



Report to the Ranking Member,
Subcommittee on Oversight, Committee
on Science, Space, and Technology,
House of Representatives

January 2017

ELECTRICITY

Federal Efforts to Enhance Grid Resilience

GAO Highlights

Highlights of [GAO-17-153](#), a report to the Ranking Member, Subcommittee on Oversight, Committee on Science, Space, and Technology, House of Representatives

Why GAO Did This Study

In light of increasing threats to the nation's electricity grid, national policies have stressed the importance of enhancing the grid's resilience—its ability to adapt to changing conditions; withstand potentially disruptive events, such as the loss of power lines; and, if disrupted, to rapidly recover. Most of the electricity grid is owned and operated by private industry, but the federal government has a significant role in promoting the grid's resilience. DOE is the lead agency for federal grid resiliency efforts and is responsible for coordinating with DHS and other relevant federal agencies on these efforts.

GAO was asked to review federal efforts to enhance the resilience of the electricity grid. This report (1) identifies grid resiliency efforts implemented by federal agencies since 2013 and the results of these efforts and (2) examines the extent to which these efforts were fragmented, overlapping, or duplicative, and the extent to which agencies had coordinated the efforts.

GAO reviewed relevant laws and guidance; identified a list of federal grid resiliency efforts; sent a questionnaire to officials at DOE, DHS, and FERC to collect information on each effort and its results; analyzed questionnaire responses and agency documents to assess whether federal efforts were fragmented, overlapping, or duplicative and how agencies coordinated those efforts; and interviewed agency officials and industry group representatives.

This report contains no recommendations. DOE, DHS, and FERC provided technical comments, which GAO incorporated as appropriate.

View [GAO-17-153](#). For more information, contact Frank Rusco, (202) 512-3841, ruscof@gao.gov

January 2017

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Federal Efforts to Enhance Grid Resilience

What GAO Found

The Department of Energy (DOE), the Department of Homeland Security (DHS), and the Federal Energy Regulatory Commission (FERC) reported implementing 27 grid resiliency efforts since 2013 and identified a variety of results from these efforts. The efforts addressed a range of threats and hazards—including cyberattacks, physical attacks, and natural disasters—and supported different types of activities (see table). These efforts also addressed each of the three federal priorities for enhancing the security and resilience of the electricity grid: (1) developing and deploying tools and technologies to enhance awareness of potential disruptions, (2) planning and exercising coordinated responses to disruptive events, and (3) ensuring actionable intelligence on threats is communicated between government and industry in a time-sensitive manner. Agency officials reported a variety of results from these efforts, including the development of new technologies—such as a rapidly-deployable large, high-power transformer—and improved coordination and information sharing between the federal government and industry related to potential cyberattacks.

Types of Activities Supported by 27 Federal Grid Resiliency Efforts

Activity type	Number of federal efforts
Emergency preparedness and response	19
Research and development	15
Modeling, analytics, and risk assessment	12
Standard setting	12
Information sharing	10
Institutional support and technical assistance	10
Regulatory guidance	1

Source: GAO analysis of DOE, DHS, and FERC questionnaire responses. | GAO-17-153

Note: Because agency efforts often supported more than one type of activity, the number of efforts across the types of activities exceeds 27, the number of federal efforts GAO identified in this review.

Federal grid resiliency efforts were fragmented across DOE, DHS, and FERC and overlapped to some degree but were not duplicative. GAO found that the 27 efforts were fragmented in that they were implemented by three agencies and addressed the same broad area of national need: enhancing the resilience of the electricity grid. However, DOE, DHS, and FERC generally tailored their efforts to contribute to their specific missions. For example, DOE's 11 efforts related to its strategic goal to support a more secure and resilient U.S. energy infrastructure. GAO also found that the federal efforts overlapped to some degree but were not duplicative because none had the same goals or engaged in the same activities. For example, three DOE and DHS efforts addressed resiliency issues related to large, high-power transformers, but the goals were distinct—one effort focused on developing a rapidly deployable transformer to use in the event of multiple large, high-power transformer failures; another focused on developing next-generation transformer components with more resilient features; and a third focused on developing a plan for a national transformer reserve. Moreover, officials from all three agencies reported taking actions to coordinate federal grid resiliency efforts, such as serving on formal coordinating bodies that bring together federal, state, and industry stakeholders to discuss resiliency issues on a regular basis, and contributing to the development of federal plans that address grid resiliency gaps and priorities. GAO found that these actions were consistent with key practices for enhancing and sustaining federal agency coordination.

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Figure 1: Overlap in Type of Activities Supported by Federal Grid Resiliency Efforts

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Abbreviations

CEDS	Cybersecurity for Energy Delivery Systems
CRISP	Cybersecurity Risk Information Sharing Program
DOD	Department of Defense
DOE	Department of Energy
DHS	Department of Homeland Security
ES-C2M2	Electricity Subsector Cybersecurity Capability Maturity Model
FERC	Federal Energy Regulatory Commission
GRIDS	Grid-Scale Rampable Intermittent Dispatchable Storage
ISER	Infrastructure Security and Restoration Program
NERC	North American Electric Reliability Corporation
RecX	Recovery Transformer
TRAC	Transformer Resilience and Advanced Components

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January 25, 2017

The Honorable Don Beyer
Ranking Member
Subcommittee on Oversight
Committee on Science, Space, and Technology
House of Representatives

Dear Mr. Beyer:

The electricity grid delivers the electricity essential to modern life. As a result, the reliability of the grid—its ability to meet consumers' electricity demand at all times—has been a long-standing area of national interest. According to the 2015 Quadrennial Energy Review, natural and human-made threats to the grid are increasing and are expected to continue to grow in frequency and magnitude.¹ In light of these increasing threats and with recognition that it is not possible to prevent all disruptions to the electricity grid, government and industry have focused on enhancing the grid's resilience. This focus on resilience complements the long-standing focus on reliability. Resilience represents the grid's ability to adapt to changing conditions and withstand potentially disruptive events—such as the loss of power plants or power lines—and, if disrupted, to rapidly recover.² In particular, government and industry recently have emphasized efforts to improve the grid's resilience to high-consequence, low-probability events, including severe natural disasters such as Hurricane Sandy; major geomagnetic disturbances; significant cyberattacks on computer systems that control parts of the system; and coordinated terrorist attacks on specific facilities.

