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Volume 3

Department of Energy
FY 2016 Congressional Budget Request

Energy Efficiency and Renewable Energy
Electricity Delivery and Energy Reliability
Nuclear Energy
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Naval Petroleum and Oil Shale Reserves
Strategic Petroleum Reserve
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Elk Hills School Lands Fund
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FUNDING BY APPROPRIATION

(Discretionary dollars in thousands)

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

Electricity Delivery and Energy Reliability

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Electricity Delivery and Energy Reliability
Proposed Appropriation Language

For Department of Energy expenses including the purchase, construction, and acquisition of plant and capital equipment, and other expenses necessary for electricity delivery and energy reliability activities in carrying out the purposes of the Department of Energy Organization Act (42 U.S.C. 7101 et seq.), including the acquisition or condemnation of any real property or any facility or for plant or facility acquisition, construction, or expansion, [$147,306,000] *$270,100,000*, to remain available until expended: Provided, That [$27,606,000] *$32,600,000* shall be available until September 30, [2016] *2017*, for program direction.

Public Law Authorizations

Public Law 95–91, "Department of Energy Organization Act", 1977

Public Law 109-58, "Energy Policy Act of 2005"

Public Law 110-140, "Energy Independence and Security Act, 2007"

Electricity Delivery and Energy Reliability
($K)

FY 2014 Enacted	FY 2014 Current	FY 2015 Enacted	FY 2016 Request
147,242	144,205	146,975	270,100

Overview

The Office of Electricity Delivery and Energy Reliability (OE) leads the Department's efforts to strengthen, transform, and improve our energy infrastructure so that consumers have access to reliable, secure, and clean sources of energy. To accomplish this critical mission, OE works with private industry and Federal, state, local, and tribal governments on a variety of initiatives to modernize the electric grid.

Grid modernization is critical to achieving public policy objectives, sustaining economic growth, supporting environmental stewardship, and mitigating risks to secure the Nation. The goal for the future grid is to provide a platform for U.S. economic prosperity and energy innovation in a global clean energy economy. It will deliver reliable, affordable, and clean electricity to consumers where, when, and how they want it.

Within the next decade, proactive, coordinated, and innovative steps are needed that address four critical challenges:

- Changes in demand driven by population growth, adoption of more energy efficient technologies, dynamic economic conditions, and broader electrification, including possible mass-markets for electric vehicles;
- Changes in the supply mix (such as renewables, nuclear energy, natural gas, and coal) and location (centralized, distributed, and off-shore) of the Nation's generation portfolio driven by technology, market, and policy developments;
- Increasing variability and uncertainty from both supply and demand, including integration of variable renewables, more active consumer participation, and accommodating new technologies and techniques; and
- Increasing challenges to the reliability and security of the electric infrastructure (such as more frequent and intense extreme weather events, cyber and physical attacks, and interdependencies with natural gas and water).

Due to the critical role the electric grid plays in successfully implementing an all-of-the-above energy strategy across Federal, state, and local jurisdictions, OE programs are working in an integrated manner, in partnership with industry and other stakeholders as well as other DOE offices, to enhance key characteristics of the U.S. electric transmission and distribution systems:

- Reliability—consistent and dependable delivery of high quality power;
- Flexibility—the ability to accommodate changing supply and demand patterns and new technologies;
- Efficiency—low losses in electricity delivery and more optimal use of system assets;
- Resiliency—the ability to withstand and quickly recover from disruptions and maintain critical function;
- Affordability—more optimal deployment of assets to meet system needs and minimize costs;
- Security—the ability to protect system assets and critical functions from unauthorized and undesirable actors; and
- Minimal environmental footprint—grid system designs that reduce total environmental impact of grid components and connected systems

OE programs are aligned with the Administration's report, *A Policy Framework for the 21st Century Grid: Enabling Our Secure Energy Future* (June 2011), the *President's Climate Action Plan* (June 2013), and other Departmental efforts to address energy infrastructure needs and challenges. Timely action is needed to ensure a reliable electric power grid that enables the clean energy economy and the vitality of other critical sectors that depend on electricity, such as telecommunications, banking and finance, water, and public health and safety. A reliable and resilient power grid is critical to U.S. economic competiveness and leadership in the global clean energy economy.

Within the appropriation, OE funds:

- Research and Development—pursues technologies to improve grid reliability, efficiency, flexibility, functionality, and security; investments and demonstrations are aimed at bringing new and innovative technologies to maturity and helping them transition to market;
- Modeling and Analytics—develops core analytic, assessment, and engineering capabilities that can evolve as the technology and policy needs mature to support decision making within the Department and for stakeholders; analyses explore complex interdependencies such as energy-water and electric-gas;

- Institutional Support and Technical Assistance—builds capacity in the industry and convenes stakeholders to coordinate modernization efforts; provides technical assistance to states and regions to improve policies, utility incentives, state laws, and programs that facilitate the modernization of the electric infrastructure;
- Coordination of Federal Transmission Permits—streamlines permits, special use authorizations, and other approvals required under Federal law to site electric transmission facilities; and
- Emergency Preparedness and Response—enhances the reliability, survivability, and resiliency of energy infrastructure, and expedites recovery from disruptions to energy supply.

Highlights and Major Changes in the FY 2016 Budget Request

The FY 2016 request reflects the Administration's priority on modernizing the electric grid and boosting the resilience of infrastructure. The request accelerates ongoing efforts to support the Administration's all-of-the-above energy strategy and emphasizes programs that increase electric grid resilience, including managing risks, increasing system flexibility and robustness, increasing visualization and situational awareness, and deploying advanced control capabilities.

Clean Energy Transmission and Reliability ($40,000,000; +$5,738,000) increases primarily due to an expansion of university research in mathematics for power systems.

Smart Grid Research and Development ($30,000,000; +$14,561,000) increases to promote higher performing grids by integrating new assets and information streams with advanced distribution management systems and exploring new market-based control paradigms that can more efficiently integrate distributed generation resources.

Cybersecurity for Energy Delivery Systems ($52,000,000, +$6,001,000) supports research on cutting edge cybersecurity solutions, information sharing to enhance situational awareness, implementing tools to aid industry to improve their cybersecurity posture, and building an effective, timely, and coordinated cyber incident management capability in the energy sector. The increase establishes a virtual energy sector advanced digital forensics analysis platform, which can be used to analyze untested and untrusted code, programs, and websites without allowing the software to harm the host device.

Energy Storage ($21,000,000; +$9,000,000) addresses challenges in cost competitive energy storage technology, validated reliability and safety, an equitable regulatory environment, and industry acceptance. New and advanced energy storage technologies will enable the stability, resiliency and surety of the modernized grid as well as support increased levels of renewables.

Transformer Resilience and Advanced Components ($10,000,000) is a new budget line in FY 2016 to address unique challenges facing transformers and other critical grid components in a more dynamic and vulnerable operating environment. The request expands the study of geomagnetic disturbances impacts on large power transformers to include electromagnetic pulses and supports power electronics R&D.

National Electricity Delivery ($7,500,000; +$1,500,000) expands institutional support activities, including expanding the modeling and analytical tools for decision makers at the state, regional, and Federal levels. It is critical to grid modernization to help ensure state, local, regional, and tribal entities have the capabilities and support to deal with rapidly evolving technologies, policies, and regulatory structures.

Infrastructure Security and Energy Restoration ($14,000,000; +$8,000,000) supports operations of DOE Emergency Operations Center as an operational environment with the technology and tools to enable analysts to, in real time, monitor, simulate, and track energy disruptions. Funding for Federal staff supporting Operational Energy and Resilience operations is requested within Program Direction.

State Energy Reliability and Assurance Grants ($63,000,000) is a new program including $27,500,000 of grants to states localities, regions, and tribal entities for long-term electricity transmission, storage, and distribution reliability planning to promote and integrate reliability, efficiency, environmental protection (including climate adaptation), and climate resilience planning and action, as well as $35,500,000 for energy assurance formula grants to states, localities, and tribes to enhance and/or develop plans to enhance resilience through energy assurance planning and exercises.

Crosscutting Initiatives

The FY 2016 Budget Request continues crosscutting programs that coordinate across the Department and seek to tap DOE's full capability to effectively and efficiently address the United States' energy, environmental, and national security challenges. OE is part of the Grid Modernization and Cybersecurity crosscuts.

Grid Modernization: U.S. prosperity and energy innovation in a global clean energy economy depends on the modernization of the National Electric Grid. To support this transformation, the Department of Energy's Grid Modernization Initiative will create tools and technologies that measure, analyze, predict, and control the grid of the future; focus on key policy questions related to regulatory practices, market designs, and business models; ensure the development of a secure and resilient grid; and collaborate with stakeholders to test and demonstrate combinations of promising new technologies. The Grid Modernization crosscut encompasses the entire OE program, save for Grants for Energy Assurance within the State Energy Reliability and Assurance Grants program and Program Direction.

Cybersecurity: DOE engages in three categories of cyber-related activities: protecting the DOE enterprise from a range of cyber threats that can adversely impact mission capabilities; bolstering the U.S. Government's capabilities to address cyber threats; and improving cybersecurity in the electric power subsector and the oil and natural gas subsector. The cybersecurity crosscut supports central coordination of the strategic and operational aspects of cybersecurity and facilitates cooperative efforts such as the Joint Cybersecurity Coordination Center (JC3) for incident response and the implementation of Department-wide Identity Control and Access Management (ICAM).

FY 2016 Crosscuts ($K)

	Grid Modernization	Cybersecurity	Total
Clean Energy Transmission and Reliability	40,000	0	40,000
Smart Grid Research and Development	30,000	0	30,000
Cybersecurity for Energy Delivery Systems	52,000	52,000	52,000[a]
Energy Storage	21,000	0	21,000
Transformer Resilience and Advanced Components	10,000	0	10,000
National Electricity Delivery	7,500	0	7,500
Infrastructure Security and Energy Restoration	14,000	0	14,000
State Energy Reliability and Assurance Grants	27,500	0	27,500
Total, Crosscuts	**202,000**	**52,000**	**202,000**

FY 2014 Key Accomplishments

Clean Energy Transmission and Reliability

An enhanced wide-area, oscillation detection system was demonstrated for the first time in the Eastern Interconnection. This system accommodates four times the phasor measurement unit signals of previous systems and provides grid operators with greater visibility into system conditions. Furthermore, the program demonstrated significantly increased speed and fidelity of models and simulations for the electric system. These advanced grid models along with the improved measurement network support grid reliability, helping to contain or avoid outages.

To support the transition of synchrophasor research into commercial-grade tools, OE competitively awarded six projects to facilitate quick and effective response to grid conditions; utility partners have committed to deploying these tools after the two-year projects are complete.

OE completed a pilot study that explores the feasibility of assessing the impacts of sea level rise on energy infrastructure, which included facilities in the oil, natural gas, and electric sectors for four major metropolitan statistical areas: Houston, Miami, Los Angeles, and New York City. The pilot program resulted in a repeatable framework which could be used broadly to better inform long-term planning decisions by potentially impacted stakeholders.

Smart Grid Research and Development

In support of the collaborative framework established in the MOU between DOE and New Jersey, OE completed a Resiliency Assessment and Feasibility Study for constructing and operating a microgrid to provide resilient power to multimodal transportation systems in New Jersey (*NJ TRANSIT Grid*), as well as a conceptual design with a portfolio of buildings identified to be serviced by the microgrid in Hoboken, NJ, in support of rebuilding from Hurricane Sandy.

[a] The entire $52,000,000 for the Cybersecurity for Energy Delivery Systems program is included within both the Cybersecurity and Grid Modernization crosscuts but is only counted once in the total.

In a second phase of a two-phase effort to develop and deploy smart grid data access tools, OE selected a project, from among seven Phase I projects, to empower 400,000 residential customers to better manage their electricity use through improved access to their electricity consumption data.

Cybersecurity for Energy Delivery Systems

Cutting edge cybersecurity solutions transitioned to the energy sector in 2014 included substation control system components and field devices designed to allow only expected cyber-activity, strengthening protections against unauthorized access, communications or executable processes.

Two documents that provide guidance to enhance cybersecurity to industry were issued. An expanded *Integrating Electricity Subsector Failure Scenarios into a Risk Assessment Methodology* provides guidance to utilities on developing and implementing a risk assessment process using various failure scenarios. The *Cybersecurity Procurement Language for Energy Delivery Systems* provides a common understanding of appropriate cybersecurity controls in the energy sector that can be considered by utilities and suppliers during the procurement process. It helps utilities know what to ask for, and suppliers know what cybersecurity controls are appropriate for their products.

The Electric Sector Cybersecurity Capability Maturity Model (C2M2), which encourages adoption of best practices and informs cybersecurity investment decisions in industry, was expanded through increased industry participation and tool development. In addition, a C2M2 version for the oil and natural gas sector was developed and released in collaboration with stakeholders. OE also worked with industry to develop guidance on the use of C2M2 to meet the objectives of the National Institutes of Standards and Technology Cybersecurity Framework for reducing cyber risks to critical infrastructure.

Energy Storage

OE expanded work in redox flow battery electrode and cell optimization, and component life testing, along with improved testing techniques. This resulted to the development of a bench top redox flow battery with 4 times the power and operating at a 50 percent greater current density compared to FY 2013, resulting in a cost equivalent of $400 per kWh for a projected 4-hour system.

A first-of-a-kind system was installed for testing grid-connected, second-use electric vehicle batteries in stationary applications. If successful, this system could provide a subsequent use for electric vehicle batteries, after they are no longer capable of meeting vehicle needs, rather than having them go directly into disposal. A testing platform was constructed, and the first year of testing was completed based on collected residential load data to validate the control and economic potential of distributed energy storage systems.

National Electricity Delivery

Consistent with its responsibilities for Federal authorization of transmission projects that cross the Canadian and Mexican borders, OE completed the Final Environmental Impact Statement for Champlain Hudson Power Express Transmission Line. The 336-mile transmission line will bring up to 1,000 megawatts of clean, renewable power from Canada to the New York metro area. The successfully completed EIS was a basis for the Department's issuance of its Record of Decision approving the project for final permitting.

OE expanded opportunities for stakeholder input in the development of the *National Electric Transmission Congestion Studies*, preparing a consultation draft of the current study, which was distributed to states and regional reliability entities for comment, followed by a revised draft released in August 2014 for public comment. The principal finding of the draft study is that transmission congestion has declined in most areas of the Nation due to long-term trends such as slower growth in electricity demand, lower prices for natural gas as generation fuel, and continued utility investment in transmission expansion projects.

At the request of western states, OE developed a framing analysis of the possible challenges to electric utility business models from high levels of customer-owned generation (solar and natural gas) and related business developments. State electricity decision makers affirmed that this analysis was very useful in their regulation of electric utilities because it enabled them to understand better the problems they and their utilities are likely to face over the next several years.

Infrastructure Security and Emergency Restoration

OE supported 24 energy emergency events, physical security events, wild fires, winter storms, fuel shortages, national security events, storms, and typhoons, seven of which were Presidentially-designated disasters pursuant to the Stafford Act.

OE began the expansion of monitoring and visualization capabilities, including development of tools such as Lantern-Live (a mobile application being designed to inform the public during energy emergencies), the hardware and software stabilization of OE's EAGLE-I, and the identification of newer capability requirements to be added into EAGLE-I or as standalone architecture. In FY 2014, the user base for EAGLE-I increased to over 600 accounts for users from DOE and 20 other Federal agencies.

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

	FY 2014 Enacted	FY 2014 Current[a]	FY 2015 Enacted	FY 2016 Request	FY 2016 vs FY 2015
Clean Energy Transmission and Reliability	32,383	31,474	34,262	40,000	+5,738
Smart Grid Research and Development	14,592	14,125	15,439	30,000	+14,561
Cybersecurity for Energy Delivery Systems	43,476	42,301	45,999	52,000	+6,001
Energy Storage	15,192	14,706	12,000	21,000	+9,000
Transformer Resilience and Advanced Components	0	0	0	10,000	+10,000
National Electricity Delivery	5,997	5,997	6,000	7,500	+1,500
Infrastructure Security and Energy Restoration	7,996	7,996	6,000	14,000	+8,000
State Energy Reliability and Assurance Grants					
Grants for Electricity Transmission, Storage, and Distribution Reliability	0	0	0	27,500	+27,500
Grants for Energy Assurance	0	0	0	35,500	+35,500
Total, State Energy Reliability and Assurance Grants	0	0	0	63,000	+63,000
Program Direction	27,606	27,606	27,606	32,600	+4,994
Subtotal, Electricity Delivery and Energy Reliability	**147,242**	**144,205**	**147,306**	**270,100**	**+122,794**
Rescission of prior year balances	0	0	-331	0	+331
Total, Electricity Delivery and Energy Reliability	**147,242[b]**	**144,205**	**146,975**	**270,100**	**+123,125**
Federal FTEs	**80**	**80**	**83**	**99**	**+16**
Additional FE FTEs at NETL supporting OE[c]	31	31	29	29	0
Total OE-funded FTEs	111	111	112	128	+16

SBIR/STTR:

- FY 2014 Transferred: SBIR: $2,657; STTR: $380
- FY 2015 Projected: SBIR: $2,702; STTR: $373
- FY 2016 Request: SBIR: $3,720; STTR: $559

[a] Funding reflects the transfer of SBIR/STTR to the Office of Science.
[b] The $147,306,000 appropriation was reduced by $64,000 for a rescission for Contractor foreign travel.
[c] OE funds 29 FTEs at FE's National Energy Technology Laboratory who support OE activities. The 29 FTEs are in FE's FTE totals and are not included in the OE FTE totals shown on the "Federal FTEs" line.

