	**1,469**	**0**	**0**
Total, SLAC National Accelerator Laboratory	**1,469**	**0**	**0**

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Energy Efficiency and Renewable Energy	**FY 2013 Current**	**FY 2014 Enacted**	**FY 2015 Request**
Washington Headquarters			
Energy Efficiency and Renewable Energy			
Biomass and Biorefinery Systems R&D	3,500	0	0
Wind Energy	6,634	14,778	15,027
Program Direction	119,788	130,197	128,277
Geothermal Technologies	2,109	1,827	4,305
Hydrogen & Fuel Cell Technologies	1,922	2,000	2,000
Water Power	1,563	7,037	7,000
Solar Energy	23,594	14,692	6,328
Vehicle Technologies	10,263	16,395	23,777
Building Technologies	34,837	51,044	61,150
Industrial Technologies	27,394	0	0
Federal Energy Management Program	13,432	11,266	14,628
Weatherization Assistance	129,985	171,817	209,800
State Energy Program	39,160	41,520	41,500
Tribal Energy Activities	280	300	0
Advanced Manufacturing	0	27,901	53,084
Strategic Programs	9,134	8,985	6,709
Bioenergy Technologies	0	4,000	3,500
Clean Energy and Economic Development Partnerships	0	0	1,000
Total, Energy Efficiency and Renewable Energy	**423,595**	**503,759**	**578,085**
Total, Washington Headquarters	**423,595**	**503,759**	**578,085**
Total, Energy Efficiency and Renewable Energy	**1,773,333**	**1,913,441**	**2,321,962**