¹The White House, *Quadrennial Energy Review: Energy Transmission, Storage, and Distribution Infrastructure* (Washington, D.C.: April 2015). This interagency review focused on the challenges facing the nation's energy infrastructures, including the electricity grid, and made recommendations for federal energy policy.

²For the purposes of this report, we use the definition of resilience in Presidential Policy Directive 21, which establishes national policy for critical infrastructure security and resilience. Specifically, Presidential Policy Directive 21 defines resilience as the ability to prepare for and adapt to changing conditions and withstand and recover rapidly from disruptions, including deliberate attacks, accidents, and naturally occurring threats or incidents. The White House, *Presidential Policy Directive/PPD-21: Critical Infrastructure Security and Resilience* (Washington, D.C.: Feb. 12, 2013).

The private sector and the government share responsibility for the resilience of the electricity grid. Most of the electricity grid—the commercial electric power transmission and distribution system comprising power lines and other infrastructure—is owned and operated by private industry. However, federal, state, local, tribal, and territorial governments also have significant roles in enhancing the resilience of the electricity grid. In 2013, the President directed federal agencies to work with owners and operators of critical infrastructure and state, local, tribal, and territorial governments to take proactive steps to manage risk and strengthen the security and resilience of critical infrastructure from all hazards, including natural disasters, cyberattacks, and acts of terrorism.³ The Department of Energy (DOE) was designated as the lead agency for federal resiliency efforts in the energy sector, which includes the electricity grid. In this role, DOE is responsible for coordinating with the Department of Homeland Security (DHS), itself responsible for coordinating the overall federal effort to promote the security and resilience of the nation's critical infrastructure. DOE is also responsible for coordinating with other relevant federal agencies and for collaborating with critical infrastructure owners and operators to prioritize and coordinate federal resiliency efforts. In addition, the Federal Energy Regulatory Commission (FERC), which regulates the interstate transmission of electricity, is responsible for reviewing and approving standards developed by the North American Electric Reliability Corporation (NERC) to provide for the reliable operation of the bulk power system.⁴ These standards include requirements for planning and operating the bulk power system to provide for its reliable operation.⁵ For example, one reliability standard requires that system planners plan and develop their systems to meet the demand for electricity even if equipment on the bulk power system, such as a single generating unit or transformer, is damaged or otherwise unable to operate. According to

³*Presidential Policy Directive/PPD-21.*

⁴The North American Electric Reliability Corporation (NERC), the federally designated U.S. electric reliability organization, is overseen by FERC. NERC is responsible for conducting reliability assessments and developing and enforcing mandatory standards to provide for the reliable operation of the bulk power system. The bulk power system includes the facilities and control systems necessary for operating the interconnected electricity transmission network and the electric energy from certain generation facilities needed for reliability.

⁵Federal efforts to enhance resilience are similar to efforts focused on ensuring that electricity supplies are reliable, i.e. that consumers have access to sufficient quantities of electricity.

FERC officials, these reliability standards can lead to actions that enhance the resilience of the electricity grid by improving the grids' ability to withstand potentially disruptive events and, if disrupted, to rapidly recover.

The fact that multiple agencies have roles in enhancing the resilience of the electricity grid raises questions about the potential for fragmentation, overlap, or duplication in federal efforts. As we have previously reported, federal programs can be inefficient or ineffective if they are fragmented, overlapping, or duplicative.⁶ We have routinely reviewed federal programs to identify any that may pose these problems; each year since 2011, we have reported on programs that do pose these problems.⁷ Fragmentation occurs when more than one federal agency—or more than one organization within an agency—is involved in the same broad area of national need. Overlap occurs when multiple agencies or programs have similar goals, engage in similar activities or strategies to achieve these goals, or target similar beneficiaries. Duplication occurs when two or more agencies or programs have the same goals, are engaged in the same activities, or provide the same services to the same beneficiaries. We have previously reported that coordination across programs may help address fragmentation, overlap, and duplication.⁸ We also have reported that, in some cases, it may be appropriate or beneficial for multiple agencies or entities to be involved in the same programmatic or policy area because of the complex nature or magnitude of the federal effort.⁹

⁶GAO, *Fragmentation, Overlap, and Duplication: An Evaluation and Management Guide*, [GAO-15-49SP](#) (Washington, D.C.: Apr. 14, 2015).

⁷See GAO, *Opportunities to Reduce Potential Duplication in Government Programs, Save Tax Dollars, and Enhance Revenue*, [GAO-11-318SP](#) (Washington, D.C.: Mar. 1, 2011); *2012 Annual Report: Opportunities to Reduce Duplication, Overlap and Fragmentation, Achieve Savings, and Enhance Revenue*, [GAO-12-342SP](#) (Washington, D.C.: Feb. 28, 2012); *2013 Annual Report: Actions Needed to Reduce Fragmentation, Overlap, and Duplication and Achieve Other Financial Benefits*, [GAO-13-279SP](#) (Washington, D.C.: Apr. 9, 2013); *2014 Annual Report: Additional Opportunities to Reduce Fragmentation, Overlap, and Duplication and Achieve Other Financial Benefits*, [GAO-14-343SP](#) (Washington, D.C.: Apr. 8, 2014); *2015 Annual Report: Additional Opportunities to Reduce Fragmentation, Overlap, and Duplication and Achieve Other Financial Benefits*, [GAO-15-404SP](#) (Washington, D.C.: Apr. 14, 2015); and *2016 Annual Report: Additional Opportunities to Reduce Fragmentation, Overlap, and Duplication and Achieve Other Financial Benefits*, [GAO-16-375SP](#) (Washington, D.C.: Apr. 13, 2016).

⁸[GAO-11-318SP](#).

⁹[GAO-15-49SP](#).

In this context, you asked us to review federal efforts to enhance the resilience of the electricity grid. Our objectives were to identify (1) grid resiliency efforts implemented by federal agencies since 2013 and their known results and (2) the extent to which these federal grid resiliency efforts were fragmented, overlapping, or duplicative, if at all, and the extent to which agencies have coordinated these efforts.