Clean Energy Transmission and Reliability

Overview

The Clean Energy Transmission and Reliability (CETR) program improves energy system decision-making through system measurement, modeling, and risk analysis. CETR develops and demonstrates the transmission-level measurement systems, as well as software models and tools, that enable electricity system stakeholders to better manage their systems. The results of CETR's investments include operational improvements that allow operators to better monitor system conditions and maintain system stability, incorporate new generating resources, manage demand response resources, and accommodate active consumer loads. CETR also improves system planning under deep uncertainty in policy, technology, system evolution, and demand for electricity, among other factors. Further, CETR assesses integrated energy system performance and risk, working closely with Federal-, state-, and local-level partners and stakeholders to encourage risk-informed investments and operations.

The electricity system depends upon the inherent stability of a network of traditional power plants to balance electricity supply and demand. When disruptions occur, operators typically are able to direct actions to maintain system stability. But the basis of the system is changing:

- Changing sources of electricity generation reduce the inertia, and thus the inherent stability, of the system.
- Wind and solar generating resources are highly variable and their increasing use introduces uncertainty in whether the resource is available and how it interacts with the system.
- A wide range of loads are becoming active participants in the electricity system, adding an additional level of complexity to system modeling and operations.

The electricity system must provide key services even during disruptions. Recent weather-related events have reinforced the urgent need for reliable and robust monitoring, modeling, and analytical capabilities to support not only the industry, but also emergency response efforts at the state and Federal levels.

CETR organizes its activities into three subprograms, Transmission Reliability, Advanced Modeling Grid Research, and Energy Systems Risk and Predictive Capability (formerly Energy Systems Predictive Capability), which support research, development, and demonstration in three areas:

- **Measurements** builds on the deployment of time-synchronized, phasor measurement units (PMUs), commonly referred to as synchrophasors, and the establishment of the communication networks that link these devices together. CETR managed nine Recovery Act projects that deployed measurement and communication systems; as a result of these investments, the number of synchrophasors on the network has increased from 200 at the start of the program to almost 2,000 today, and wide-area visibility into the grid is a reality. CETR is now focused on demonstrating value-added applications of the technology that include: performing forensic analysis after an event (e.g., after the 2011 Southwest Blackout); identifying when a power system component is failing, thus enhancing equipment maintenance; improving the estimate of the state of the system, thus improving market behavior and reliability; and enhancing overall system efficiency and asset utilization.
- **Advanced modeling** transforms real-time measurements of what is happening into information about what could happen, improving operational decision making. When a reliability or security event occurs, model-based decision support tools are essential to identify opportunities for operational flexibility that help guide operators quickly along a path to recovery.
- **Predictive analytics** for energy systems combines Big Data and energy systems analysis to assess energy infrastructure system risks. CETR uses the analysis results to inform emergency response to events affecting energy systems and to develop tools to assist stakeholders in near- and long-term risk-informed decision making, helping to minimize potential disruptions.

CETR directly engages energy stakeholders and decision makers to disseminate research results and to promote application development, innovation, and risk-informed energy system decisions. CETR activities also focus on advancing university-based power systems research, thus ensuring an enduring strategic national capability for advancement in this essential area.

Highlights of the FY 2016 Budget Request

CETR's investments will lay the foundation for a modern grid and ensure that investments made to improve energy infrastructure appropriately factor risk and uncertainty as a key element. For FY 2016, CETR focuses its efforts in the following ways:

- Research investments target fundamental measurements and tools needed by the grid to ensure continued reliability, economic competitiveness, and resilience.
- Applications and solutions are developed in close partnership with the electricity industry to guarantee wide deployment of new grid management tools.
- A thorough accounting of risks to energy systems and services facilitates decision-making by states and communities, the private sector, and the Federal government to make appropriate tradeoffs regarding investments in energy systems.
- Robust engagement and joint problem-solving with the private sector, states, and communities accelerates innovation, the translation of research and development to commercial application, and risk-informed decision making regarding energy infrastructure.

Within the FY 2016 Budget Request, CETR supports the Departmental Grid Modernization crosscut. The goal of the Grid crosscut is to create tools and technologies that measure, analyze, predict, and control the grid of the future; focus on key policy questions related to regulatory practices, market designs, and business models; and collaborate with stakeholders to test and demonstrate combinations of promising new technologies. The entire CETR program supports this crosscut.

FY 2016 Crosscuts ($K)

	Grid Modernization
Clean Energy Transmission and Reliability	40,000

Clean Energy Transmission and Reliability
Funding ($K)

	FY 2014 Enacted	FY 2014 Current[a]	FY 2015 Enacted	FY 2016 Request	FY 2016 vs FY 2015
Clean Energy Transmission and Reliability					
Transmission Reliability	18,190	17,608	17,424	18,000	+576
Advanced Modeling Grid Research	10,195	9,868	10,648	15,000	+4,352
Energy Systems Risk and Predictive Capability	3,998	3,998	6,190	7,000	+810
Total, Clean Energy Transmission and Reliability	**32,383**	**31,474**	**34,262**	**40,000**	**+5,738**

SBIR/STTR:

- FY 2014 Transferred: SBIR: $795; STTR: $114
- FY 2015 Projected: SBIR: $814; STTR: $112
- FY 2016 Request: SBIR: $990; STTR: $149

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

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

	FY 2016 vs FY 2015
Transmission Reliability: Increased support for value-added applications of synchrophasors for transmission asset owners.	**+576**
Advanced Modeling Grid Research: Increase reflects expansion of university research in mathematics for power systems, and a competitive solicitation focused on maturing basic research into industrial applications to improve operational reliability and security.	**+4,352**
Energy Systems Risk and Predictive Capability: The increase will help connect and further integrate the research outputs of the Transmission Reliability and Advanced Modeling Grid Research subprograms into the products developed by ESRPC. In FY 2016, Energy Systems Predictive Capability has been renamed to Energy Systems Risk and Predictive Capability.	**+810**
Total, Clean Energy Transmission and Reliability	**+5,738**

Description

The Transmission Reliability subprogram supports partnerships among DOE national laboratories, universities, and the electricity industry to develop and deploy advanced technologies that enhance the reliability of U.S. electricity transmission infrastructure. Competition and market forces are increasing the volume of power transactions exponentially. In addition, coal plant retirements, abundant low-cost natural gas, and integration of large wind plants are transforming the nature and character of electricity generation and causing the grid to be used in ways for which it was not designed. Time synchronized measurements from advanced sensors (the sensors are phasor measurement units [PMUs] and their measurements become synchrophasors when aggregated) installed on the transmission system can monitor the flow of electricity with much greater precision and provide unprecedented insight into system health. Transmission Reliability funds the development of cyber-secure applications employing synchrophasor data to enhance the flexibility, reliability, and resilience of the Nation's power system.

Following the 2003 Northeast blackout report and findings, DOE and the North American Electric Reliability Corporation (NERC) joined with North American electric utilities, vendors and researchers to form the North American Synchrophasor Initiative (NASPI) with the goal of improving the reliability of the power system through wide-area measurement, analysis tools, and control. The collaborative has worked to deploy networked phasor measurement units and visualization tools nationwide, advance information sharing, and promote joint problem solving among utilities, vendors, universities, and governments. Funding from the Recovery Act accelerated this process and catalyzed investment: from 2009 through 2013 the number of networked phasor measurement units deployed on the U.S. electricity transmission system grew from approximately 200 to over 1,600.

In FY 2016, OE will complete development of multiple synchrophasor-based, production-grade software applications that will be purchased by utilities committed to installing these applications at their own expense. These applications will monitor and control the grid with advanced analysis, visualization, and decision-support tools, and will maximize the value of synchrophasor data now available to grid operators to improve reliability.

OE will also focus on inter-entity data exchange to ensure seamless and secure operations and operational planning. Although some neighboring utilities exchange real-time operational data, it is not done consistently or uniformly across interconnections. Moreover, exchanged data is often in a form that cannot readily be processed by neighbors' applications. This effort will develop an operational platform that enables neighboring utilities to exchange not only raw data but also the outputs of key applications including state estimation and contingency analysis. By accomplishing these objectives, Transmission Reliability promotes the transformation of the electricity transmission system from one based on models supported by few measurements to one based on direct real-time measurement with value-added models.

As synchrophasor data become available, Transmission Reliability accelerates the development of advanced operational tools that detect, analyze, and track grid dynamics and provide system operators with better monitoring through real-time visualization measurements of system conditions. These capabilities will continue to improve over time as more data are collected, thus feeding operator decision-support tools based on real-time measurement and advanced visualization. OE expects these advances to lead to automated system control applications and increased visibility for operators, resulting in measurable decreases in both the spread and duration of system outages by 2020.

Had PMUs been in place, the start of the 2003 blackout would have been detected by system operators 90 seconds prior to the initial event versus seven minutes later when the final cascading failure occurred on the system. PMUs provided immediately accessible data to conduct forensic analysis of the 2011 Southwest Blackout; in 2003, data had to be collected from each affected utility and the process took months. Thus investigators completed their work in weeks in 2011 rather than eight months as in 2003.

Transmission Reliability activities directly support the Grid Sensing and Measurement, and Design and Planning Tools pillars of the Grid Modernization crosscut. Success in this program is also essential to achieve the System Control and Power Flow goals of the Grid Modernization initiative.

Activities and Explanation of Changes

FY 2015 Enacted	FY 2016 Request	Explanation of Changes FY 2016 vs FY 2015
Transmission Reliability $17,424,000	**$18,000,000**	**+$576,000**
• Continue technical support for the North American Synchrophasor Initiative (NASPI) and related efforts to publically document Smart Grid Investment Grant synchrophasor project results and benefits. • Analyze the content of synchrophasor data to identify possible signatures characteristic of physical attacks, incipient equipment failures, and health on the transmission grid. • Co-fund the National Science Foundation Center for Ultra-Wide-area Resilient Electric Energy Transmission Networks (CURENT) Engineering Research Center. • Demonstrate a synchrophasor-based model-less state estimator. • Continue development of the grid-planning tools using high-fidelity representations of the system rather than approximations as is the case today.	• Install PMU-based technology to perform on-line generator model validation that is required by NERC for all large generators. • Continue support of NASPI to advance information sharing and joint problem-solving among utilities, vendors, universities, and the government, including two annual workgroup sessions. • Co-fund National Science Foundation CURENT Engineering Research Center. • Develop PMU-based algorithms that allow transmission operators to identify and react to incipient equipment malfunction, physical attacks, and geomagnetic disturbance events on the grid, thus improving system reliability and providing direct value to transmission system owners and operators.	• Increased support for value-added applications of synchrophasors for transmission asset owners. • Expand analysis of potential applications of synchrophasor technology to local electric distributions systems with respect to emerging resources integration including microgrids, distributed generation and storage, demand response monitoring, and electric vehicle charging that is responsive to grid reliability and economic efficiency requirements.

Clean Energy Transmission and Reliability
Advanced Modeling Grid Research

Description

The Advanced Modeling Grid Research subprogram supports research and development of more sophisticated, model-based analytical tools, which are necessary for effective planning and operations of the electric system. Research focuses on the modeling, computational, and mathematical advancements that are the foundation of energy management systems used by operators to plan, monitor, and control the electric system. This level of decision-making support requires integrating data-driven analytics, based on real-time operational measurements from across the electric system, with advanced modeling and simulation capabilities. Results inform control and protection approaches, as well as how information is displayed to operators to support timely decision making. Investments will increase the operational efficiency of the electric system, promote seamlessness between operations and operational planning, improve reliability, enhance resilience, and allow for visibility and control across the electricity transmission and distribution systems.

Advanced Modeling Grid Research will enhance reliability and enable advanced mitigation and recovery strategies, by:

- *Accelerating performance*—improving grid resilience to fast time-scale phenomena that drive cascading network failures and blackouts;
- *Developing predictive decision-support capabilities*—relying on high-fidelity measurements and improved models to represent the operational attributes of the electric system, improving prediction of system behavior and identification of system anomalies, assessing uncertainties, and proactively informing operator decision-making; and
- *Integrating model platforms*—capturing the interactions and interdependencies that improve operational planning, facilitating development and validation of new control and protection techniques, improving insight into the delicate balance between generation and load, and enabling dynamic reconfiguration of electric system elements to achieve both technical and economic objectives.

The program supports research and development in three major areas:

- **Data Management and Analytics.** These activities focus on the way data are collected, used, stored, and archived to facilitate the use of large, multi-source datasets to support operations and off-line planning.
- **Mathematical Methods and Computation.** These activities develop new algorithms and software libraries for use on high performance computing platforms, which leverage the investments of the Advanced Scientific Computing Research program in the Office of Science and work at ARPA-e in stochastic optimization. These new methods will form the foundation of the next generation of tools that operators and operational planners will use to manage the system.
- **Models and Simulations.** These activities perform research and development on new classes of models and fast simulations that are able to incorporate operational data, analyze potential futures, and guide decision making to ensure reliable operation in a large-scale, dynamic, and uncertain environment.

In FY 2016, the program plans to conduct a competitive solicitation to accelerate the transition of the foundational research in mathematics and models into industry-relevant applications to improve reliability and security.

Advanced Modeling Grid Research activities directly support a key pillar of the Grid Modernization cross cut: development of advanced Design and Planning tools. Success in this program is also essential to achieve the System Control and Power Flow goal of the Grid Modernization initiative, which is dependent on the mathematical and computational advances pursued by Advanced Modeling Grid Research.

Activities and Explanation of Changes

FY 2015 Enacted	FY 2016 Request	Explanation of Changes FY 2016 vs FY 2015
Advanced Modeling Grid Research $10,648,000	**$15,000,000**	**+$4,352,000**
• Continue research to accelerate state estimation and contingency analysis, to achieve "faster than real-time" dynamic simulations, and to consolidate planning and system protection models. • Continue development of a software repository for mathematical methods and solvers. • Foster dissemination of open source software developed for power system applications. • Construct a set of dynamic models for the Eastern Interconnection. • Demonstrate a VAR planning tool using representative industry data. • Validate prototype tool to assess the effect of extreme contingencies across wide areas.	• Expand mathematics and computational research to include uncertainty quantification, model formulation and reduction, and controls. • Continue efforts in architecture and data analytics. • Assess performance of open source mathematical methods and solvers (from the software repository) in prototype power system application. • Characterize system performance under dynamic and abnormal conditions. Release competitive solicitation focused on demonstrating the capability to forecast grid behavior under uncertainty thus improving the ability of operators to respond to changes in the system.	• Increase reflects expansion of university research in mathematics for power systems, and a competitive solicitation focused on maturing basic research into industry applications to improve operational reliability and security.

Clean Energy Transmission and Reliability
Energy Systems Risk and Predictive Capability[a]

Description

The devastating effects of Superstorm Sandy in 2012, Hurricanes Gustav and Ike in 2008, Katrina and Rita in 2005, and the 2013-2014 western drought and accompanying wildfires illustrate the need for national capabilities to assess near- and long-term risks to energy infrastructures, the services they provide, risks, and reliability.

The Energy Systems Risk and Predictive Capability (ESRPC) subprogram performs predictive modeling and risk analyses on a system-level basis to assess how interdependent energy infrastructure systems are impacted by forecasted and unforeseen events. ESRPC builds and develops products that assess energy system risks from both natural and man-made threats. The products developed by ESRPC inform energy industry and government decision makers regarding how energy systems operate and respond to disturbances and provide analytical and modeling support to long-term planning activities.

ESRPC's goal is to advance risk informed decision making regarding energy systems. Potential near-term actions include developing strategies to reduce the risk of system interruptions due to extreme weather, while longer-term actions include identifying a portfolio of energy system improvements that could potentially reduce the system-wide risks from events. Developing a predictive capability is necessary because understanding potential impacts to the energy system in advance and communicating them to officials and responders in anticipation of a disruption can assist in near- and long-term planning and response, motivate system improvements that enhance reliability, and reduce vulnerability to other events

In FY 2016, ESRPC will focus on furthering the development of analytical tools that estimate seasonal and regional extreme weather risks to energy systems for stakeholders including the general public, the energy industry, and State and Federal partners. ESRPC focuses its risk analysis on events which affect large geographic areas including extreme temperature events, snow and ice storms, tropical cyclones (hurricanes), and drought-based events, including wildfires. Funding in FY 2016 will also be used to connect and further integrate the research outputs of the Transmission Reliability and Advanced Modeling Grid Research subprograms into the products developed by ESRPC.