To conduct this work, we reviewed relevant laws, orders, and guidance and interviewed agency officials and industry group representatives.¹⁰ To identify grid resiliency efforts implemented by federal agencies since 2013 and their known results, we first reviewed agency documents and interviewed DOE, DHS, and FERC officials to develop an initial list of potentially relevant federal efforts to enhance grid resilience.¹¹ Next, we provided each of the three agencies with a list of its potentially relevant grid resiliency efforts, along with our definitions and criteria, and asked the agencies to confirm that the listed efforts were relevant, to add any relevant grid resiliency efforts that were not on the list, and to identify any other federal agencies that might have implemented relevant grid resiliency efforts from fiscal year 2013 through fiscal year 2016.¹² If officials wanted to remove an effort from our list, we requested additional information to support the removal. Using this process, we determined

¹⁰Specifically, we interviewed representatives from the American Public Power Association, the Edison Electric Institute, and the National Rural Electric Cooperative Association. We selected these three industry groups because together they represent the owners of most of the electricity grid.

¹¹For the purposes of this report, we defined federal efforts to enhance grid resilience as programs or groups of activities that aimed to enhance the resilience of the electricity grid through a specific emphasis or focus, even if enhancing the resilience of the electricity grid was only one aim of a broader effort. We did not consider individual projects within a broader effort—such as specific grant awards, agreements, or contracts—to be efforts in themselves. We excluded federal efforts that could indirectly enhance grid resilience but did not have that outcome as a specific emphasis or focus, as well as efforts aimed solely at enhancing the resilience of an agency's own electricity infrastructure assets.

¹²We considered an effort to have been implemented from fiscal year 2013 through fiscal year 2016 if it was planned, funded, executed, or authorized at some point during that time frame, even if the effort had ended or was completed by the end of fiscal year 2016.

that there were 27 federal grid resiliency efforts across the three agencies that met our criteria.¹³

After identifying these 27 efforts, we developed a questionnaire to collect additional information from officials at the three agencies about each effort. This questionnaire included questions to collect information on an effort's key characteristics; funding; actions to coordinate internally and with other federal agencies, states, and industry; and results. We conducted pretests with officials involved in three different efforts at three different agencies to check that (1) the questions were clear and unambiguous, (2) terminology was used correctly, (3) the questionnaire did not place an undue burden on agency officials, (4) the information could feasibly be obtained, and (5) the questionnaire was comprehensive and unbiased. An independent GAO reviewer also reviewed a draft of the questionnaire prior to its administration. Based on feedback from these pretests and independent review, we revised the questionnaire to improve its clarity. We administered the questionnaire and received responses for each effort, resulting in a response rate of 100 percent.¹⁴ After we reviewed the responses, we conducted follow-up e-mail exchanges or telephone discussions with agency officials as needed. Because this was

¹³DHS officials identified the Department of Defense (DOD) as another federal agency with potentially relevant grid resiliency efforts. In response, we provided our definitions and criteria to DOD and asked the agency to identify any relevant grid resiliency efforts it had implemented from fiscal year 2013 through fiscal year 2016 and to identify any other federal agencies that might have implemented relevant grid resiliency efforts. After interviewing DOD officials and reviewing their written response to our list, we determined that none of the department's efforts fell within the scope of our work because those efforts were aimed solely at enhancing the resilience of DOD's own electricity infrastructure assets rather than enhancing the resilience of the commercial electricity grid. For information on DOD efforts related to the resilience of its own electricity infrastructure assets, see GAO, *Defense Infrastructure: Improvements in DOD Reporting and Cybersecurity Implementation Needed to Enhance Utility Resilience Planning*, [GAO-15-749](#) (Washington, D.C.: July 23, 2015); *Defense Infrastructure: Improvement Needed in Energy Reporting and Security Funding at Installations with Limited Connectivity*, [GAO-16-164](#) (Washington, D.C.: Jan. 27, 2016); and *DOD Renewable Energy Projects: Improved Guidance Needed for Analyzing and Documenting Costs and Benefits*, [GAO-16-487](#) (Washington, D.C.: Sept. 8, 2016).

¹⁴We sent questionnaires to the appropriate agency liaisons in an attached Microsoft Word form, and the agency liaisons sent the questionnaires to the appropriate officials.

not a sample questionnaire, it has no sampling errors.¹⁵ To determine funding levels for the 27 efforts, we asked the agencies about their obligations for each effort.¹⁶ To assess the reliability of obligations data, we included questions about the data systems used to generate those data. Based on the responses we received, we determined that the data used in this report were of sufficient quality for the purposes of our reporting objectives. To identify the extent of any fragmentation, overlap, and duplication among federal grid resiliency efforts, as well as the extent to which agencies have coordinated those efforts, we analyzed the information we collected from our questionnaire to determine the extent of fragmentation, overlap, and duplication in the goals and activities of federal grid resiliency efforts. We then interviewed agency officials responsible for federal grid resiliency efforts for follow-up information as needed. In addition, we used agency documents, questionnaire responses, and interviews to identify coordination activities within and among the three agencies and with states and industry. For a copy of our questionnaire, see appendix I.

We conducted this performance audit from January 2016 to January 2017 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

¹⁵The practical difficulties of conducting any questionnaire may introduce errors, commonly referred to as nonsampling errors. For example, difficulties in interpreting a particular question, the sources of information available to respondents, or entering data into a database or analyzing them can introduce unwanted variability into the results. However, we took steps to minimize such nonsampling errors while developing the questionnaire—including using a social science survey specialist for designing and pretesting the questionnaire. We also minimized the nonsampling errors when collecting and analyzing the data, including using a computer program for analysis, and verifying the accuracy of keypunched records by comparing them with their corresponding questionnaires.

¹⁶For the purposes of this report, we refer to federal obligations as federal funding. An obligation is a definite commitment that creates a legal liability of the government for the payment of goods and services ordered or received, or a legal duty on the part of the United States that could mature into a legal liability. Payment may be made immediately or in the future. An agency incurs an obligation, for example, when it places an order, signs a contract, awards a grant, purchases a service, or takes other actions that require the government to make payments to the public or from one government account to another.