ESRPC analyses generally will fall in one of three categories:

- **Analytical and predictive modeling products supporting emergency response.** Activities measurably improve the preparation for, response to, and recovery from disruptions to U.S. energy systems by providing real-time information regarding the extent of the disruption and likely near- and long-term effects. This capability develops analytical products that rely upon data-driven predictive analytics. ESRPC also assesses the performance of systems and predictive models after events.
- **Analytical products supporting risk-informed decision making in energy system planning**. ESRPC performs long-range modeling and analysis of U.S. energy infrastructure risks. The targeted decision time frame is 5 to 8 years in the future, which corresponds to the time frame that public and private decision makers approve and build expansion projects. However, because infrastructure decisions could last 30 years or more, appropriately communicating long-term uncertainty is essential to a successful process. The result is that the government, system owners and operators, and the public are able to make quantitative risk-informed tradeoffs regarding energy system investments, such that the performance of energy systems and the private and social benefits are clear. For example, in 2014 OE completed an analysis of the impact of sea-level rise on energy infrastructure in four cities.
- **Analytical tools supporting contingency planning from non-traditional events.** ESPC develops analytical tools and methods to support system planning and operations stakeholder evaluations of risk to energy systems from non-traditional sources of man-made risk (such as supply chain disruptions). The tools and methods provide system planners, system operators, and government stakeholders rigorous, consistent, and data-driven methods to evaluate risks to energy systems.

For ESRPC to achieve its goals, it is essential that it maintain strong partnerships with key decision makers. ESRPC maintains formal and informal partnerships with organizations that collect data on the U.S. energy system including the Energy Information Administration, the Federal Energy Regulatory Commission, and the North American Electric Reliability Corporation. ESPRC also maintains strategic relationships with the National Oceanic and Atmospheric Administration, the U.S. Department of Homeland Security, including the Federal Emergency Management Agency; the Department of

[a] The Energy Systems Risk and Predictive Capability subprogram was formerly named Energy Systems Predictive Capability.

Transportation; the Environmental Protection Agency, the Pipeline and Hazardous Materials Safety Administration; industry trade associations; owners and operators from the electricity, oil and natural gas sectors; universities and researchers; National Laboratories; and state and local governments.

ESRPC directly supports the Grid Security and Resilience pillar of the Grid Modernization crosscut by assessing and communicating risks to energy infrastructure systems.

Activities and Explanation of Changes

FY 2015 Enacted	FY 2016 Request	Explanation of Changes FY 2016 vs FY 2015
Energy System Risk and Predictive Capability		
$6,190,000	**$7,000,000**	**+$810,000**
• Validate and verify outputs developed using the analytical platform. • Continue integration of historical and operational data feeds into the analytical platform. • Provide analytic support for the OE's emergency response activities under ISER in advance of and following energy system events. • Continue analyzing interdependent energy infrastructure risks. • Test analytical capabilities to deliver risk and impact analysis of events that impact energy system reliability. • Begin building a capability to analyze the performance of and risks to oil and natural gas infrastructure. • Design an open-source representation of the electricity system for use in near- and long-term risk assessment, modeling, and simulation. • Develop and pilot test a program which educates stakeholders how to understand, assess, and communicate risks to the energy system, thus advancing risk-informed decision making regarding energy infrastructure investment.	• Advance predictive analytics on interconnected energy infrastructure systems to include understanding of how historical performance predicts future system performance. • Begin connecting research data from the Transmission Reliability and Advanced Modeling Grid Research subprograms to the ESRPC analytical platform. • Advance real-time predictive analytics to enhance Federal, State, local, and industry knowledge for events. • Continue to enhance and strengthen partnerships to ensure the program delivers value to all stakeholders. • Begin wide-scale deployment of a program to educate stakeholders on how to understand, assess, and communicate risk to the energy system. • Provide real time analysis support for all high profile events. • Deploy a capability to assess risks to interdependent energy infrastructure.	• The increase will help connect and further integrate the research outputs of the Transmission Reliability and Advanced Modeling Grid Research subprograms into the products developed by ESRPC.

Clean Energy Transmission and Reliability
Performance Measures

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

	FY 2014	FY 2015	FY 2016
Performance Goal (Measure)	**Transmission Reliability**—Demonstrate and implement technologies and tools that improve the monitoring of transmission system health and the ability of operators to respond quickly and effectively to address issues.		
Target	Demonstrate an Oscillation Detection System in the Eastern Interconnection.	Demonstrate an open-source, synchrophasor-based tool that can be used for demonstrating compliance with the frequency response requirements contained NERC Standard BAL-003.	Develop a prototype wide-area synchrophasor-based voltage stability tool.
Result	Met		
Endpoint Target	Realization of a nationwide synchrophasor network with 100% sensor coverage of the transmission system by 2020, allowing for complete, real-time monitoring of transmission component health and system health and system status.		
Performance Goal (Measure)	**Advanced Modeling Grid Research**—Development of capabilities in understanding, modeling, and predicting grid behavior in real-time.		
Target	Demonstrate (at laboratory scale) fast state estimation, fitting steady-state model with 5-second SCADA data.	Demonstrate (at laboratory scale) high-performance dynamic simulation capability for assessing potentially destabilizing events.	Demonstrate simulation capabilities in a prototype operational tool that can be used in real-time to identify available operating margins.
Result	Met		
Endpoint Target	Realization of advanced modeling capabilities, including dynamic operation, real-time analysis, and predictive response.		

	FY 2014	FY 2015	FY 2016
Performance Goal (Measure)	**Energy System Risk and Predictive Capability**—Provide Federal agencies, states, and sector stakeholders with independent and transparent analyses of risks to energy infrastructure systems and supply chain impacts.		
Target	N/A	Validate and verify energy risk analysis products developed using the analytical framework.	Release products to stakeholders incorporating advanced predictive analytics on interconnected energy infrastructure systems to include understanding of how historical asset performance affects overall system performance.
Result	N/A		
Endpoint Target	This subprogram develops tools and robust predictive analytic products which assist decision makers in assessing current and future risks to the reliability of inter-dependent energy systems.		

Smart Grid Research and Development

Overview

The Smart Grid program focuses primarily on the development of technologies, tools, and techniques to modernize the distribution portion of the electric delivery system: the infrastructure that takes power from the transmission system and delivers it to individual businesses and homes. Smart Grid pursues strategic investments to improve reliability, operational efficiency, and resiliency, and outage recovery, building upon previous and ongoing grid modernization efforts, including the American Recovery and Reinvestment Act of 2009 (ARRA) Smart Grid Investment Grants and Smart Grid Regional Demonstrations. Significant progress has been made towards grid modernization within the distribution infrastructure, but many technical challenges requiring continued Federal R&D investment remain.

One challenge driving distribution system modernization is the ever changing capabilities necessary to meet our Nation's the evolving electricity needs. These include accommodating greater numbers of customer owned distributed generation, including solar photovoltaics (PV); supporting the shift towards the electrification of transportation such as electric automobiles; enabling greater customer choice and control over electricity consumption; being more resilient to extreme weather events such as Superstorm Sandy; reducing the length and number of outages overall; and, at the same time, maintaining affordability.

Information and communication technology advances have initiated opportunities to leverage increased data volumes as never before possible to begin addressing many distribution grid operation technical challenges, including increased demand and supply variability; bi-directional power flow, data management, and security; interoperability between new and legacy technologies and devices; and the increasing interdependencies between distribution and transmission operations.

Microgrid research investments have shown success in addressing reliability, efficiency, emissions reduction, and resilience and will continue to be a major thrust within the Smart Grid program. New approaches and technologies will also be investigated, ranging from Advanced Distribution Management System (ADMS) enabling a whole new level of visibility and control across a utility's entire service territory, to transformative approaches in Market-Based Control paradigms that rely on competitive forces to control and optimize distribution assets, to the development of new applications leveraging system data for improved utility operations and to stimulate new products and services for consumers. Exploring innovative and transformative solutions based on data driven applications will continue to be the cornerstone of OE's Smart Grid Program.

Highlights of the FY 2016 Budget Request

The FY 2016 request includes a new investment in developing the Advanced Distribution Management System. An initial version of an open source integrated software platform for varying vendor systems will be developed which supports the full suite of distribution management applications (such as voltage and reactive power optimization; fault location, isolation, and service restoration; economic dispatches; and optimization routines).[a] This integrated platform, based on specifications and requirements to be developed jointly with utilities, will allow information to flow between individual applications across the entire utility enterprise, enabling enhanced visibility and controllability of system assets. Development and evaluation of the ADMS platform will be conducted in a utility-centric environment, involving qualified system operators from distribution utilities of varying sizes, to ensure that the capabilities being developed are applicable to the largest possible cross section of utilities. Investments leveraging the increased types and volume of available system data, due to a recent surge in advanced technology deployments, will also be explored to develop new applications. These new applications will greatly enhance observability and controllability required to integrate large amounts of renewables in a safe and effective manner, utilize assets more efficiently during restorations, enable much wider range of choices for consumers, and maintain affordable electricity rates.

Smart Grid investments will also explore market-based controls in FY 2016. Coupling market-based control signals with electric distribution operations, generally known as transactive energy, will create value to both utilities and customers. This new control paradigm will enable utilities to balance supply and demand at all levels of the grid, by actively seeking

[a] Vendor systems for integration by ADMS include traditional DMS, geographic information systems, outage management systems, customer information systems, advanced metering infrastructure/automatic meter reading, and supervisory control and data acquisition (SCADA).

participation of customer-owned and third-party assets in grid services through transparent, competitive forces of demand and supply. The prices or incentives offered by market forces will engage the self-interest of customers and other third parties, and will also serve as a control signal to coordinate operations of their assets with the power grid. Hence, transactive energy will result in greatly increased flexibility needed for maintaining reliability in a low-carbon future, while allowing customers to fully participate in grid operations

Market-Based Control Signal activities in FY 2016 include developing simulation tools and test cases, as well as validating tools using the initial test cases that were developed under ARRA Grid Modernization projects. Transactive approaches developed by research organizations and industry will be evaluated to refine controllability, stability limits, and efficacy of operating distributed assets (end-use devices, distributed generation, batteries, PV solar systems, inverters, EV chargers, etc.) and networked communication systems.

Finally, Smart Grid will expand investments in activities to achieve the DOE 2020 microgrid performance targets and meet the R&D needs for a resilient electric distribution grid, both of which were formulated with engagement of a broad range of stakeholder groups.[a] FY 2016 Microgrid R&D activities support ongoing work to develop reliable and resilient microgrid concepts and will also include new projects to be awarded through a funding opportunity announcement (FOA) on networked microgrids, following the defined R&D pathway from single microgrids toward an integrated network of multiple microgrids as a building block for the smarter grid of the future. National laboratory R&D will continue, including completion of a second-generation Microgrid Design Toolset prototype for microgrid design analysis with enhanced features recommended by the Industry Advisory Group, and development of a grid interactive microgrid controller to support distribution system applications, while being visible to the transmission system operator.

Resilient Electric Distribution Grid R&D activities in FY 2016 will continue to support the Administration's initiatives to establish partnerships with U.S. cities and tribal communities on deployment of smart grids and microgrids for climate preparedness and resilience. Technical assistance from national labs will support the communities selected from the FY 2015 Resilient Electricity Delivery Infrastructure (REDI) FOA, encompassing risk assessment and management, resilient energy system analysis, and deployment of best practices/technologies/tools. National laboratory R&D will continue in developing a decision support analysis tool by leveraging models developed under the DHS National Infrastructure Simulation and Analysis Center to enable distribution grid planners to determine and prioritize system upgrades and expansions needed for enhanced resiliency. In addition, the Electric Resilience Assessment Program—Distribution (ERAP-D) tool prototype will be ready for use by distribution utilities to conduct holistic assessment of grid resilience through the synthesis of physical infrastructure information as well as company plans, policies, and procedures. The ERAP-D tool development builds on the resilience assessment tool developed under the DHS Regional Resiliency Assessment Program.

The planned FY 2016 Smart Grid investments in ADMS, Market-Based Controls, Microgrids, and Resilience Electric Distribution Grid R&D strengthen the resilience of electrical infrastructure against adverse effects of future extreme weather phenomena and other unforeseen occurrences, directly supporting the efforts to prepare the Nation for the impacts of climate change. Further, Microgrid R&D is a strategy element in the DOE Implementation of the President's Climate Action Plan. Smart Grid activities support the President's vision of generating 80 percent of America's electricity from clean sources by 2035. Lastly, Smart Grid activities respond to one of the four pillars, empowering consumers and enabling them to make informed decisions, identified in the Administration's report "*A Policy Framework for the 21st Century Grid: Enabling Our Secure Energy Future*" by the National Science and Technology Council.[b]

Within the FY 2016 Budget Request, Smart Grid supports the Departmental Grid Modernization crosscut. The Grid crosscut goal is to create tools and technologies that measure, analyze, predict, and control the grid of the future; focus on key policy questions related to regulatory practices, market designs, and business models; and collaborate with stakeholders to test and demonstrate combinations of promising new technologies. The entire Smart Grid program supports this crosscut.

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[a] The DOE 2020 microgrid performance targets and associated key R&D activities are documented in the 2012 *DOE Microgrid Workshop Summary Report*, available at http://energy.gov/oe/downloads/2012-doe-microgrid-workshop-summary-report-september-2012. Key R&D needs and projects for a resilient electric distribution grid are documented in the 2014 *DOE Resilient Electric Distribution Grid R&D Workshop Summary Report,* available at http://energy.gov/oe/articles/final-report-and-other-materials-2014-resilient-electric-distribution-grid-rd-workshop.

[b] http://www.whitehouse.gov/sites/default/files/microsites/ostp/nstc-smart-grid-june2011.pdf.

FY 2016 Crosscuts ($K)

	Grid Modernization
Smart Grid Research and Development	**30,000**

Smart Grid Research and Development
Funding ($K)

	FY 2014 Enacted	FY 2014 Current[a]	FY 2015 Enacted	FY 2016 Request	FY 2016 vs FY 2015
Smart Grid Research and Development	**14,592**	**14,125**	**15,439**	**30,000**	**+14,561**

SBIR/STTR:

- FY 2014 Transferred: SBIR: $409; STTR: $58
- FY 2015 Projected: SBIR: $448; STTR: $62
- FY 2016 Request: SBIR: $900; STTR: $135

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

Smart Grid Research and Development
Explanation of Major Changes ($K)

	FY 2016 vs FY 2015
The increase expands development of the Advanced Distribution Management System (ADMS) and Market-Based Control Signals.	**+14,561**

Activities and Explanation of Changes

FY 2015 Enacted	FY 2016 Request	Explanation of Changes FY 2016 vs FY 2015
Smart Grid Research and Development $15,439,000	**$30,000,000**	**+14,561,000**
• Launch a direct current (DC) microgrid initiative to achieve climate-neutral buildings with awards for new industry and national laboratory projects. • Continue to support national laboratory microgrid R&D on developing a prototype Microgrid Design Toolset and an integrated microgrid controller, as well as for resiliency focusing on operational response to grid disturbances, and distribution system restoration and recovery. • Continue to support resilient grid R&D by national labs, including development of a prototype of the optimal resilience tool for multiple hazards (ice and flooding in FY 2015) by leveraging models developed under the DHS National Infrastructure Simulation and Analysis Center, and the proof-of-concept Electric Resilience Assessment Program—Distribution tool that builds on the resilience assessment tool developed under the DHS Regional Resiliency Assessment Program. • Establish partnerships with U.S. cities and tribal communities, through the Resilient Electricity Delivery Infrastructure (REDI) FOA, to deploy smart grids and microgrids for climate preparedness and resilience. • Continue support of interoperability and conformance testing to promote standards acceptance by utilities.	• Award new projects in networked microgrid R&D through a FOA to achieve full integration of a network of multiple microgrids with distribution systems. • Continue to support national laboratory microgrid R&D, including transitioning the Microgrid Design Toolset and a grid interactive microgrid controller to industry for microgrid planning/design and operations/control, respectively; DC microgrids for climate-neutral buildings; and microgrids as a grid resource for reliability and resilience. • Continue to support national laboratory resilient grid R&D, including: further development of a decision support analysis tool for other extreme weather hazards; and transitioning of the ERAP-D tool for use by distribution utilities. • Continue to support the REDI projects by providing technical assistance from national labs to awarded U.S. cities and tribal communities. • Develop the specifications for an open source ADMS platform for interconnection and interoperability with various systems and applications. • Begin work on ADMS test cases and an ADMS test bed for evaluation under operating environments; begin testing of ADMS platform utilizing the test bed and test cases.	The increase launches efforts in ADMS and Market-Based Control Signals. In ADMS: • Begin construction of an open source ADMS platform based on the specifications developed jointly with utilities. • Develop utility defined use cases. • Develop data analytics for large volumes of grid data from connected devices for enhanced visibility and for validation of distribution grid operations. In Market-based Control Signals: • Evaluate the performance of various transactive approaches developed by research organizations and industry; enhance existing tools to refine controllability, stability limits, and efficacy. • Establish a standard means of quantifying the value of various grid services and determining the net value provided by the distributed assets.