Background

Recent national policies and federal preparedness efforts have highlighted the importance of enhancing the resilience of the nation's critical infrastructure, including the electricity grid. Presidential Policy Directive 21, issued in February 2013, established national policy on critical infrastructure security and resilience. The directive expanded the nation's focus from protecting critical infrastructure against terrorism to protecting critical infrastructure and increasing its resilience against all hazards, including natural disasters, terrorism, and cyber incidents.¹⁷ In addition, the directive recognizes that proactive and coordinated efforts are necessary to strengthen and maintain critical infrastructure that is secure and resilient. It also identifies 16 critical infrastructure sectors, including the energy sector—which encompasses the electricity grid—and designates lead federal agencies to coordinate and prioritize security and resiliency activities in each sector. DOE was designated as the lead federal agency for the energy sector. Reflecting the shift in focus in Presidential Policy Directive 21, the December 2013 update to the National Infrastructure Protection Plan elevated security and resilience to be the primary aim of federal critical infrastructure planning efforts.¹⁸ The update established a set of broad national goals for critical infrastructure security and resilience and directed that each of the 16 critical infrastructure sectors update its sector-specific plan—a planning document that complements and tailors the application of the National Infrastructure Protection Plan to the specific characteristics and risks of each critical infrastructure sector. In response, DOE in 2015 led the development of an updated Energy Sector-Specific Plan to help guide and integrate efforts to improve the security and resilience of the energy sector's critical infrastructure, including the electricity grid.¹⁹ The plan identified three federal priorities for enhancing the security and resilience of the grid: (1) developing and deploying tools and technologies to enhance awareness of potential disruptions, (2) planning and exercising coordinated responses to disruptive events, and (3) ensuring actionable intelligence on threats is communicated between government and

¹⁷ *Presidential Policy Directive/PPD-21*.

¹⁸ Department of Homeland Security, *National Infrastructure Protection Plan, Partnering for Critical Infrastructure Security and Resilience* (Washington, D.C.: December 2013). The *National Infrastructure Protection Plan* is a comprehensive national plan for securing the key resources and critical infrastructure of the United States. DHS leads the plan's development in collaboration with relevant stakeholders, including other federal agencies, states, and industry.

¹⁹ Department of Energy and Department of Homeland Security, *Energy Sector-Specific Plan, 2015* (Washington, D.C.: 2015).

industry in a time-sensitive manner. In addition, in 2016 the United States developed an action plan and issued a joint strategy with Canada for strengthening the security and resilience of the North American electricity grid.²⁰

As table 1 shows, federal roles and responsibilities related to enhancing the resilience of the electricity grid are defined in policy and law, including Presidential Policy Directive 21 and certain provisions of the Fixing America’s Surface Transportation Act of 2015.²¹

Table 1: Selected Federal Roles and Responsibilities Related to Enhancing Electricity Grid Resilience

Source	Federal roles and responsibilities
Presidential Policy Directive 21: Critical Infrastructure Security and Resilience	<p>The Department of Homeland Security (DHS) is responsible for providing strategic guidance, promoting a national unity of effort, and coordinating the overall federal effort to promote the security and resilience of the nation’s critical infrastructure.</p> <p>As the lead federal agency for the energy sector, the Department of Energy (DOE) is responsible for, among other things:</p> <ul style="list-style-type: none">• coordinating with DHS and other relevant federal agencies and collaborating with critical energy infrastructure owners and operators; independent regulatory agencies; and state, local, tribal, and territorial entities;• serving as a day-to-day federal interface for the prioritization and coordination of energy-sector security and resiliency activities;• carrying out incident management responsibilities consistent with statutory authority and other appropriate policies, directives, or regulations; and• providing, supporting, or facilitating technical assistance and consultations for the energy sector to identify vulnerabilities and help mitigate incidents, as appropriate.
Fixing America’s Surface Transportation Act of 2015	<p>The Secretary of Energy is authorized to issue emergency orders to protect or restore the reliability of critical electric infrastructure to entities, including critical electric infrastructure owners and operators, if the President provides a written directive or determination identifying a grid security emergency.</p> <p>DOE is the lead federal agency for cybersecurity for the energy sector.</p> <p>DOE is required to submit a plan to Congress on establishing a strategic transformer reserve to store, in strategically located facilities, spare large power transformers and emergency mobile substations in sufficient numbers to temporarily replace critically damaged large power transformers and substations.</p>

Source: GAO analysis of Presidential Policy Directive 21 and selected provisions of the Fixing America’s Surface Transportation Act. | GAO-17-153

²⁰Executive Office of the President, *National Electric Grid Security and Resilience Action Plan* (Washington, D.C.: December 2016) and the Executive Office of the President and the Government of Canada, *Joint United States-Canada Electric Grid Security and Resilience Strategy* (Washington, D.C.: December 2016).

²¹Fixing America’s Surface Transportation Act, Pub. L. No. 114-94, §§ 61002-61004 129 Stat. 1312, 1772-82 (2015) (codified at 16 U.S.C. §§ 824, 824a, and 824o-1 (2016)).

States and industry also play key roles in enhancing the resilience of the electricity grid. States, through their public utility commissions, regulate retail electricity service and facility planning and siting. States also enact policies that can affect the resilience of the portion of the electricity grid that is within their borders. Industry owns and operates most of the electricity grid, so the actions that owners and operators take to protect and maintain their assets can contribute to grid resilience.²² In addition, owners and operators of the electricity grid are responsible for complying with mandatory reliability standards that can contribute to grid resilience.

Three Federal Agencies Implemented 27 Grid Resiliency Efforts since 2013 and Reported a Variety of Results

DOE, DHS, and FERC reported implementing 27 grid resiliency efforts since 2013 that supported a range of activities and that addressed multiple hazards and federal priorities for enhancing the resilience of the electricity grid. Agency officials reported a variety of results stemming from these efforts.

DOE, DHS, and FERC Efforts Addressed a Range of Activities, Hazards, and Federal Priorities

In response to our questionnaire, DOE, DHS, and FERC officials reported implementing 27 efforts since 2013 that aimed at enhancing the resilience of the electricity grid. Of these 27 efforts, 12 were FERC regulatory efforts tied to the agency's role in reviewing and approving mandatory reliability standards for the bulk power system. FERC officials also reported that the agency oversaw another effort in which it acted on a petition by a private company to provide regulatory findings related to the company's plan to establish a subscription service for spare critical transmission equipment, including transformers. The remaining 14 efforts—11 implemented by

²²Publicly owned utilities and electric cooperatives also own and operate portions of the electricity grid. Similar to industry, the actions that publicly owned utilities and electric cooperatives take to protect and maintain their assets can contribute to grid resilience.

DOE and 3 by DHS—were programmatic in nature.²³ Federal funding for the DOE and DHS grid resiliency activities from fiscal year 2013 through fiscal year 2015 totaled approximately \$240 million.²⁴ The 27 efforts that DOE, DHS, and FERC officials reported implementing supported a range of activities, addressed a variety of potential threats and hazards, and addressed federal priorities for enhancing the resilience of the electricity grid (see app. II for more information on each effort).

Types of Activities

As table 2 shows, the reported federal grid resiliency efforts supported a range of activities, with the most prevalent being:

- emergency preparedness and response activities (e.g. providing coordination, planning, training, and exercise programs to prepare for potential disaster operations; providing situational awareness during an event; coordinating response efforts; and helping facilitate system restoration);
- research and development activities (e.g. pursuing tools, technologies, and demonstrations aimed at bringing new and innovative technologies to maturity and helping them transition to industry);
- modeling, analytics, and risk assessment activities (e.g. modeling, simulation, and analysis of electricity grid risks and vulnerabilities); and
- standard-setting activities (e.g. the development or approval of standards for industry).

For example, DOE reported that its Strategic Transformer Reserve effort supported emergency preparedness and response activities through planning for the potential loss of large, high-power transformers by evaluating the feasibility of establishing a reserve of those transformers

²³For example, DOE's Transformer Resilience and Advanced Components Program aims to ensure the resilience of aging assets; identify new requirements for future grid components; and accelerate the development, demonstration, and deployment of next-generation components to enhance the resilience of the electricity grid. Also, DHS's Solar Storm Mitigation effort aims to provide owners and operators of the electricity grid with advanced and actionable information about anticipated geomagnetically induced current levels in the event of a solar storm.

²⁴FERC officials told us that the agency could not provide information on the federal funding for its grid resiliency efforts related to reviewing and approving reliability standards because FERC could not break down by individual standard the costs associated with reviewing and approving reliability standards.

for use during an emergency. Similarly, FERC reported that its efforts supported emergency preparedness and response activities as well as activities to set standards by approving a reliability standard that requires owners and operators of the electricity grid to develop and implement procedures to mitigate the potential effects of geomagnetic disturbances on the bulk power system.²⁵ In addition, DHS reported that its Recovery Transformer Program supported research and development activities by designing and demonstrating a type of rapidly deployable large, high-power transformer for use in the event of the unexpected loss of multiple large, high-power transformers.

Table 2: Types of Activities Supported by Federal Grid Resiliency Efforts

Agency	Federal grid resiliency effort	Type of Activity						
		Emergency preparedness and response	Research and development	Modeling, analytics, and risk assessment	Standard setting	Information sharing	Institutional support and technical assistance	Regulatory Guidance
DOE	Cybersecurity for Energy Delivery Systems Program	Yes	Yes	Yes	No	Yes	Yes	No
DOE	Cybersecurity Risk Information Sharing Program	No	Yes	No	No	Yes	Yes	No
DOE	Electric Distribution Grid Resilience Research and Development Program	No	Yes	Yes	No	No	No	No
DOE	Electricity Subsector Cybersecurity Capability Maturity Model	Yes	No	Yes	No	Yes	Yes	No
DOE	Energy Storage Program	Yes	Yes	Yes	No	Yes	Yes	No
DOE	Grid-Scale Rampable Intermittent Dispatchable Storage Program	No	Yes	No	No	No	No	No

²⁵Geomagnetic disturbances occur when the sun ejects charged particles that interact with and cause changes in the earth’s magnetic fields. These charged particles can cause currents to enter the electricity grid through long conductors, such as transmission lines. These currents can disrupt the normal operation of the grid and, in some cases, damage equipment such as transformers.

Agency	Federal grid resiliency effort	Type of Activity						
		Emergency preparedness and response	Research and development	Modeling, analytics, and risk assessment	Standard setting	Information sharing	Institutional support and technical assistance	Regulatory Guidance
DOE	Infrastructure Security and Energy Restoration Program	Yes	Yes	Yes	No	Yes	Yes	No
DOE	Microgrid Research and Development Program ^a	Yes	Yes	Yes	No	No	Yes	No
DOE	State and Regional Energy Risk Assessment Initiative	Yes	Yes	Yes	No	Yes	Yes	No
DOE	Strategic Transformer Reserve	Yes	Yes	Yes	No	Yes	Yes	No
DOE	Transformer Resilience and Advanced Components Program	No	Yes	Yes	No	No	No	No
DHS	Recovery Transformer Program	No	Yes	No	No	No	No	No
DHS	Resilient Electric Grid Program	No	Yes	No	No	No	No	No
DHS	Solar Storm Mitigation	No	Yes	Yes	No	No	No	No
FERC	Reliability Standards (12 Individual Standards) ^b	Yes (12)	Yes (2)	Yes (2)	Yes (12)	Yes (3)	Yes (2)	No
FERC	Grid Assurance, LLC Spare Transmission Equipment Service Petition	No	No	No	No	No	No	Yes
Total^c		19	15	12	12	10	10	1

Source: GAO analysis of questionnaire responses from the Department of Energy (DOE), the Department of Homeland Security (DHS), and the Federal Energy Regulatory Commission (FERC). | GAO-17-153

^aAccording to a DOE document, a microgrid is a local energy grid with control capability, which means it can disconnect from the grid and operate autonomously. A microgrid generally operates while connected to the grid, but it can break off and operate on its own using local energy generation in times of crisis, such as storms or power outages or for other reasons.

^bThe 12 individual reliability standards are consolidated.

^cBecause agency efforts often supported more than one type of activity, the total number of efforts across the types of activities exceeds 27, the number of federal efforts we identified in our review.