FY 2015 Enacted	FY 2016 Request	Explanation of Changes FY 2016 vs FY 2015
	• Launch research activities to develop new applications compatible with the open source ADMS platform that leverage the vast amounts of available system data for improved grid operations. • Establish a standard means of quantifying the value of various grid services and determining the net value provided by the distributed assets. • Develop control algorithms for end-use devices (water heaters, refrigerators, clothes dryers, and variable speed drives) to respond to market-based control signals for the provision of ancillary services. • Evaluate transactive approaches developed by research organizations and industry, and enhance existing simulation and modeling tools to attain stable, predictable response with increased efficiency.	

Smart Grid Research and Development
Performance Measures

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

	FY 2014	FY 2015	FY 2016
Performance Goal (Measure)	Increase in load factor, reduction in outage durations (system average interruption duration index, or SAIDI) of the distribution system, and reduction in outage time of critical loads on smart microgrids.		
Target	Demonstrate a grid-connected microgrid equipped with an advanced control algorithm, to achieve enhanced distribution system restoration.	Complete development of a prototype Microgrid Design Toolset that is used by at least one A&E firm for microgrid design analysis.	Complete development and pilot testing of a prototype Electric Resilience Assessment Program—Distribution tool to provide a holistic picture of grid resilience to utility owners and operators.
Result	Met		
Endpoint Target	Achievement of a self-healing and resilient distribution grid, with integration of networked microgrids and market-based control signals operating under the ADMS, that allows for widespread deployment of distributed renewable and clean energy resources and demand response by 2030.		

Cybersecurity for Energy Delivery Systems

Overview

The energy sector, which includes both the electricity and oil and natural gas sectors, has been subjected to a dramatic increase in focused cyber probes, data exfiltration, and malware development for potential attacks in recent years. The sophistication and effectiveness of these intrusions mark the transition to an era of state actor level threats to the United States. As the energy sector-specific agency (SSA), DOE has the mission and domain expertise to work with industry to mitigate the risk resulting from the cyber-physical coupling within the energy environment. DOE's long history of collaboration with industry has created integral relationships to activities that expand situational awareness (e.g., data exfiltration) and information sharing to reduce cyber risk. Reliable and resilient energy infrastructure is essential to our economy, health and safety, and national security. Energy delivery system cybersecurity has emerged as one of the Nation's most vital grid modernization and infrastructure security issues. Innovative solutions designed to meet the unique requirements of high-reliability energy delivery systems are urgently needed to ensure the success of grid modernization and transformation of the Nation's energy systems to meet future needs for economic growth. Effective solutions must be based on industry best practices, sound risk management processes, and improved situational awareness, and will require multi-disciplinary collaborations and shared expertise in power systems engineering, computer science, and cybersecurity.

As the energy SSA, the Department's ongoing collaboration with vendors, utility owners, and operators of the electricity and oil and natural gas sectors strengthens the cybersecurity of critical energy infrastructure against current and future threats. Presidential Policy Directive 21, *Critical Infrastructure Security and Resilience*, directs the SSAs to serve as a day-to-day Federal interface for the dynamic prioritization and coordination of sector-specific activities; carry out incident management responsibilities consistent with statutory authority and other appropriate policies, directives, or regulations; and provide, support, or facilitate technical assistance and consultations for each sector to identify vulnerabilities and help prevent or mitigate the effects of incidents, as appropriate.[a] In meeting this requirement for the Department, OE's Cybersecurity for Energy Delivery Systems (CEDS) program is supporting cyber risk and incident management activities with four key objectives:

- accelerating information sharing to enhance situational awareness;
- expanding implementation of the Cybersecurity Capability Maturity Models and Risk Management Process;[b]
- research and develop technologies to improve energy reliability and resilience; and
- exercising and refining the energy sector's cyber incident response capabilities.

OE's mission to modernize the electric grid cannot be achieved without the research, development, and integration of secure energy delivery control systems. The FY 2016 request supports research and development (R&D) to enhance the reliability and resiliency of the Nation's energy infrastructure by reducing the risk of energy disruptions due to cyber attacks.

The CEDS program structure aligns with the *2011 Roadmap to Achieve Energy Delivery Systems Cybersecurity*, which presents a strategic framework and advances the vision that resilient energy delivery control systems are designed, installed, operated, and maintained to survive a cyber incident while sustaining critical functions.[c] The DOE-facilitated, energy sector-driven Roadmap strategic framework has five focus areas: build a culture of security, assess and monitor risk, develop and implement new protective measures to reduce risk, manage incidents, and sustain security improvements.

CEDS maintains a research, development, and operations portfolio that includes long-, mid-, and short-term efforts that address the long-, mid-, and short-term milestones in the energy sector's Roadmap. National laboratory participation in CEDS projects ensures critical skill sets remain current and sustain core capabilities, ensuring they can provide support to the energy sector in case of a cyber event. CEDS efforts engage energy sector stakeholders from the earliest stages and align with the Roadmap strategy to ensure that CEDS is working the right problems. This approach enables the continuous

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[a] Presidential Policy Directive 21: http://www.whitehouse.gov/the-press-office/2013/02/12/presidential-policy-directive-critical-infrastructure-security-and-resil

[b] Cybersecurity Capability Maturity Models: http://energy.gov/oe/services/cybersecurity/electricity-subsector-cybersecurity-capability-maturity-model; Risk Management Process: http://energy.gov/oe/services/cybersecurity/cybersecurity-risk-management-process-rmp

[c] *Roadmap to Achieve Energy Delivery Systems Cybersecurity*: http://energy.gov/sites/prod/files/Energy%20Delivery%20Systems%20Cybersecurity%20Roadmap_finalweb.pdf

transition of long-term innovative research from the national laboratories and academia into capabilities that the energy sector can put into practice to reduce cyber risk. The dynamic cyber threat landscape, continuous advances in energy delivery system technologies, and the use of legacy devices in ways not previously envisioned underscore the importance of this continuous transition. In addition, CEDS provides strategic leadership on cybersecurity aspects of the energy sector's operational security, asset protection, baseline practices, risk management, situational awareness, incident management, and other issues needed to achieve the Roadmap vision.

Highlights of the FY 2016 Budget Request

The FY 2016 request reflects the critical need to accelerate and expand efforts to strengthen the energy infrastructure against cyber threats. Working closely with the Energy Sector and our government partners, the request includes a continued focus in the following areas:

- **Accelerating information sharing to enhance situational awareness in the electricity and oil and natural gas sectors.** In FY 2014, the Cybersecurity Risk Information Sharing Program (CRISP) transitioned from a small DOE-funded electricity sector pilot to a private-sector program primarily funded and managed by the North American Electric Reliability Corporation (NERC) and the electricity subsector companies that participate in the program. NERC expanded its Electricity Sector Information Sharing and Analysis Center duties to include the management of the unclassified elements of CRISP, and DOE is expanding its capability to perform critical classified elements of CRISP. CRISP is a government–energy sector collaboration to facilitate the timely bi-directional sharing of classified and unclassified threat information and develop and deploy situational awareness tools to enhance the sector's ability to identify and mitigate threats and coordinate the protection of critical infrastructure. In FY 2016, unclassified analytic and situational awareness functions managed by NERC will continue to expand, while DOE continues to fund and perform its classified analytical and reporting role. In addition, DOE will issue a competitive solicitation to identify and fund commercially available technologies and services that can be incorporated into CRISP via operational pilots designed to enhance all aspects of the program. As the energy SSA, DOE will also work with the oil and natural gas sector to bring it into CRISP.
- **Expanding implementation of the Cybersecurity Capability Maturity Model and Risk Management Process for both the electricity and oil and natural gas sectors.** In FY 2016, CEDS is expanding online access to the Cybersecurity Capability Maturity Model (C2M2) and Risk Management Process (RMP) guidelines and conducting benchmarking and data analytics of C2M2 evaluation tool results. C2M2 was developed in 2012 with Federal and industry partners to encourage best practice adoption and inform cybersecurity investments. RMP was developed in 2012 with industry partners to enable effective and efficient risk management decisions. Both C2M2 and RMP help utilities improve their organizational and process level cybersecurity posture.
- **Researching, developing, and demonstrating cutting edge cybersecurity solutions in the electricity and oil and natural gas sector**. Energy delivery control systems are uniquely designed and operated to control real-time physical processes that deliver continuous and reliable power to support national and economic security. Cybersecurity technologies developed to protect business IT computer systems and networks can inadvertently damage energy delivery control systems, which require cybersecurity solutions meeting unique performance requirements and operational needs. For example, some energy delivery system communications must be fast, such as time-critical responses of less than four milliseconds for protective relaying. In addition, they must have high availability; they cannot be patched or upgraded without extensive testing and validation, normally planned weeks or months in advance, to ensure that the change does not jeopardize power system operations. In FY 2016, CEDS will issue a competitive solicitation for energy sector-led R&D to advance cybersecurity for energy delivery systems to transition mid-term R&D projects into real world cybersecurity capabilities that address the changing threat landscape. In addition, CEDS will continue to support applied research and strengthen the core capabilities at the national laboratories.
- **Exercising and refining the energy sector's cyber incident response capabilities.** CEDS is leading the Energy Sector-Cybersecurity Incident Management Capability effort to build effective, timely, and coordinated cyber incident management capabilities for operations, information exchange, and technology in the energy sector. In collaboration with DHS, the Federal Energy Regulatory Commission (FERC), the Electricity Sector Information Sharing and Analysis Center, and industry, DOE is leveraging governmental and non-governmental resources to create a suite of deliverables that will improve processes and enhance technologies for cybersecurity for energy delivery systems. In FY 2016 CEDS will enhance situational awareness with relevant local and Federal agencies and informational analysis centers through increased information sharing and collaborative regional exercises.

- **Establish a Virtual Energy Sector Advanced Digital Forensics Analysis Platform.** The energy sector is a prime target for malicious cybersecurity attacks, but most utilities and companies within the sector do not have post-incident analysis tools to distinguish between a normal system failure and malicious activity. The ability to detect and mitigate the malicious activity is critical. The development of a virtual environment for forensic analysis will enable analysts to safely inspect malware, zero-day vulnerabilities, and advanced threats across multiple stages and different vectors and test mitigations. In FY 2016, CEDS will conduct a competitive solicitation to establish a virtual collaborative environment for conducting real-time advanced digital forensics analysis for the energy sector. This environment could be used to analyze untested and untrusted code, programs, and websites without allowing the software to harm the host device. This initiative would be implemented over a two-year timeframe, after which it would transition to the private sector where it would become self-sustaining.

Within the FY 2016 Budget Request, CEDS supports two Departmental crosscuts: Grid Modernization and Cybersecurity. The Grid crosscut goal is to create tools and technologies that measure, analyze, predict, and control the grid of the future; focus on key policy questions related to regulatory practices, market designs, and business models; and collaborate with stakeholders to test and demonstrate combinations of promising new technologies. The Cybersecurity crosscut supports central coordination of the strategic and operational aspects of cybersecurity and facilitates cooperative efforts. The entire CEDS program supports both crosscuts.

FY 2016 Crosscuts ($K)

	Grid Modernization	Cybersecurity	Total
Cybersecurity for Energy Delivery Systems	**52,000**	**52,000**	**52,000**[a]

[a] The entire $52,000,000 request for the Cybersecurity for Energy Delivery Systems program is included within both the Cybersecurity and Grid Modernization crosscuts.

Cybersecurity for Energy Delivery Systems
Funding ($K)

	FY 2014 Enacted	FY 2014 Current[a]	FY 2015 Enacted	FY 2016 Request	FY 2016 vs FY 2015
Cybersecurity for Energy Delivery Systems	**43,476**	**42,301**	**45,999**	**52,000**	**+6,001**

SBIR/STTR:

- FY 2014 Transferred: SBIR: $1,028; STTR: $147
- FY 2015 Projected: SBIR: $1,092; STTR: $151
- FY 2016 Request: SBIR: $900; STTR: $135

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

Cybersecurity for Energy Delivery Systems
Explanation of Major Changes ($K)

	FY 2016 vs FY 2015
The increase establishes a virtual energy sector advanced digital forensics analysis platform	**+6,001**

Activities and Explanation of Changes

FY 2015 Enacted	FY 2016 Request	Explanation of Changes FY 2016 vs FY 2015
Cybersecurity for Energy Delivery Systems		
$45,999,000	**$52,000,000**	**+$6,001,000**
• Develop a C2M2 web accessible portal that will have a benchmarking capability that will allow a utility to compare its self-evaluation against similar entities. • Issue a competitive solicitation for an academic collaboration with expertise in power system engineering and cybersecurity computer science to innovate and transition cybersecurity capabilities to the energy sector to reduce the risk of power disruption resulting from a cyber incident. • Issue a competitive solicitation for the energy sector to transition mid-term research and development projects into real world cybersecurity capabilities for the energy sector through industry-led cost-shared short-term research and development. Examples include advanced capabilities to detect compromise of supply chain integrity for energy delivery system cyber assets; identification of adversarial cyber activity that attempts to evade detection by exploiting allowed operation of power grid components; and ability to survive a cyber incident while sustaining critical energy delivery functions. • Continue development of the Wireless Test Bed to address national challenges in infrastructure security, communications interoperability, spectrum utilization, and wireless technology reliability.	• Continue to fund the CRISP classified analytic and reporting functions. • Issue a competitive solicitation to identify commercially available technologies and services to enhance CRISP capabilities. • Expand online access to the C2M2 and RMP tools and conduct benchmarking and data analytics. • Issue a competitive solicitation for energy sector-led R&D to advance cybersecurity for energy delivery systems to transition mid-term R&D projects into real world cybersecurity capabilities that address the changing threat landscape. • Continue to support mid-term as well as long-term high-risk/high-payoff research and strengthen the core capabilities at the national laboratories through competitive processes. • Enhance situational awareness with relevant local and Federal agencies and informational analysis centers through information sharing development and practicing regional cybersecurity incident response communications. • Establish a Virtual Energy Sector Advanced Digital Forensics Analysis Platform through a competitive solicitation.	• Establish the capability of a virtual collaborative environment for conducting real-time advanced digital forensics analysis for the energy sector to detect and mitigate malicious activity.

FY 2015 Enacted	FY 2016 Request	Explanation of Changes FY 2016 vs FY 2015
• Continue high risk/high payoff research at the national laboratories, including research areas such as analysis of the risk posed to the energy sector if energy delivery control systems were exploited by selected malware, and tailored trustworthy spaces that tailor cybersecurity protections to accommodate needs at different levels of the energy delivery system architecture.		

Cybersecurity for Energy Delivery Systems
Performance Measures

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

	FY 2014	FY 2015	FY 2016
Performance Goal (Measure)	**Cybersecurity**—Demonstrate new protective measures to reduce risks from cyber incidents.		
Target	Demonstrate a tool that designs-in enhanced communications security for one substation control system component	Demonstrate a tool that designs-in enhanced communications security between control centers	Demonstrate a tool that establishes a tailored trustworthy space for one energy delivery field device
Result	Met		
Endpoint Target	By 2020, resilient energy systems are designed, installed, operated, and maintained to survive a cyber incident while sustaining critical functions.		

Energy Storage

Overview

The Energy Storage program supports the Secretary's strategy to support a more economically competitive, environmentally responsible, secure, and resilient U.S. energy infrastructure. The program is designed to develop and demonstrate new and advanced energy storage technologies that will enable the stability, resiliency, and reliability of the future electric utility grid as it transforms into a resilient grid. Additionally, Energy Storage enables increased deployment of variable renewable energy resources such as wind and solar power generation. The Energy Storage program focuses on accelerating the development and deployment of energy storage in the electric system through directly addressing the four principal challenges identified in the 2013 DOE Strategic Plan for Grid Energy Storage: cost competitive energy storage technology, validated reliability and safety, equitable regulatory environment, and industry acceptance.[a]

The deployment of grid-scale energy storage projects throughout the country is accelerating. For example, in 2013, the California Public Utility Commission mandated installation of 1.3GW of energy storage to compensate for variability accompanying increased renewable generation. Microgrids involving storage are being installed by the military for energy surety and by states, including New Jersey and Massachusetts, for emergency preparedness. In addition, the Federal Energy Regulatory Commission (FERC) has mandated fair pricing for frequency regulation, which would double the value of energy storage facilities offering this service. Many of these projects are based on technology developed under the Energy Storage program. However, storage technology still needs to make substantial improvements in safety, cycle life, energy density, and cost before becoming fully competitive.