Types of Threats and Hazards

As table 3 shows, the agencies reported that their federal grid resiliency efforts addressed a range of threats and hazards, including cyberattacks (i.e. computer-related attacks); physical attacks (e.g. attacks on physical infrastructure such as targeted shooting of transformers or intentional

downing of power lines); natural disasters (e.g. extreme weather events and geomagnetic disturbances); and operational accidents (e.g. unintentional equipment failures or operator error). For example, DOE and FERC reported implementing several grid resiliency efforts to address the threat of cyberattacks. DOE's Electricity Subsector Cybersecurity Capability Maturity Model effort was a public-private partnership that developed a tool kit modeled on a common set of industry-vetted cybersecurity practices; the effort made this tool kit available to the electricity industry to help owners and operators evaluate, prioritize, and improve their cybersecurity capabilities. Similarly, of the 12 reliability standards FERC approved, several require owners and operators of the electricity grid to take actions to mitigate the threat posed by cyberattacks on the bulk power system.

Table 3: Types of Threats or Hazards Addressed by Federal Grid Resiliency Efforts

Threat or hazard	Number of federal efforts addressing
Cyberattack	15
Physical attack	12
Natural disaster	12
Operational accident	5

Source: GAO analysis of questionnaire responses from the Department of Energy (DOE), the Department of Homeland Security (DHS), and the Federal Energy Regulatory Commission (FERC). | GAO-17-153

Note: Because agency efforts often addressed more than one type of threat or hazard, the total number of efforts across the types of threats or hazards addressed exceeds 27, the number of federal efforts we identified in our review.

Federal Priorities for
Enhancing Grid Resilience

As table 4 shows, the reported federal grid resiliency efforts collectively addressed each of the three federal priorities for enhancing the security and resilience of the electricity grid that were identified in the 2015 *Energy Sector-Specific Plan*.²⁶ For example, DHS's Solar Storm Mitigation effort addressed the federal priority of developing and deploying tools and technologies to enhance awareness of potential disruptions; the effort addressed this priority by providing owners and operators of the electricity grid with advanced and actionable information about anticipated impacts of a solar storm. Similarly, DOE's Cybersecurity Risk Information Sharing Program addressed the federal priority to ensure actionable intelligence on threats is communicated between government and industry in a time-sensitive manner; the effort addressed this priority by facilitating the timely sharing of unclassified and classified cybersecurity threat

²⁶*Energy Sector-Specific Plan, 2015.*

information and developing situational awareness tools to better identify, prioritize, and coordinate the protection of critical electricity infrastructure.

Table 4: Federal Priorities for Enhancing the Security and Resilience of the Electricity Grid Addressed by Federal Grid Resiliency Efforts

Federal priority	Number of federal efforts addressing
Tools and technology	
Developing and deploying tools and technologies to enhance awareness of potential disruptions	24
Incident response	
Planning and exercising coordinated responses to disruptive events	18
Information flow	
Ensuring actionable intelligence on threats is communicated between government and industry in a time-sensitive manner	10

Source: GAO analysis of questionnaire responses from the Department of Energy (DOE), the Department of Homeland Security (DHS), and the Federal Energy Regulatory Commission (FERC). | GAO-17-153

Note: Because agency efforts often addressed more than one federal priority for enhancing the resilience of the electricity grid, the total number of efforts across the federal priorities exceeds 27, the number of federal efforts we identified in our review .

Agencies Reported a Variety of Results from Their Efforts

In their questionnaire responses, agency officials reported a variety of results from both ongoing and completed federal grid resiliency efforts. As shown in the selected examples in table 5, these results included the development, and in some cases the deployment, of new technologies and analytical tools; the planning and exercising of coordinated responses to disruptive events; and improved coordination and information sharing between the federal government and industry related to potential cyberattacks and other threats or hazards to the electricity grid.

Table 5: Selected Examples of Results from Federal Grid Resiliency Efforts

Type of Results	Examples
Development and deployment of new technologies and analytical tools	<ul style="list-style-type: none">The Department of Homeland Security's (DHS) Resilient Electric Grid Program developed a new superconductor cable that can connect several urban substations and in so doing mitigate or prevent disruptions by enabling multiple paths for electricity to flow if a single substation loses power.DHS's Recovery Transformer Program developed a rapidly deployable large, high-power transformer and demonstrated that it was capable of being transported, installed, and energized in less than 1 week if a large, high-power transformer on the grid is unexpectedly damaged.
Planning and exercising coordinated responses to disruptive events	<ul style="list-style-type: none">The Department of Energy's (DOE) Infrastructure Security and Energy Restoration program developed lessons learned from an annual exercise program that tests government and industry's ability to restore energyservices in the aftermath of catastrophic incidents. Those lessons were summarized and reported to energy sector stakeholders to improve their policies, plans, and procedures for energy emergencies.The Federal Energy Regulatory Commission (FERC) approved two reliability standards (Reliability Standards EOP-010-1 and TPL-007-1) that required industry to develop and implement plans and procedures to mitigate the effects of geomagnetic disturbances on the bulk power system. Geomagnetic disturbances occur when the sun ejects charged particles that interact with and cause changes in the earth's magnetic fields. These charged particles can cause currents to enter the electricity grid through long conductors, such as transmission lines, and in so doing disrupt the normal operation of the grid and, in some cases, damage equipment.
Improved coordination and information sharing between the federal government and industry	<ul style="list-style-type: none">DOE's Electricity Subsector Cybersecurity Capability Maturity Model effort developed a tool kit modeled on a common set of industry-vetted cybersecurity practices and made it available to industry to help owners and operators of the electricity grid evaluate, prioritize, and improve their cybersecurity capabilities.DOE's Cybersecurity Risk Information Sharing Program facilitated the timely sharing of unclassified and classified information on cybersecurity threats with companies that cover about 60 percent of continental U.S. customers.

Source: GAO analysis of questionnaire responses from the Department of Energy (DOE), the Department of Homeland Security (DHS), and the Federal Energy Regulatory Commission (FERC). | GAO-17-153

Federal Efforts Were Fragmented with Some Overlap but Were Not Duplicative, and Agencies Have Taken Actions to Coordinate Their Efforts

We found that the 27 federal efforts to enhance the resilience of the electricity grid were fragmented across DOE, DHS, and FERC and overlapped to some degree, but we did not find any instances of duplication among these efforts. In their questionnaire responses, agency officials reported engaging in a number of activities and mechanisms to coordinate their efforts and avoid duplication. These activities and mechanisms include serving as members on formal coordinating bodies that bring together federal, state, and industry stakeholders in the energy sector to discuss resiliency issues on a regular basis; contributing to the development of federal plans and reviews that address grid resiliency gaps and priorities; and participating in direct coordination activities at the program level.