Research and Development (R&D) activities focus on lowering cost while improving the value, performance, safety, and reliability of stationary energy storage technologies for utility-scale applications. Additionally, the program develops and demonstrates energy storage technologies, devices, and systems that can reduce power disturbances, improve system flexibility to better incorporate variable and intermittent renewable resources, reduce peak demand, and provide resiliency for the grid. Together these efforts are accelerating implementation of emerging storage technologies to advance the modernization of the electrical utility grid.

To maximize the benefits of energy storage, work must be done to address the goals of four focus areas:

- Cost Competitive Energy Storage—Develop material and system enhancements to resolve these key cost and performance challenges with respect to novel flow, lithium, sodium, magnesium, nitrogen-oxygen, and thermoelectrochemical batteries and associated electrodes, dielectrics, membranes, electrolytes, interconnects, and supporting power electronics.
- Validated Reliability and Safety—For energy storage systems to be ubiquitously accepted the technology must be demonstrated to be safe and reliable. This activity's goal is to develop a scientifically derived knowledge base that will improve understanding and predictability, engineer new safer more reliable systems, and ultimately lead to the development of new protocols, codes, and standards for safety and reliability.
- Regulatory Environment—Value propositions for grid storage depend on reducing institutional and regulatory hurdles to levels comparable with those of other grid resources. To accomplish this objective, the Energy Storage program is partnering with Federal, state and municipal entities using analyses of the use of energy storage systems, costs and benefits of energy storage, and development of tools for utility customers and regulatory agencies for planning and implementing the deployment and use of energy storage. This accelerates the community's ability to overcome regulatory hurdles and provides an environment where energy storage deployment and service opportunities are recognized, appropriately valued, and implemented.
- Industry Acceptance—Demonstrating the value, performance, and reliability of energy storage systems in both controlled and fielded deployments is critical to achieving industry acceptance. The Energy Storage program enables confident development, deployment, and operation of grid energy storage through the conduct of controlled testing of prototype commercial storage technologies (such as flow, zinc-nickel, lead-carbon, lithium-ion, and redox flow), through support, facilitation, monitoring, and reporting of results from field demonstrations of grid storage systems, and by development of tools for utility customers and regulatory agencies for planning, deployment, and use of energy storage.

[a] Grid Energy Storage:
http://energy.gov/sites/prod/files/2013/12/f5/Grid%20Energy%20Storage%20December%202013.pdf

Highlights of the FY 2016 Budget Request

Energy storage is a key component of a clean and cost-effective future grid. The FY 2016 request supports work on materials research, device development, demonstrations, and grid analysis. Efforts will be in collaboration with industry, states, and other Federal agencies.

Storage system R&D, which has been successful in developing technology for reducing cost and improving performance, will turn its focus toward new electrochemical systems and improved power conversion technologies. In particular, the electrochemical systems efforts will include new redox-flow battery chemistries where substantial improvements are expected. Work will include organic carbonyl/phenol systems; multi-variant redox couples; lithium, magnesium, and sodium metal–organic hybrids; and zinc-iodine hybrid flow systems that promise some ten times the density of current flow batteries. Research will also include the development of new low-cost sodium metal technologies capable of operating at room temperature (compared to current 250°C) for greater safety. Finally, the second use of EV/PHV batteries will be evaluated for stationary applications through experiments and analysis.

Power conversion systems are a significant cost element of grid-connected battery storage systems. The program will continue to develop advanced wide band gap electronic devices that allow considerable reduction in size as well as expanded operating range increase the overall power conversation efficiency and power density by 30 percent.

Safety and reliability are cornerstones to the acceptance of new technologies. The Energy Storage program, in close collaboration of utilities, vendors, regulatory agencies, and underwriters, will maintain a coordinated series of Stationary Energy Storage Safety and Reliability projects to assess potential failure modes, prepare mitigation measures, and develop guidelines for operation and incident preparedness. This work will maintain DOE's role as a leader in safety and reliability of energy storage and help accelerate invention and deployment.

Widespread deployment of storage would not be possible without standardization and extensive grid-scale testing in test-beds and field trials. OE will continue efforts to establish grid energy storage standards for performance, control interface, and grid interconnection, and to promulgate these standards internationally, to facilitate deployment of U.S. storage technologies domestically and abroad. Collaborative test-bed and field trial evaluation of new storage technologies will be undertaken in collaboration with states, utilities, and storage providers to elucidate storage benefits, integration challenges, and opportunities, and to build confidence regarding the safety and performance of deployed technologies. These activities influence the development of the regulatory environment and accelerate acceptance of these new technologies by industry.

Within the FY 2016 Budget Request, Energy Storage supports the Departmental Grid Modernization crosscut. The Grid crosscut goal is to create tools and technologies that measure, analyze, predict, and control the grid of the future; focus on key policy questions related to regulatory practices, market designs, and business models; and collaborate with stakeholders to test and demonstrate combinations of promising new technologies. The entire Energy Storage program supports this crosscut.

FY 2016 Crosscuts ($K)

	Grid Modernization
Energy Storage	**21,000**

Energy Storage
Funding ($K)

	FY 2014 Enacted	FY 2014 Current[a]	FY 2015 Enacted	FY 2016 Request	FY 2016 vs FY 2015
Energy Storage	**15,192**	**14,706**	**12,000**	**21,000**	**+9,000**

SBIR/STTR:

- FY 2014 Transferred: SBIR: $425; STTR: $61
- FY 2015 Projected: SBIR: $348; STTR: $48
- FY 2016 Request: SBIR: $630; STTR: $95

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

Energy Storage
Explanation of Major Changes ($K)

	FY 2016 vs FY 2015
Increase enables:	**+9,000**

- Expanded efforts on energy storage safety to improve acceptance and speed deployment of storage, including a quarterly Energy Storage Safety Forum for the storage community;
- Initiation of energy storage reliability efforts with stakeholder workshop and research to improve operating lifetimes of energy storage systems;
- Growth of co-funded state and regional energy storage demonstrations to quantify storage performance and develop valuation tools under a wide variety of applications; and
- Acceleration of R&D efforts to advance new battery chemistries with the potential to dramatically improve cost/benefit ratio of storage.

Activities and Explanation of Changes

FY 2015 Enacted	FY 2016 Request	Explanation of Changes FY 2016 vs FY 2015
Energy Storage $12,000,000	**$21,000,000**	**+$9,000,000**
• Maintain development of advanced redox flow batteries (RFB) and selected metal/metal-ion based batteries and license specific technologies to industry. • Initiate research on emerging technologies such as non-aqueous redox battery and Na-based inorganic and organic batteries with potential for lower cost storage systems. • Demonstrate 2nd use EV battery systems for grid application in a realistic field trial. • Continue Grid-scale, test-bed evaluations of industry supplied energy storage systems. • Monitor technical and economic performance data of energy storage demonstration projects constructed under ARRA. • Promote the development of US and international energy storage safety codes and standards efforts.	• Accelerate development of next generation RFBs, with significant potential to provide lower cost systems. • Conduct Grid-scale tests and collaborative field trials with states, utilities, and storage providers, to elucidate energy storage benefits, understand grid integration issues, and implement safety and performance protocols. • Provide enhanced tools and data to U.S. industry for development and use of grid-scale batteries. • Organize a Stationary Energy Storage Reliability workshop with industry, developer, and utility stakeholders. • Demonstrate various capabilities and optimization of Distributed Energy Storage System aggregation in large-scale electrical distribution model. • Develop characterization methods, test procedures, and understanding of failure and degradation phenomena enabling improved design and accelerated aging tests. • Develop industry standards for safety, reliability, testing and evaluation, and promulgation to international standards bodies. • Support and organize quarterly Energy Storage Safety Forum meetings for the energy storage community to increase acceptance of storage technologies. • Continue development of power conversion systems (primarily power electronics) specifically for grid energy storage applications.	• Expanded efforts to ensure the safe design and operation of large-scale storage systems. • Supports industry wide Energy Storage Safety Forum to develop uniform safety standards and identify key scientific developments required to speed adoption of storage technologies. • Expansion of standards beyond battery performance testing to include safety, reliability, grid integration, control logic, and packaging. • Establish Energy Storage Reliability thrust to determine reliability testing criteria, accelerated aging protocols, and understand fundamental degradation mechanisms impacting the useful lifetimes of energy storage systems • Supports additional state and regional demonstrations by providing specific use case analysis and valuation methodologies. • Broadens research into alternate battery chemistries with the potential to offer safer and more cost effective storage solutions. • Expanded testing of advanced power conditioning systems for improved reliability.

FY 2015 Enacted	FY 2016 Request	Explanation of Changes FY 2016 vs FY 2015
	• Perform analysis to select best carbon fiber product for flywheel production and application.	

Energy Storage
Performance Measures

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

	FY 2014	FY 2015	FY 2016
Performance Goal (Measure)	**Energy Storage**—Lower the cost of grid-scale (over 1 MW) energy storage technologies.		
Target	400 $/kWh for a 4 hour system	325 $/kWh for a 4 hour system	300 $/kWh for a 4 hour system
Result	Met		
Endpoint Target	By 2020, improve the cost-benefit ratio of storage to compete with current peak generation resources and increase the commercial use of grid scale storage to buffer renewables to 5 percent.		

Transformer Resilience and Advanced Components

Overview

The Transformer Resilience and Advanced Components (TRAC) program supports modernization and resilience of the grid by addressing the unique challenges facing transformers and other critical components that are responsible for transporting electricity from where it is generated to where it is needed. As the electric power system evolves to enable a more resilient and clean energy future, R&D and testing will be needed to understand the physical impact these changes have on transformers and other vital grid components and to encourage adoption of new technologies and approaches.

Transformers and substation equipment are often exposed to the elements and are vulnerable to natural and man-made threats. To ensure a reliable and resilient power system, grid components need to be designed and built to withstand the impact of lightning strikes, extreme terrestrial or space weather events, electrical disturbances, accidents, equipment failures, and attacks. Currently, 70 percent of large power transformers (LPTs) are 25 years or older, 60 percent of circuit breakers are 30 years or older, and 70 percent of transmission lines are 25 years or older. The age of these components degrade their ability to withstand physical stresses and may result in higher failure rates. Failure of key components can lead to widespread outages and long recovery times. For instance, a single LPT that is damaged can temporarily disrupt power to 500,000 homes and, as a typically custom-designed piece of equipment weighing over 100 tons, it could take up to two years to manufacture and deliver a replacement.

Expanding on existing concerns of ground-induced currents (GIC) from a coronal mass ejection, the TRAC program will address the impact of geomagnetic disturbances (GMD), electromagnetic pulses (EMP), and other physical stressors on transformers and grid components in a systematic and comprehensive manner, in close cooperation with equipment manufacturers and electricity asset owners and operators. Additionally, increased deployment of distributed generation will introduce new challenges with reversed power flows, increased harmonics, and larger fault currents that can impact transformers and other grid components.

Highlights of the FY 2016 Budget Request

This is a new funding line in FY 2016 to focus on transformers. Activities expand upon initial work funded in OE's Infrastructure Security and Emergency Response (ISER) program to monitor and analyze GIC impacts on the electric infrastructure and support power electronics activities.

This area will advance the understanding of risks associated with GMD/EMP and their impact on LPTs, the most critical pieces of equipment in the grid. Induced currents from GMD/EMP can overload LPTs, damaging internal components and increasing failure rates. However, the vulnerability of different types of transformers to GMD/EMP as well as the predictability of GMD phenomena is not well understood.

FY 2016 activities will support the Administration's strategy on resilience and physical security. Working with the National Aeronautics and Space Administration, National Oceanic and Atmospheric Administration, U.S. Geological Survey, National Institute of Standards and Technology, and National Science Foundation, OE will examine transformer failure mechanisms through multi-physics modeling and engaging in reduced- and full-scale physical testing. Assessing mitigation options such as testing of blocking devices, solid state solutions, conducting system-wide analyses, and monitoring GICs will be included.

This program will also address the research opportunities for additional components and power electronics systems identified as critical to the future grid and necessary for increasing system resilience.

Within the FY 2016 Budget Request, TRAC supports the Departmental Grid Modernization crosscut. The Grid crosscut goal is to create tools and technologies that measure, analyze, predict, and control the grid of the future; focus on key policy questions related to regulatory practices, market designs, and business models; and collaborate with stakeholders to test and demonstrate combinations of promising new technologies. The entire TRAC program supports this crosscut.

FY 2016 Crosscuts ($K)

	Grid Modernization
Transformer Resilience and Advanced Components	**10,000**

Transformer Resilience and Advanced Components
Funding ($K)

	FY 2014 Enacted	FY 2014 Current	FY 2015 Enacted	FY 2016 Request	FY 2016 vs FY 2015
Transformer Resilience and Advanced Components	**0**	**0**	**0**	**10,000**	**+10,000**

SBIR/STTR:

- FY 2016 Request: SBIR: $300; STTR: $45

Transformer Resilience and Advanced Components
Explanation of Major Changes ($K)

	FY 2016 vs FY 2015
The FY 2016 request establishes the Transformer Resilience and Advanced Components program to address transformer testing, analysis and solutions.	**+10,000**

Transformer Resilience and Advanced Components

Activities and Explanation of Changes

FY 2015 Enacted	FY 2016 Request	Explanation of Changes FY 2016 vs FY 2015
Transformer Resilience and Advanced Components $0	**$10,000,000**	**+$10,000,000**
• Activities related to GMD impacts on electric infrastructure are included in ISER in FY 2015 (about $60,000).	• Begin modeling and testing of transformers to evaluate vulnerability to GMD/EMP. • Evaluate GMD/EMP mitigation, blocking devices, and solid state solutions. • Continue improvement of GIC monitoring, modeling, and prediction.	• This expanded program will address challenges facing transformers and other critical components.

National Electricity Delivery

Overview

The National Electricity Delivery (NED) program helps states, regional, local and tribal entities to develop, refine, and improve their programs, policies, and laws related to electricity, facilitating the development and deployment of reliable and affordable electricity infrastructure, whether generation, transmission, storage, distribution, or demand side electricity resources.

The electric industry must respond to several major new challenges and opportunities including a changing electric generation mix, replacing aging infrastructure (transmission, storage, distribution, and generation), updating communication networks (e.g., analog to digital), and accommodating new end-use technologies such as distributed resources, planning for increased interdependencies between natural gas, water and electricity systems, and addressing business models that manage these challenges in providing reliable and affordable electricity service. All of this must be balanced against the need for cost control, physical security and cybersecurity, improved or sustained reliability and resiliency, and flexibility to deal with market uncertainties and a changing climate. Additional opportunities exist because of increasing natural gas production from shale and by cheaper information technologies that allow grid operators to better monitor and control the grid and customers to better manage usage.

NED's assistance helps identify approaches that encourage the development and deployment of reliable and affordable electricity infrastructure, whether generation, transmission, storage, distribution, or demand side electricity resources. OE's intent through this work is to support strengthening these individual systems, which in-turn strengthens the entire electricity infrastructure.

The types of technical and policy expertise provided to states, regions, localities and tribal entities spans a wide variety of current and future electricity-related issues, including:

- integrating new technologies (e.g., variable generation, smart grid/demand response, and distributed generation) into electric utility planning and operations and its regulation;
- the effects of increasing shale gas production and reducing base load coal and nuclear generation on utility resource planning and transmission requirements;
- gaining a better understanding of complex interdependencies (e.g., gas/electric and energy/water) germane to electric utility planning and operations and its regulation;
- implementing state renewable and energy efficiency mandates (portfolio and standards);
- new approaches to transmission planning;
- implications for regulation from evolving utility business models;
- management of risk by state electricity regulators and other state officials (e.g., electricity policy uncertainty, changing markets, and extreme weather); and
- the potential effect of Environmental Protection Agency regulations on system reliability.

In addition, NED plays important related roles at the Federal level involving government's role in electricity export authorization and permitting for the construction of transmission infrastructure across international borders; conducting a triennial national transmission congestion study; and helping better coordinate permitting of transmission on Federal lands—the last two in accordance with the Federal Power Act.

These important roles include the responsibility for DOE and interagency coordination on policy matters affecting the power industry. To implement OE's legal responsibilities surrounding the transmission infrastructure, NED carries out a range of activities that include:

- conducting and publishing the triennial *National Transmission Congestion Study*;
- preparing and publishing DOE's annual *Transmission Data Review*
- conducting environmental and technical analyses needed for Federal authorization of transmission projects that cross the Canadian and Mexican borders;
- coordinating Federal permitting by other agencies of new transmission that involves Federal lands, as required by section 216(h) of the Federal Power Act; and

- evaluating applications under Section 1222 of the Energy Policy Act of 2005, which authorizes DOE to participate in third-party-financed transmission projects within the Western Area Power Administration (WAPA) and the Southwestern Power Administration (SWPA) regions.