Efforts Were Fragmented Across Agencies with Some Overlap but Were Not Duplicative

According to our analysis of agency questionnaire responses, federal grid resiliency efforts were fragmented and overlapped to some degree, but none were duplicative. In addition, industry group representatives we interviewed did not identify any instances of duplication among federal grid resiliency efforts.

Fragmentation. The 27 federal efforts to enhance the resilience of the electricity grid were fragmented in that they were implemented by three different agencies—DOE, DHS, and FERC—and addressed the same broad area of national need: enhancing the resilience of the electricity grid. We have previously reported that fragmentation has the potential to result in duplication of resources.²⁷ For example, fragmentation can lead to technical or administrative functions being managed separately by individual agencies, when these functions could be shared among programs. However, we also have reported that fragmentation, by itself, is not an indication that unnecessary duplication of efforts or activities exists.²⁸ There can be advantages to having multiple federal agencies involved in a broad area of national need; for example, agencies can tailor initiatives to suit their specific missions and needs, among other things. In the case of federal grid resiliency efforts, we found that DOE, DHS, and FERC generally have tailored their efforts to contribute to their specific missions and needs. For example, DOE’s 11 efforts related to its strategic goal to support a more secure and resilient U.S. energy infrastructure; DHS’s 3 efforts addressed its strategic priority to enhance critical infrastructure security and resilience by, among other things, promoting resilient critical infrastructure design; and FERC’s 13 efforts related to the agency’s roles in reviewing and approving reliability standards and regulating the interstate transmission of electricity. Moreover, fragmentation of federal grid resiliency efforts within agencies is limited—10 of the 11 DOE efforts, all 13 FERC efforts, and all 3 DHS efforts were implemented by one organization within each respective agency.

Overlap. We found that 23 of the 27 federal grid resiliency efforts overlapped to some degree with at least one other effort in that they addressed similar goals. These overlaps included:

²⁷[GAO-11-318SP](#).

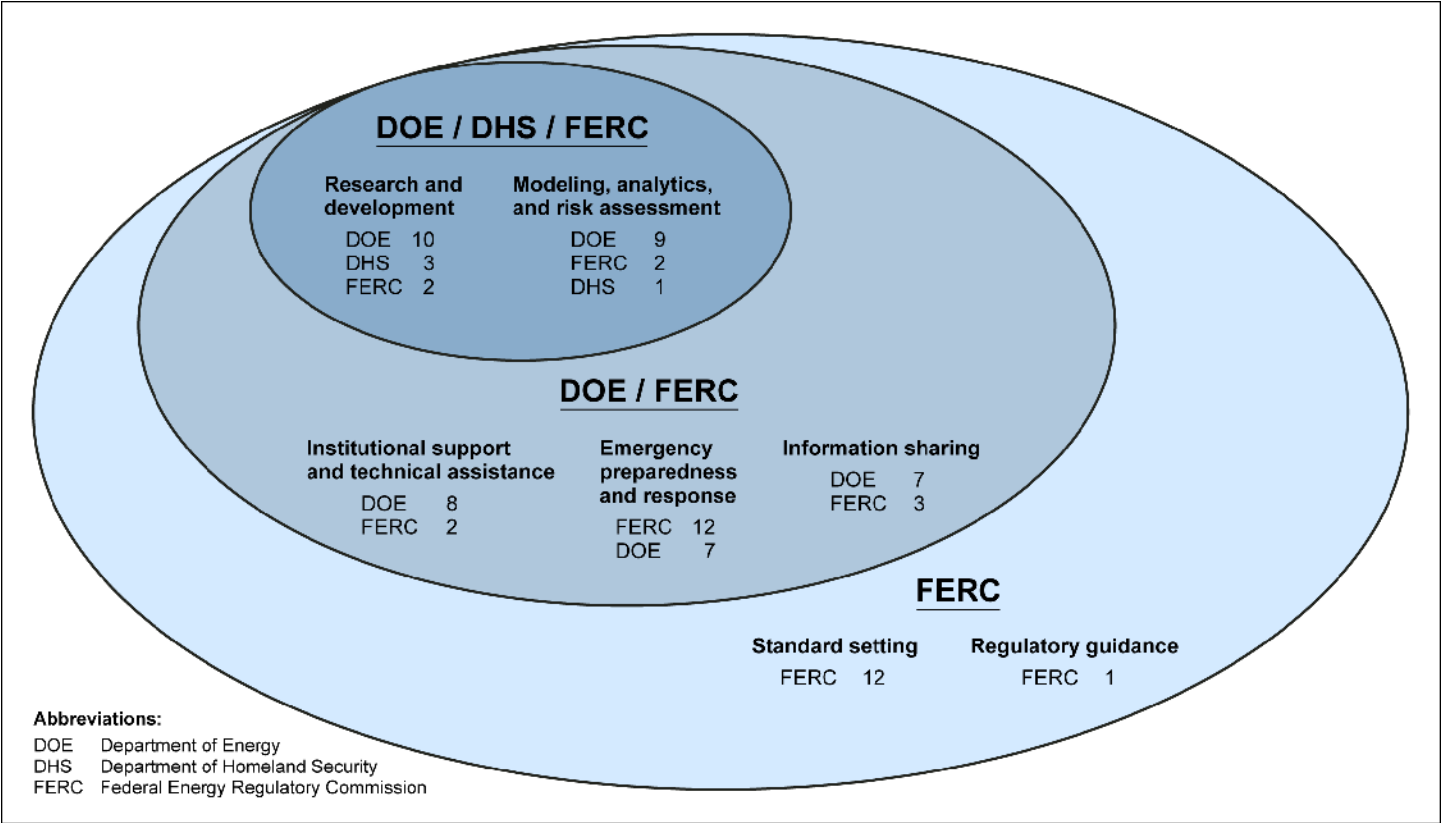
²⁸[GAO-11-318SP](#).

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- 12 efforts with similar goals related to enhancing the cybersecurity of the electricity grid;
 - 4 with similar goals related to enhancing the resilience and availability of large, high-power transformers;²⁹
 - 3 with similar goals related to enhancing the grid's resilience to geomagnetic disturbances;
 - 2 with similar goals related to enhancing energy storage technology; and
 - 2 with similar goals related to enhancing the resilience of the grid's distribution system.