Highlights of the FY 2016 Budget Request

Provide Expertise to Assist States, Regions, Localities and Tribes

Electricity-Related Laws, Regulations, and Policies

The FY 2016 request supports providing policy expertise and technical assistance, upon request, to state public utility commissions, state legislatures, regional state associations, Governors' offices, localities, and tribes on the implementation of their jurisdictional electricity-related laws, regulations, and policies. These officials sometimes find themselves without sufficient resources to address electricity-related issues of state, regional, and, ultimately, national importance; it is in the national interest to provide targeted assistance on key topics.

Support Transition to Performance-Based Regulation and Alternative Business Models for Utilities

Traditionally, steady growth in electricity demand has enabled utilities to raise the capital needed for new investment. Now, however, many parts of the U.S. are experiencing low growth in electricity sales, due to modest economic growth and continued penetration of energy efficiency and customer-owned generation technologies. At the same time, the need for new infrastructure investment by utilities is increasing to replace aging assets and meet the needs associated with a more complex grid. Since many utilities' revenues are dependent chiefly on electricity sales volume, it can be difficult to finance new investments when revenues are stagnant or declining. Regulators in some states have begun to consider alternative ratemaking concepts and utility business models that link utility revenues to other performance indices, but this is a complex and controversial subject that will require sustained attention and analysis over the next several years. In FY 2016, NED will initiate an expanded effort in this area with exploratory efforts such as workshops and stakeholder discussions to determine how it can best assist regulators and stakeholders.

Assisting States and Others to Develop Long-Term Energy System Reliability Plans

The FY 2016 request supports two independent, but related, activities to facilitate comprehensive long-term plans for reliable and affordable energy infrastructure. First, NED will work with state-based organizations (for example, the National Association of State Energy Officials, Western Governors Association, and National Association of Regulatory Utility Commissioners) to engage public/private energy leaders and other stakeholders to identify best practices for a toolkit for states to use to prepare state energy profiles, needs assessments, long-term energy planning processes and market/policy design work. Technical assistance to customize and apply the toolkit will be supported.

Second, DOE will provide planning grants to states, localities, and tribes for long-term electricity transmission, storage, and distribution reliability planning. This activity is requested under the State Energy Reliability and Assurance Grants program.

Achieve Statutory Objectives

Support for Timely Construction and Efficient Operation of Electric Transmission Capacity

The FY 2016 request supports several statutes designed to facilitate timely construction and efficient operation of transmission capacity:

- drawing attention to areas of the country where transmission congestion is a significant concern with a triennial congestion study; (Section 1221, EPAct 2005) and publication of DOE's annual *Transmission Data Review*;
- facilitating the coordinated review by multiple Federal agencies of permit applications for transmission lines affecting Federal land under the agencies' control; (Section 216 (h), Federal Power Act) and
- issuing Presidential permits for new transmission lines crossing U.S. borders with Canada or Mexico. (Executive Order 10485, as amended by Executive Order 12038)

Completion of Integrated Interagency Pre-application Process for Improved Federal Agency Transmission Permitting

The FY 2016 request continues to support coordination of permitting transmission infrastructure pursuant to section 216(h) of the Federal Power Act, which requires DOE to coordinate Federal permitting for new transmission projects involving Federal lands. In addition, the request builds on the progress made to achieve multi-agency recognition of an Integrated

Interagency Pre-Application (IIP) process for transmission projects requiring Federal authorizations. (As required by a June 7, 2013 Presidential Memorandum, *Transforming our Nation's Electric Grid Through Improved Siting, Permitting, and Review.*)

DOE's implementation of the IIP will be through regulations for revised Federal permitting of transmission infrastructure. Successful IIP implementation will improve coordination among project proponents and Federal agencies prior to formal application submission, leading to better applications and more efficient Federal permitting timelines. NED will also support the continued development of a transmission toolkit, providing valuable information to both project proponents and Federal agencies engaged in transmission permitting.

Support Informed Decision Making

Access to Modeling and Analytical Tools

Decision-making can be better informed by understanding the range of potential futures and their impacts before decisions are made. Expanded analytical tools can better support internal DOE decisions and could be made available to support other decision makers at the state, regional, and Federal levels. These tools can also help manage the complexity of the grid and the additional complexities associated with interdependent infrastructures such as electricity and gas, as well as energy and water. The capability to analyze infrastructure requirements on a range of potential futures is critical as it helps provide solutions to energy transmission infrastructure (e.g., wires and pipes) in a timely manner by quantifying the long-term benefits and costs of constructing long-lived assets, which markets may not adequately signal.

Two recent examples are: 1) NED funded the Western Electricity Coordinating Council, representing the Western Interconnection, to examine grid-water interfaces, and Sandia National Laboratory to create a compatible tool to allow water-energy needs at the county level to be assessed; and 2) NED supported Argonne National Laboratory's development of EZ Mapper, a GIS-based Energy Zone Mapping Tool for use by Eastern states and others to analyze options for shaping deployment of all types of clean energy generation, demand side resources, and corridors for transmission and pipelines. The tool now has over 1,000 registered users.

Analytical tools that can inform regulatory decisions fall into six broad areas: resource adequacy; system planning; grid operations and interactions; valuation of technologies in context of a given system; finance and markets, including rates; and designs and business models. Wherever possible, development of new tools should build on what is currently available and familiar to decision-makers and stakeholders. Tool development should be done making best use of code and capabilities developed for other tools. In FY 2016, NED will work with stakeholders to determine priorities as a first step in supporting tool development, and then work with experts from the national labs, universities, or elsewhere to develop and enhance tools.

Within the FY 2016 Budget Request, NED supports the Departmental Grid Modernization crosscut. The Grid crosscut goal is to create tools and technologies that measure, analyze, predict, and control the grid of the future; focus on key policy questions related to regulatory practices, market designs, and business models; and collaborate with stakeholders to test and demonstrate combinations of promising new technologies. The entire NED program supports this crosscut.

FY 2016 Crosscuts ($K)

	Grid Modernization
National Electricity Delivery	**7,500**

National Electricity Delivery
Funding ($K)

	FY 2014 Enacted	FY 2014 Current	FY 2015 Enacted	FY 2016 Request	FY 2016 vs FY 2015
National Electricity Delivery	**5,997**	**5,997**	**6,000**	**7,500**	**+1,500**

National Electricity Delivery
Explanation of Major Changes ($K)

	FY 2016 vs FY 2015
The increase will strengthen the modeling and analytical tools available to state regulators/policymakers to assist states and others to develop long-term energy system reliability plans.	**+1,500**

Activities and Explanation of Changes

FY 2015 Enacted	FY 2016 Request	Explanation of Changes FY 2016 vs FY 2015
National Electricity Delivery $6,000,000	**$7,500,000**	**+$1,500,000**
• Structure the application requirements, terminology, and decision process for the 216(h), Presidential Permit and Section 1222 programs in a consistent manner to create more efficient reviews for potential applicants. • Complete the Environmental Impact Statement for the Northern Pass cross-border Transmission Line Project. The applicant's proposed project as currently designed, would be capable of transmitting up to 1,200 megawatts (MW) of power in either direction (Canada to U.S. and U.S. to Canada). • Provide technical assistance on electricity-related topics, upon request, to states, public utility commissions, tribes, and other regional and Federal entities. • Continue coordinating and reviewing draft revisions of regulations for Presidential Permits and Export Authorizations. • Revise proposed Integrated Interagency Pre-Application (IIP) Process based on comments from Request for Information in FY 2014. Draft revisions of regulations for better coordination of Federal permitting of transmission infrastructure pursuant to section 216(h).	• Expand suite of tools for grid scenario discussions at the federal, state and local levels. • Provide technical assistance on electricity-related topics, upon request, to states, public utility commissions, tribes, and other regional and Federal entities. • Conduct studies related to Performance Based Regulation (by states) and grid planning in the Eastern and Western Interconnections. • Implement Integrated Interagency Pre-application process to improve Federal permitting of transmission infrastructure pursuant to section 216(h).	• Increase expands institutional support for activities needed to facilitate grid modernization, including strengthening the long-term integrated system reliability modeling and analytical tools available to states and others.

National Electricity Delivery
Performance Measures

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

	FY 2014	FY 2015	FY 2016
Performance Goal (Measure)	**National Electricity Delivery**—Number of states to which the program provides, upon request, assistance in designing and implementing electricity policies, statutes and regulations.		
Target	35 states/tribes assisted	40 states/tribes assisted	50 states/tribes assisted
Result	Met		
Endpoint Target	Increased access to reliable, affordable and sustainable energy sources.		

Infrastructure Security and Energy Restoration

Overview

The Infrastructure Security and Energy Restoration (ISER) program leads national efforts, in cooperation with public and private sector stakeholders (including asset owners and operators), to enhance the reliability, survivability, and resiliency of the U.S. energy infrastructure (electricity, petroleum, and natural gas). The program's goals are to mitigate consumer energy disruptions and drive an efficient restoration process when energy emergencies occur. ISER key partners include industry and states.

The Nation's energy infrastructure is diverse and complex. It includes distributed networks, varied system structures (electricity, oil, and natural gas), operating models (public and private), and systems in both the physical space and cyberspace. The energy sector consists of thousands of electricity, oil, and natural gas assets that are geographically dispersed and provide for all nationally important systems and networks. Therefore, interdependency within the sector and across the Nation's critical infrastructure sectors is significant. Coordinating the security and resilience of energy assets is complicated by the borderless nature of energy and reliance on predominately privately-owned infrastructure. Unlike other sector specific agencies that have directive or regulatory authorities, ISER relies on public-private partnerships to facilitate efforts upgrading, restoring, or securing critical energy infrastructure. While ISER's primary responsibility is to help secure the U.S. energy infrastructure against all hazards, reduce the impact of disruptive events, and assist industry in quickly restoring energy, it also develops incident management tools and applies new technologies to enhance ISER capabilities for prevention, mitigation, response and recovery. In addition, ISER's efforts with state and local governments, responding to and recovering from energy disruptions, ensure seamless collaboration at all levels. In an effort to maximize its capabilities within an efficient framework, ISER aligns all of its activities under three focus areas:

- executing effective emergency preparedness, response, and restoration operations;
- providing reliable energy infrastructure tactical analysis (event analysis) and situational awareness to all stakeholders; and
- encouraging a risk-based approach to energy system assurance.

ISER provides long-term strategic actions to help secure the U.S. energy supply by addressing topics like high-impact, low-frequency (HILF) events. The ISER program continues to identify potential technical solutions and suppliers of prevention and mitigation technologies. Opportunities are also sought to facilitate the seamless integration of advanced technologies into an operational framework.

Upon request, ISER also provides technical assistance to international partners, in collaboration with U.S. Department of State, to analyze and secure energy assets. It conducts an initial engineering assessment to provide expert advice to key energy producing allies on securing their critical infrastructure, with any further international assistance provided on a cost reimbursable basis.

ISER approaches its responsibilities through the following major focus areas:

<u>Emergency Preparedness, Response, and Restoration</u>

- Influences national policy to better prepare for emergencies and improves mobilization of response teams, made up of Regional Coordinators and Voluntary Responders, to ensure rapid and coordinated response with Federal partners, affected states, and energy sector leaders.
- Defines prevention, protection, mitigation, response, and recovery options for existing, newly identified, and evolving threats.
- Conducts national and regional-level exercises, workshops, and forums to enhance information sharing with Federal, state, and industry partners in support of national preparedness mission areas (prevention, protection, mitigation, response, and recovery).
- Works closely with energy partners to enhance system preparedness, plan and conduct exercises, understand supply chain issues, and identify and implement mitigation solutions and lessons learned across the energy system.
- Provides the Secretary of Energy and key Federal agencies with situation awareness of the critical energy infrastructure and key resources, including the operational status of the system, the supply and delivery of energy and fuels (including electricity, oil, natural gas, coal, and other types of fuels), and near-term threat information provided by the U.S. intelligence community.

- Supports responses to energy emergency events including physical security events, wildfires, winter storms, fuel shortages, national security events, storms, and typhoons. ISER responded to 24 events during 2014.

Tactical Analysis and Situational Awareness

- Provides information to the public on the status of energy infrastructure and briefs senior government officials, the White House, and Congress.
- Provide Federal leadership and technical guidance by publishing analytic reports on issues of concern impacting the energy sector.
- Maintains energy system data sets to support impact projection prior to events, improves awareness of actual system impacts to support response operations, and facilitates the assessments of system conditions and influences in post-event forensics.

Energy Assurance

- Provides assistance to the states by working toward a standardized, comprehensive energy assurance and resilience approach that benefits localities, states, and the Nation. Objectives include gaining understanding of state and local needs; education and training on priority issues; assistance in building collaborative partnerships; provision of tools, templates, resource materials, and lessons learned from exercises and incidents; and promotion and facilitation of coordination and sharing of information including best practices.
- As the Energy Sector-Specific Agency (SSA), coordinates with private- and public-sector partners to take proactive steps to manage risk and strengthen the security and resilience of the Nation's critical energy infrastructure, provides technical assistance and consultations, and supports innovation of technology and strategies across the energy sector.
- Monitors and facilitates the exchange of actionable information with industry partners on new and evolving threats, vulnerabilities, and mitigation options. These exchanges are vital to the economy and public safety, and key stakeholders have come to rely upon them.
- Manages and coordinates the Department's activities under the 2010 DOE–DOD Energy Security Memorandum of Understanding (MOU). The MOU has led to several high-profile collaborations between the Departments to enhance national energy security and provide Federal leadership in transforming the U.S. energy system.

Highlights of the FY 2016 Budget Request

The FY 2016 budget request funds ISER activities necessary to continue executing emergency preparedness, response, and restoration missions while taking an all-hazards approach.

To further strengthen OE's ability to secure the U.S. energy infrastructure, the request continues to support the development of advanced mitigation solutions for hardening infrastructure against all hazards, natural and man-made. The primary focus will continue to be on those hazards posing the greatest risk to the Nation's energy infrastructure, including HILF events and more frequent physical threats such as devastating weather events. The request supports the development of technical specifications and other capabilities for security systems for high valued, critical energy infrastructure sites. It will also continue to fund the Department's engagement with private/public partners as part of the Energy SSA responsibilities.

The FY 2016 request will enable ISER to expand its strategy to build and sustain preparedness in light of new challenges that affect the Nation's critical energy infrastructure and systems by conducting site exercises. Challenges include more frequent, stronger, and more destructive weather events; increasing incidents of physical attacks; potential accidents as a result of aging infrastructure or human error; HILF threats such as a catastrophic earthquake and extended droughts; and the continuing cyber threat. These challenges are amplified by the increasing complexity of the energy infrastructure and systems and the interdependencies affecting other critical industries.

This strategy will increase the breadth and number of energy emergency preparedness exercises and those participating by expanding the focus to address physical security, energy cybersecurity, and HILF events impacting the energy critical assets. The request will also support energy-focused exercises for state, local, tribal and territorial entities to assess and strengthen their Energy Assurance Plans.

ISER will continue to provide reliable energy infrastructure tactical analysis and situational awareness to all stakeholders. The FY 2016 funding will also support activities that promote a risk-based approach to energy systems assurance with all

stakeholders, and further strengthen OE's monitoring and visualization capabilities. Those capabilities will be available for integration into a Department of Energy Response and Operations Center. (DOE-ROC)

The FY 2016 request will contribute to the Department's construction of a DOE-ROC. The request will also maintain OE's efforts at the DOE-ROC and the continued development and maintenance of real-time monitoring, visualization, and information sharing capabilities for the Department. The DOE-ROC, located within DOE's Washington, D.C. headquarters, will continue to be a steady-state operations center, where the Department monitors, receives and analyzes real-time threat and energy sector status and coordinates and shares this information with all energy sector stakeholders. During emergencies, the DOE-ROC will serve as the collaboration hub for DOE, other Federal agencies, and energy sector partners, including critical infrastructure owners and operators, and will be responsible for status and information sharing between DOE and other emergency operation centers (Federal and state) during emergencies. The DOE-ROC will fully support the continued presence of DOE's deployed Emergency Support Function 12 (ESF 12) personnel at the National Response Coordination Center, as well as applicable Regional Response Coordination Centers during events. The goal of OE's efforts through the DOE-ROC is to ensure faster restoration and recovery of energy infrastructure systems after disruptions. The OE Program Direction budget additionally includes 10 new FTEs who directly support incident response and recovery in the field in support of the ISER program.

Energy-Focused Preparedness Exercises

The FY 2016 request will enable ISER to develop and execute a strategy to build and sustain preparedness in light of the challenges that affect the Nation's energy infrastructure and systems as well as the independencies of all critical infrastructure with the energy sector.

This strategy will allow for a programmatic approach to a test, training, and exercise (TT&E) effort guided by a policy outlining the organization's internal and external requirements associated with training personnel, exercising plans, and testing activities and procedures. It will also Identify TT&E roles and responsibilities, establish an overarching TT&E schedule, and document the TT&E methodology, including design, development, conduct, and evaluation of TT&E events cumulating in a Corrective Action Program to document and track improvement plans and actions. The strategy will also increase the scope and number of energy focused exercises and those participating by expanding the focus to align with the core capabilities and all hazards methodology directed in the National Preparedness Goal as provided for by PPD-8, "National Preparedness."

Beginning in FY 2015, ISER is implementing the recommendation of the National Petroleum Council report on Emergency Preparedness, which included an extensive and progressive TT&E program to improve communications and information sharing between industry and the government both before and during significant emergency incidents. The request will appropriately support these government/industry efforts as well as supporting energy-focused exercises for state, local, tribal, and territorial entities to assess and strengthen their Energy Assurance Plans.

Additional Information:

- Presidential Policy Directive (PPD) 8, *National Preparedness*: http://www.dhs.gov/xabout/laws/gc_1215444247124.shtm
- PPD 21, Critical Infrastructure Security and Resilience: http://www.whitehouse.gov/the-press-office/2013/02/12/presidential-policy-directive-critical-infrastructure-security-and-resil
- Department of Homeland Security, National Infrastructure Protection Plan: http://www.dhs.gov/nipp
- National Mitigation Framework: http://www.fema.gov/media-library-data/20130726-1914-25045-9956/final_national_mitigation_framework_20130501.pdf
- National Response Framework: http://www.fema.gov/pdf/emergency/nrf/nrf-core.pdf
- National Disaster Recovery Framework: http://www.fema.gov/pdf/recoveryframework/ndrf.pdf
- National Protection Framework: https://s3-us-gov-west-1.amazonaws.com/dam-production/uploads/1406717583765-996837bf788e20e977eb5079f4174240/FINAL_National_Protection_Framework_20140729.pdf

Within the FY 2016 Budget Request, ISER supports the Departmental Grid Modernization crosscut. The Grid crosscut goal is to create tools and technologies that measure, analyze, predict, and control the grid of the future; focus on key policy questions related to regulatory practices, market designs, and business models; and collaborate with stakeholders to test and demonstrate combinations of promising new technologies. The entire ISER program supports this crosscut.

FY 2016 Crosscuts ($K)

	Grid Modernization
Infrastructure Security and Energy Restoration	**14,000**

Infrastructure Security and Energy Restoration
Funding ($K)

	FY 2014 Enacted	FY 2014 Current	FY 2015 Enacted	FY 2016 Request	FY 2016 vs FY 2015
Infrastructure Security and Energy Restoration					
Infrastructure Security and Energy Restoration	5,997	5,997	6,000	14,000	+8,000
Operational Energy and Resilience[a]	1,999	1,999	0	0	0
Total, Infrastructure Security and Energy Restoration	**7,996**	**7,996**	**6,000**	**14,000**	**+8,000**

[a] In FY 2015 and 2016, OER-related work is funded within the base Infrastructure Security and Energy Restoration program.

Infrastructure Security and Energy Restoration
Explanation of Major Changes ($K)

	FY 2016 vs FY 2015
Increase to ISER base program:	**+2,000**
• Continue to develop and implement sensor technologies and other procedural enhancements to address geomagnetic disturbances and the potential impact on grid resiliency through the information sharing/visualization portal for the geomagnetically induced current (GIC) nodes deployed for the SUNBURST program. • Develop data collection and analytical processes for these specific sensor technologies.	
Conduct a series of regional energy assurance training workshops to assess state and local governments' response to energy events.	**+3,000**
Contribute to the DOE-ROC to create an operational environment with the technology, methods, and tools to enable analysts to, in real time, monitor, simulate, and track energy disruptions	**+3,000**
• Enhance operational capability in the DOE-ROC, including continuous development and maintenance of monitoring, visualization and information sharing capabilities • Lay the groundwork for a pro-active, Infrastructure Hardening and Resiliency effort through direct engagement with Industry and states, identifying focused mitigation solutions and addressing any impediments to implementation. • Enhancements to the Eagle-I situational awareness tool. • Plan and conduct joint Industry and Government tests, training, and exercise events, including states as appropriate. • Develop a Physical Security Capability and Maturity Model (PSCM2).	
Total, Infrastructure Security and Energy Restoration	**+8,000**

Activities and Explanation of Changes

FY 2015 Enacted	FY 2016 Request	Explanation of Changes FY 2016 vs. FY 2015
Infrastructure Security and Energy Restoration		
$6,000,000	**$14,000,000**	**+$8,000,000**
• Train 100 percent of Regional Coordinators and 80 percent of Voluntary Responders on regional energy infrastructure; test training by participating in National Level Exercise 2015. • Facilitate the necessary actions to bring together key oil and natural gas stakeholders for the establishment of an ISAC-like structure for information sharing and dissemination. • Develop a structure for sharing physical security awareness of suspicious incidents, information alerts, and analysis at the local, regional, and federal level in coordination with the Electricity Subsector Coordinating Council. • Develop improved U.S.-wide ground conductivity map, including comparisons of the effectiveness of using 3-dimensional models at coastal boundaries. • Support development of Equipment Monitoring Applications using Phasor Measurement Units (PMU). • Develop technical specs for security systems for high valued, critical energy infrastructure sites. • Continue implementation of National Preparedness and Critical Infrastructure Security and Resilience mandates and the coordination of other national energy preparedness policies. • Serve on the National I-MAT teams during an emergency, as required.	• Train 100 percent of Regional Coordinators and 85 percent of Voluntary Responders on regional energy infrastructure; test training by participating in National Level Exercise 2016 and selected Regional Exercises. • Continue implementation of National Preparedness and Critical Infrastructure Security and Resilience mandates and the coordination of other national energy preparedness policies. • Develop a Physical Security Capability and Maturity Model (P2CM2) and perform PSCM2 Assessments. • Support NERC Reliability Standard to Enhance Physical Security Measures. • Continue development of technical specifications for security systems for high valued, critical energy assets. • Facilitate the necessary actions to expand the Oil and Natural Gas ISAC (expected to be created by industry in FY 2015) from cyber-focus to all-hazards focus. • Continue to support development of Equipment Monitoring Applications using PMUs. • Increase the breadth and number of energy emergency preparedness exercises by expanding focus to address all hazards impacting the energy critical assets. In addition the request will support energy-focused exercises for state, local, tribal and territorial entities to assess and strengthen their Energy Assurance Plans.	• Increased funding supports expanded energy-focused exercises to improve local, state and regional preparedness. • FY 2016 funding supports general operations and maintenance costs of the operations center.

FY 2015 Enacted	FY 2016 Request	Explanation of Changes FY 2016 vs. FY 2015
	• Support the Department's construction of a DOE-ROC and continued development of a new generation of real-time monitoring, visualization and situation awareness capability. • Continue to enhance the DOE-ROC's ability of receiving multiple and disparate near real-time data feeds, simultaneously visualizing and overlaying over the impacted area, so that decision makers can appropriately respond. • Leverage on physical security work identified in ISER subprogram to identify efficient ways to monitor and develop appropriate situational awareness capabilities. • Increase the ability for the monitoring and visualization technology to rapidly adapt, when possible, to new emerging threats. • Providing mitigation solutions through enhanced awareness of infrastructure interdependencies and supply chain that impact energy assurance through a regional risk assessment focused on threats and gaps. • Conducting a series of regional energy assurance training workshops using the state Energy Assurance Plans to assess state and local governments' response to energy events including fuel resiliency. • Providing risk management support to strengthen the security and response to critical energy infrastructure. • Validate analysis of the geoelectric field and GIC calculations through study of a few historically large, well-observed geomagnetic storms and comparison with storm-time GIC measurements, followed by detailed validation for 5–10 locations.	

FY 2015 Enacted	FY 2016 Request	Explanation of Changes FY 2016 vs. FY 2015
	• Install variometers at sites specifically targeted to GIC analysis and monitoring to better understand vulnerability of transformers to geomagnetic disturbances.	

Infrastructure Security and Energy Restoration
Performance Measures

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

	FY 2014	FY 2015	FY 2016
Performance Goal (Measure)	**Infrastructure Security and Energy Restoration**—Improve awareness of near real-time monitoring situational awareness tool, across the Federal Government ensuring that this tool is available to interagency partners for use in their operations centers and other appropriate situations.		
Target	45% situational awareness capability availability	60% situational awareness capability availability	70% situational awareness capability availability
Result	Met		
Endpoint Target	Maintain the availability to near-real time energy situational awareness tools to interagency partners at greater than 90%.		

State Energy Reliability and Assurance Grants

Overview

State Energy Reliability and Assurance Grants is a new program in FY 2016 providing grants to states, localities, regions, and tribal entities (or groups of states and tribes). Under the programmatic heading are two new distinct grant programs: Grants for Electricity Transmission, Storage, and Distribution Reliability and Grants for Energy Assurance. States have significant jurisdiction over the electricity system and are excellent test beds for the evolution of the electric power system and, with federal support, can provide innovative ways to address new trends through more coordinated and efficient processes that allow the electric sector to reliably provide services that meet environmental, resiliency, efficiency, and energy assurance goals. Processes are in place for reliability, resiliency, efficiency and environmental planning and actions; however, they need to be integrated across programs within states and across states, and adequately funded. DOE has a long history of providing technical assistance to states on reliability, climate resiliency, energy and environmental planning and action. The Department is uniquely positioned to facilitate the coordination of these planning processes within states and across state lines.

Grants for Electricity Transmission, Storage, and Distribution Reliability

In FY 2016, an Electricity Transmission, Storage, and Distribution Reliability planning grants program is proposed to finance state, local, regional and tribal entities and including multi-state cooperation, to advance electric reliability planning and integrate it with environmental protection (including climate mitigation), climate resilience, and efficiency infrastructure planning and action. Building on a history of success working with states and leveraging previous technical support to states for planning tools development, DOE will provide planning grants to promote and integrate electricity reliability, efficiency, renewable energy, environmental protection (including climate adaptation), and climate resiliency planning and action.

The grants will be used for several activities germane to long-term electricity system reliability planning, including:

- integrating planning and action for transmission, storage, and distribution reliability, climate resiliency and environmental compliance;
- planning for the increasing interdependencies of electricity, natural gas and water systems;
- identifying and implementing regulatory reforms to enable transmission, storage and distribution investments that address the challenges and take advantages of the opportunities, including reforms to enable distributed generation and energy efficiency;
- developing climate resiliency metrics;
- identifying and planning upgrades of infrastructure to make it more resilient to climate change and extreme weather;
- developing incentives and enabling cost recovery for reliability and climate resiliency investments;
- collecting and sharing data on transmission, storage and distribution cost, environmental impacts, resiliency, reliability, and flexibility;
- valuing the availability of resources; and
- fostering multi-state cooperation.

The Nation’s energy infrastructure is undergoing a sweeping transformation. New technologies and changes in electricity flows including increased use of distributed resources, Internet-enabled demand response technologies, growing electric vehicle deployment, dramatic expansion of natural gas use, and integration of energy storage are placing increasing demands on the electric grid. Therefore, a more proactive and comprehensive approach to state energy market and policy designs is needed to address system interdependencies and scale up renewable integration.

Within the FY 2016 Budget Request, State Energy Reliability and Assurance Grants supports the Departmental Grid Modernization crosscut. The Grid crosscut goal is to create tools and technologies that measure, analyze, predict, and control the grid of the future; focus on key policy questions related to regulatory practices, market designs, and business models; and collaborate with stakeholders to test and demonstrate combinations of promising new technologies. Within State Energy Reliability and Assurance Grants, the Grants for Electricity Transmission, Storage, and Distribution Reliability program supports this crosscut.

FY 2016 Crosscuts ($K)

	Grid Modernization
State Energy Reliability and Assurance Grants	**27,500**

Grants for Energy Assurance

DOE's Energy Assurance planning work is aimed at improving the capacity of states, localities, and tribes to identify the potential for energy disruptions, quantify the impacts of those disruptions, and develop comprehensive plans responding to those disruptions and mitigating the threat of future disruptions. Building upon DOE's work across the states and U.S. territories, including the District of Columbia, on energy assurance planning, lessons learned include that energy assurance plans should be continually updated and exercised annually to reflect changing conditions and new threats and to maintain staff capacity to implement the plans. The new grant program will provide formula grants for states, local and tribal governments to update their energy assurance plans; require testing, training, and exercises; and ensure that plans and assessments are shared.

The goal of state and local energy assurance planning is to achieve a robust, secure, and reliable energy infrastructure that is also resilient—better able to withstand catastrophic events, able to restore services rapidly in the event of any disaster, and designed to diminish future vulnerabilities. The Federal government can help states and local governments—who are ultimately responsible for responding to disasters and disruptions—by building and maintaining preparedness and assurance capabilities.

The grants will be used for several activities relevant to short- and long-term energy assurance preparedness and planning:

- Creating and sustaining in-house expertise at the state and local level on energy assurance planning and resiliency, focusing on smart grid, critical infrastructure, interdependencies, cyber security, energy supply systems, energy data analysis, long-term risk and hazard identification and mitigation, and communications.
- Designating energy emergency assurance personnel.
- Developing new or refining existing Energy Assurance Plans to incorporate response actions to new energy portfolios, including smart grid technologies, infrastructure hardening, transportation fuel diversification, energy efficiency, distributed energy technologies, and other risk mitigation measures.
- Establishing energy emergency procedures that address multiple interdependencies across lifeline sectors (e.g., food, housing, and shelter).
- Revising appropriate policies, procedures, and practices to reflect the Energy Assurance Plans. States, localities and tribes should append the Energy Assurance Plan to the state energy plan and state hazard mitigation plan, as appropriate.
- Developing or refining a process or mechanism for tracking the duration, response, restoration and recovery time of energy supply disruption events, to include, as examples: contingency plans to ameliorate shortages of delivered fuels (e.g., propane, heating fuel, wind, natural gas); and contingency plans to accommodate interdependencies with associated sectors (e.g., telecommunications, health, and transportation).
- Training appropriate personnel on energy infrastructure and supply systems and the content and execution of energy assurance plans.
- Conducting energy emergency exercises (intra- and inter-state) to evaluate the effectiveness of the Energy Assurance Plans and to demonstrate coordination and communication strategies across government and industry and energy and interdependent sectors.
- Incorporating physical and cyber security measures and related guidance for critical energy and interdependent sectors
- Requiring annual updates to state, local and industry contacts lists.
- Leveraging other efforts such as fusion centers and regional planning and information-sharing groups to share information between state/Federal governments and the private sector to reduce risks

In FY 2016, a Grants for Energy Assurance program is proposed to finance state, local, and tribal governments to enhance resiliency through energy assurance planning and the test of, training to, and exercising of those plans. In support of these grants, ISER will continue to use its convening power to provide a forum for information and data sharing, which is critical to energy system resiliency. ISER will also engage other relevant agencies to ensure state energy assurance plans interface with state and local disaster and emergency response plans, private sector response plans, and the plans of neighboring states.

State Energy Reliability and Assurance Grants
Funding ($K)

	FY 2014 Enacted	FY 2014 Current	FY 2015 Enacted	FY 2016 Request	FY 2016 vs FY 2015
State Energy Reliability and Assurance Grants					
Grants for Electricity Transmission, Storage, and Distribution Reliability	0	0	0	27,500	+27,500
Grants for Energy Assurance	0	0	0	35,500	+35,500
Total, State Energy Reliability and Assurance Grants	**0**	**0**	**0**	**63,000**	**+63,000**

State Energy Reliability and Assurance Grants
Explanation of Major Changes ($K)

	FY 2016 vs FY 2015
Grants for Electricity Transmission, Storage, and Distribution Reliability: The increase will provide grants to states and others to develop energy system reliability plans to advance electric reliability planning and integrate it with environmental protection (including climate adaptation), climate resiliency, and efficiency infrastructure planning and action. The plans would require cooperation among energy offices, state public utility commissions, environmental regulators, and others within each state, with their counterparts in other states, and with their reliability coordinators. Multi-state (and/or tribal) cooperation will be encouraged. State electricity reliability planning would include evaluation of transmission, storage, and distribution infrastructure necessary for managing new or retiring generation, planning for the increasing interdependencies of natural gas and electricity systems, and accounting for climate change and extreme weather risks in infrastructure investments.	**+27,500**
Grants for Energy Assurance: Provide formula grants to state, local, and tribal governments to enhance resiliency through energy assurance planning, compliance, and training, including exercises.	**+35,500**
Total, State Energy Reliability and Assurance Grant Program	**+63,000**

State Energy Reliability and Assurance Grants

Activities and Explanation of Changes

FY 2015 Enacted	FY 2016 Request	Explanation of Changes FY 2016 vs. FY 2015
Grants for Electricity Transmission, Storage, and Distribution Reliability $0	**$27,500**	**+$27,500**
	• Provide grants to assist states and others to develop long-term energy system reliability plans that advance electric reliability planning and integrate it with planning and action for environmental protection, climate resiliency, and energy efficiency.	• This is a new activity in FY 2016.
Grants for Energy Assurance $0	**$35,500**	**+$35,500**
	• Provide energy assurance grants to improve the capacity of states, localities, and tribal governments to enhance resiliency through energy assurance planning, compliance, and training, including exercises.	• This is a new activity in FY 2016.

Program Direction

Overview

Program Direction funds the costs associated with the Federal workforce, including salaries, benefits, travel, training, building occupancy, IT services, and other related expenses. It also provides for the costs associated with contractor services that, under the direction of the Federal workforce, support OE's mission.

Salaries and Benefits support 128 FTEs who provide executive management, programmatic oversight, and analysis for the effective implementation of the OE program. 29 of the FTEs supporting and funded by OE are employees of the Office of Fossil Energy (FE) located at the National Energy Technology Laboratory (NETL) and are included in FE's FTE totals. The remaining 99 FTEs are located in DOE headquarters and are OE employees.

The funding increase in FY 2016 Program Direction supports the addition of 16 FTEs. 10 of the new FTEs directly support incident response and recovery in the field in support of the ISER program. 4 of the FTEs will provide real-time monitoring, analytics, and information sharing in support of the Department of Energy Response and Operations Center (DOE-ROC). The remaining 2 FTEs will provide support for the new state grant activities proposed in the 2016 request.

Travel includes transportation, subsistence, and incidental expenses that allow OE to effectively manage research and development programs and projects in the field; to provide the Department's electricity-related outreach to regions, states, and tribes with regard to planning needs and issues, policies, siting protocols and new energy facilities; and to assist the Department of Homeland Security, the Department of State and local governments, and the private sector to help protect against and recover from disruptions in the energy infrastructure through ISER.

Support Services include contractor support directed by the Federal staff to perform administrative tasks and provide analysis to management. These efforts include such needs as issue-oriented support on science, engineering, environment, and economics that benefit strategic planning; technology and market analysis to improve strategic and annual goals; development of management tools and analyses to improve overall Office efficiency; assistance with communications and outreach to enhance OE's external communication and responsiveness to public needs; development of program-specific information tools that consolidate corporate knowledge, performance tracking and inventory data, improve accessibility to this information, and facilitate its use by the entire staff; and also may include support for post-doctoral fellows (e.g., AAAS fellows) and Intergovernmental Personnel Act (IPA) assignments.

Other Related Expenses includes corporate IT support and Working Capital Fund expenses, such as rent, supplies, copying, graphics, mail, printing, and telephones. It also includes equipment upgrades and replacements, commercial credit card purchases using the simplified acquisition procedures to the maximum extent possible, and other needs.

Highlights of the FY 2016 Budget Request

The funding request for Program Direction provides for implementation and oversight of the range of program activities in support of OE's critical mission. Program Direction reflects a funding increase to support 16 additional Federal personnel.

Program Direction
Funding ($K)

	FY 2014 Enacted	FY 2014 Current	FY 2015 Enacted	FY 2016 Request	FY 2016 vs FY 2015
Program Direction Summary					
Washington Headquarters					
Salaries and Benefits	12,871	12,871	13,092	16,001	+2,909
Travel	650	650	650	715	+65
Support Services	2,906	2,906	2,905	3,292	+387
Other Related Expenses	4,241	4,241	4,214	5,467	+1,253
Total, Washington Headquarters	**20,668**	**20,668**	**20,861**	**25,475**	**+4,614**
National Energy Technology Laboratory					
Salaries and Benefits	5,890	5,890	5,700	5,720	+20
Travel	300	300	300	350	+50
Support Services	500	500	500	655	+155
Other Related Expenses	248	248	245	400	+155
Total, National Energy Technology Laboratory	**6,938**	**6,938**	**6,745**	**7,125**	**+380**
Total Program Direction					
Salaries and Benefits	18,761	18,761	18,792	21,721	+2,929
Travel	950	950	950	1,065	+115
Support Services	3,406	3,406	3,405	3,947	+542
Other Related Expenses	4,489	4,489	4,459	5,867	+1,408
Total, Program Direction	**27,606**	**27,606**	**27,606**	**32,600**	**+4,994**
Federal FTEs	**80**	**80**	**83**	**99**	**+16**
Additional FE FTEs at NETL supporting OE[a]	31	31	29	29	0
Total OE-funded FTEs	111	111	112	128	+16

[a] OE funds 29 FTEs at FE's National Energy Technology Laboratory who support OE activities. The 29 FTEs are in FE's FTE totals and are not included in the OE FTE totals shown on the "Federal FTEs" line.

	FY 2014 Enacted	FY 2014 Current	FY 2015 Enacted	FY 2016 Request	FY 2016 vs FY 2015
Support Services					
Technical Support	1,317	1,317	1,318	1,580	+262
Management Support	2,089	2,089	2,087	2,367	+280
Total, Support Services	**3,406**	**3,406**	**3,405**	**3,947**	**+542**
Other Related Expenses					
Other Support Services	855	855	855	1,260	+405
DOE/CO	500	500	500	700	+200
Working Capital Fund (WCF)	3,134	3,134	3,104	3,907	+803
Total, Other Related Expenses	**4,489**	**4,489**	**4,459**	**5,867**	**+1,408**

Activities and Explanation of Changes

FY 2015 Enacted	FY 2016 Request	Explanation of Changes FY 2016 vs FY 2015 Enacted
Program Direction $27,606,000	**$32,600,000**	**+$4,994,000**
Salaries and Benefits $18,792,000	**$21,721,000**	**+$2,929,000**
Salaries and Benefits support 112 FTEs at HQ and NETL that provide executive management, programmatic oversight, and analysis for the effective implementation of the OE program.	Salaries and Benefits support 128 FTEs at HQ and NETL that provide executive management, programmatic oversight, and analysis for the effective implementation of the OE program.	Increase reflects 16 FTEs supporting new state grant activities and incident response and recovery in support of the ISER program.
Travel $950,000	**$1,065,000**	**+$115,000**
Travel includes transportation, subsistence, and incidental expenses that allow OE to effectively facilitate its mission.	Travel includes transportation, subsistence, and incidental expenses that allow OE to effectively facilitate its mission.	The increase for travel supports OE's mission work, including the expanded resiliency efforts.
Support Services $3,405,000	**$3,947,000**	**+$542,000**
Support Services includes contractor support directed by the Federal staff to perform administrative tasks and provide analysis to management. Support Services may include support for post-doctoral fellows and Intergovernmental Personnel Act (IPA) assignments.	Support Services includes contractor support directed by the Federal staff to perform administrative tasks and provide analysis to management. Support Services may include support for post-doctoral fellows and IPA assignments.	The increase in supports services is due to escalation of management and technical support related to the increase in FTEs.
Other Related Expenses $4,459,000	**$5,867,000**	**+$1,408,000**
Other Related Expenses includes corporate IT support and working capital expense, such as rent, supplies, copying, graphics, mail, printing, and telephones. It also includes equipment upgrades and replacements, commercial credit card purchases using the simplified acquisition procedures to the maximum extent possible, and other needs.	Other Related Expenses includes corporate IT support and working capital expense, such as rent, supplies, copying, graphics, mail, printing, and telephones. It also includes equipment upgrades and replacements, commercial credit card purchases using the simplified acquisition procedures to the maximum extent possible, and other needs.	Increase primarily reflects growth in Working Capital Fund requirements due to an increase of 16 FTEs in FY 2016.

Electricity Delivery and Energy Reliability
Research and Development ($K)

	FY 2014 Current[a]	FY 2015 Enacted	FY 2016 Request	FY 2016 vs FY 2015
Basic	3,846	6,208	5,100	-1,108
Applied	55,885	54,264	59,660	+5,396
Development	32,129	32,696	52,040	+19,344
Total, R&D	91,860	93,168	116,800	+23,632

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

Electricity Delivery and Energy Reliability
Small Business Innovative Research/Small Business Technology Transfer (SBIR/STTR) ($K)

	FY 2014 Transferred	FY 2015 Projected	FY 2016 Request	FY 2016 vs FY 2015
Clean Energy Transmission and Reliability				
SBIR	795	814	990	+176
STTR	114	112	149	+37
Smart Grid Research and Development				
SBIR	409	448	900	+452
STTR	58	62	135	+73
Cybersecurity for Energy Delivery Systems				
SBIR	1,028	1,092	900	-192
STTR	147	151	135	-16
Energy Storage				
SBIR	425	348	630	+282
STTR	61	48	95	+47
Transformer Resilience and Advanced Components				
SBIR	0	0	300	+300
STTR	0	0	45	+45
Total, SBIR	**2,657**	**2,702**	**3,720**	**+1,018**
Total, STTR	**380**	**373**	**559**	**+186**

Electricity Delivery and Energy Reliability	FY 2014 Current	FY 2015 Enacted	FY 2016 Request
Ames Laboratory			
Electricity Delivery and Energy Reliability			
Clean Energy Transmission and Reliability	100	0	0
Cybersecurity for Energy Delivery Systems	0	50	0
Total, Electricity Delivery and Energy Reliability	**100**	**50**	**0**
Total, Ames Laboratory	**100**	**50**	**0**
Argonne National Laboratory			
Electricity Delivery and Energy Reliability			
Clean Energy Transmission and Reliability	2,085	1,525	1,691
Smart Grid	300	1,200	1,720
Cybersecurity for Energy Delivery Systems	2,037	100	300
National Electricity Delivery	420	171	100
Total, Electricity Delivery and Energy Reliability	**4,842**	**2,996**	**3,811**
Total, Argonne National Laboratory	**4,842**	**2,996**	**3,811**
Brookhaven National Laboratory			
Electricity Delivery and Energy Reliability			
Clean Energy Transmission and Reliability	250	0	0
Smart Grid	0	351	0
Infrastructure Security & Energy Restoration	0	50	50
Cybersecurity for Energy Delivery Systems	0	50	0
Total, Electricity Delivery and Energy Reliability	**250**	**451**	**50**
Total, Brookhaven National Laboratory	**250**	**451**	**50**
Chicago Operations Office			
Electricity Delivery and Energy Reliability			
Clean Energy Transmission and Reliability	75	0	0
Total, Chicago Operations Office	**75**	**0**	**0**
Idaho National Laboratory			
Electricity Delivery and Energy Reliability			
Clean Energy Transmission and Reliability	0	0	100
Smart Grid	0	0	350
Energy Storage	0	500	0
Cybersecurity for Energy Delivery Systems	5,819	5,050	1,300
Transformer Resilience and Advanced Components	0	0	5,000
Total, Electricity Delivery and Energy Reliability	**5,819**	**5,550**	**6,750**
Total, Idaho National Laboratory	**5,819**	**5,550**	**6,750**

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($K)

Electricity Delivery and Energy Reliability	FY 2014 Current	FY 2015 Enacted	FY 2016 Request
Lawrence Berkeley National Laboratory			
Electricity Delivery and Energy Reliability			
Clean Energy Transmission and Reliability	3,070	3,900	4,450
Smart Grid	350	655	1,800
Infrastructure Security & Energy Restoration	0	50	50
Energy Storage	0	50	0
Cybersecurity for Energy Delivery Systems	1,200	0	200
National Electricity Delivery	2,655	2,229	2,500
Total, Electricity Delivery and Energy Reliability	**7,275**	**6,884**	**9,000**
Total, Lawrence Berkeley National Laboratory	**7,275**	**6,884**	**9,000**
Lawrence Livermore National Laboratory			
Electricity Delivery and Energy Reliability			
Clean Energy Transmission and Reliability	500	900	0
Infrastructure Security & Energy Restoration	225	75	75
Cybersecurity for Energy Delivery Systems	358	0	200
Total, Electricity Delivery and Energy Reliability	**1,083**	**975**	**275**
Total, Lawrence Livermore National Laboratory	**1,083**	**975**	**275**
Los Alamos National Laboratory			
Electricity Delivery and Energy Reliability			
Clean Energy Transmission and Reliability	1,800	1,320	2,464
Smart Grid	150	252	470
Cybersecurity for Energy Delivery Systems	2,970	50	200
Total, Electricity Delivery and Energy Reliability	**4,920**	**1,622**	**3,134**
Total, Los Alamos National Laboratory	**4,920**	**1,622**	**3,134**
National Energy Technology Lab			
Electricity Delivery and Energy Reliability			
Program Direction	6,938	6,745	7,125
Clean Energy Transmission and Reliability	1,645	7,524	14,679
Smart Grid	7,445	7,900	7,200
Infrastructure Security & Energy Restoration	0	600	600
Cybersecurity for Energy Delivery Systems	11,121	34,957	38,600
National Electricity Delivery	650	1,029	1,500
Total, Electricity Delivery and Energy Reliability	**27,799**	**58,755**	**69,704**
Total, National Energy Technology Lab	**27,799**	**58,755**	**69,704**

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Electricity Delivery and Energy Reliability	FY 2014 Current	FY 2015 Enacted	FY 2016 Request
National Renewable Energy Laboratory			
Electricity Delivery and Energy Reliability			
Clean Energy Transmission and Reliability	0	400	545
Smart Grid	545	225	2,300
Infrastructure Security & Energy Restoration	0	50	50
Cybersecurity for Energy Delivery Systems	0	50	0
National Electricity Delivery	760	771	1,000
Total, Electricity Delivery and Energy Reliability	**1,305**	**1,496**	**3,895**
Total, National Renewable Energy Laboratory	**1,305**	**1,496**	**3,895**
Oak Ridge National Laboratory			
Electricity Delivery and Energy Reliability			
Clean Energy Transmission and Reliability	3,804	2,221	4,018
Smart Grid	275	600	900
Infrastructure Security & Energy Restoration	0	50	50
Energy Storage	1,031	500	1,474
Cybersecurity for Energy Delivery Systems	2,998	50	1,300
National Electricity Delivery	0	429	500
Total, Electricity Delivery and Energy Reliability	**8,108**	**3,850**	**8,242**
Total, Oak Ridge National Laboratory	**8,108**	**3,850**	**8,242**
Pacific Northwest National Laboratory			
Electricity Delivery and Energy Reliability			
Clean Energy Transmission and Reliability	5,415	5,250	5,427
Smart Grid	765	2,391	12,420
Infrastructure Security & Energy Restoration	525	125	125
Energy Storage	5,116	3,500	7,955
Cybersecurity for Energy Delivery Systems	6,236	175	2,000
Total, Electricity Delivery and Energy Reliability	**18,057**	**11,441**	**27,927**
Total, Pacific Northwest National Laboratory	**18,057**	**11,441**	**27,927**
Richland Operations Office			
Electricity Delivery and Energy Reliability			
Infrastructure Security & Energy Restoration	1,660	1,152	1,152
Total, Richland Operations Office	**1,660**	**1,152**	**1,152**

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Electricity Delivery and Energy Reliability	FY 2014 Current	FY 2015 Enacted	FY 2016 Request
Sandia National Laboratories			
Electricity Delivery and Energy Reliability			
Clean Energy Transmission and Reliability	400	700	809
Smart Grid	1,785	861	900
Infrastructure Security & Energy Restoration	125	0	0
Energy Storage	8,274	7,450	11,571
Cybersecurity for Energy Delivery Systems	3,356	50	500
National Electricity Delivery	150	257	100
Total, Electricity Delivery and Energy Reliability	**14,090**	**9,318**	**13,880**
Total, Sandia National Laboratories	**14,090**	**9,318**	**13,880**
Savannah River National Laboratory			
Electricity Delivery and Energy Reliability			
Clean Energy Transmission and Reliability	0	50	0
Cybersecurity for Energy Delivery Systems	0	50	0
Total, Electricity Delivery and Energy Reliability	**0**	**100**	**0**
Total, Savannah River National Laboratory	**0**	**100**	**0**
Washington Headquarters			
Electricity Delivery and Energy Reliability			
Program Direction	20,668	20,861	25,475
Clean Energy Transmission and Reliability	12,330	10,472	5,817
Smart Grid	2,510	1,004	1,940
Infrastructure Security & Energy Restoration	5,461	3,848	11,848
Energy Storage	285	0	0
Cybersecurity for Energy Delivery Systems	6,206	5,367	7,400
National Electricity Delivery	1,362	1,114	1,800
State Energy Reliability and Assurance Grants	0	0	63,000
Transformer Resilience and Advanced Components	0	0	5,000
Total, Electricity Delivery and Energy Reliability	**48,822**	**42,666**	**122,280**
Total, Washington Headquarters	**48,822**	**42,666**	**122,280**
Total, Electricity Delivery and Energy Reliability	**144,205**	**147,306**	**270,100**