As figure 1 illustrates, we also found that all but one federal grid resiliency effort overlapped to some degree with at least one other effort by supporting similar types of activities to achieve their goals.

²⁹According to a DOE document, large, high-power transformers carry more than 90 percent of the nation's electricity and face a number of challenges that make them one of the most vulnerable components of the electricity grid. According to the 2015 Quadrennial Energy Review, the loss of multiple critical large, high-power transformers could disrupt electricity service over a large area of the country.

Figure 1: Overlap in Type of Activities Supported by Federal Grid Resiliency Efforts



Source: GAO analysis of questionnaire responses from DOE, DHS, and FERC. | GAO-17-153

Note: Because agency efforts often supported more than one type of activity, the total number of efforts across the types of activities exceeds 27, the number of federal efforts we identified in our review.

Duplication. We did not find any instances of duplication among the 27 federal grid resiliency efforts because none of the efforts had the same goals or engaged in the same activities. For example, although 4 efforts overlapped in that they had similar goals related to enhancing the resilience of large, high-power transformers and improving their availability, those efforts were not duplicative because their goals were not the same. Specifically, DHS's Recovery Transformer Program, begun in 2008 and completed in 2014, aimed to design and demonstrate a rapidly deployable large, high-power transformer that could be used to enable rapid recovery of the grid in the event of multiple large, high-power transformer failures. In contrast, DOE's Transformer Resilience and Advanced Components Program, launched in 2016, is focused on

ensuring the resilience of aging transformers and accelerating the development, demonstration, and deployment of next-generation transformer components. Furthermore, DOE's Strategic Transformer Reserve effort is an analytical and planning activity with a goal of developing a plan for Congress related to establishing a strategic transformer reserve. Similarly, a fourth effort led by FERC was distinct from the other three efforts in that its goal was to act on a petition from a private company for regulatory findings related to the company's plan to establish a subscription service for spare critical transmission equipment, including transformers.

Agencies Reported Coordinating Efforts through Formal Coordinating Bodies, Joint Planning, and Other Activities

In their questionnaire responses, DOE, DHS, and FERC reported coordinating with each other on their federal grid resiliency efforts through a variety of activities and mechanisms. In particular, agency officials associated with all of the programmatic efforts that we identified as having overlapping characteristics (in that they supported similar goals and types of activities) reported coordinating with other federal agencies. Furthermore, many reported coordinating their efforts with states, and most also reported coordinating their efforts with industry. Coordination is important because, as we have previously reported, it can preserve scarce funds and enhance the overall effectiveness of federal efforts.³⁰

We also have previously reported that coordination across programs may help address fragmentation, overlap, and duplication.³¹ We found that coordination activities and mechanisms among DOE, DHS, and FERC were consistent with key practices we have previously identified that can help enhance and sustain federal agency coordination, such as (1) defining and articulating a common outcome; (2) establishing joint strategies, which helps align activities, core processes, and resources to accomplish a common outcome; (3) leveraging resources, which helps obtain additional benefits that would not be available if agencies or offices were working separately; and (4) developing mechanisms to monitor, evaluate, and report on results. We analyzed and grouped into seven categories the various coordination activities and mechanisms that

³⁰GAO, *Results-Oriented Government: Practices That Can Help Enhance and Sustain Collaboration among Federal Agencies*, [GAO-06-15](#) (Washington, D.C.: Oct. 21, 2005).

³¹[GAO-11-318SP](#) and GAO, *Employment for People with Disabilities: Little Is Known about the Effectiveness of Fragmented and Overlapping Programs*, [GAO-12-677](#) (Washington, D.C.: June 29, 2012).

agency officials reported in their questionnaire responses. These categories and examples of specific activities are:

- **Participating in formal coordinating bodies.** Agency officials reported participating in several formally established coordinating bodies. In particular, DOE and DHS officials identified the Electricity Subsector Coordinating Council and the Energy Sector Government Coordinating Council as key mechanisms that help coordinate grid resiliency efforts across federal agencies and with states and industry stakeholders. According to the Electricity Subsector Coordinating Council's charter, the council's purpose includes coordinating activities and initiatives designed to improve the reliability and resilience of the electricity subsector, including the electricity grid, and serving as the principal liaison between the council's membership and the Energy Sector Government Coordinating Council.³² The Energy Sector Government Coordinating Council is the government counterpart of the Electricity Subsector Coordinating Council, and its purpose is to enable interagency and cross-jurisdictional coordination on planning, implementing, and executing resilience programs for the nation's critical energy infrastructure.³³ Agency officials told us that federal grid resiliency efforts and their results are discussed at meetings of these two councils as a way to share information, coordinate efforts, and avoid duplication. We have previously found that federal programs that contribute to the same or similar results should collaborate to ensure that goals are consistent and, as appropriate, program efforts are mutually reinforcing.³⁴

³²Among other things, the Electricity Subsector Coordinating Council is meant to facilitate the identification and sharing of tools and technologies to improve electricity subsector security and resilience, and to collaborate with the federal government on coordinated government-industry preparedness and response planning for events of national significance. The council includes utility chief executive officers and trade association leaders representing all segments of the electric power industry. The council's charter calls for it to meet at least once each year.

³³Among other things, the Energy Sector Government Coordinating Council is meant to identify energy sector resiliency issues that need interagency and public-private coordination; identify strategies to correct or eliminate gaps or overlaps in plans, programs, and policies; facilitate the sharing of approaches and results of successful resiliency programs; and leverage complementary resources within and between federal agencies and industry. The council includes representatives from various levels of government (federal, state, local, territorial, and tribal) and is co-chaired by representatives from DOE and DHS. The council's charter calls for it to meet at least three times each year.

³⁴[GAO-06-15](#).

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- **Contributing to federal planning efforts.** Agency officials reported contributing to federal plans and reviews that addressed grid resiliency gaps and priorities. For example, DOE and DHS officials said they contributed to the development of the 2015 Quadrennial Energy Review, which, among other things, assessed the vulnerabilities of the electricity grid and recommended ways to enhance its resilience.³⁵ Agency officials also told us that they collaborated on the development of the 2015 Energy Sector-Specific Plan, which identified three federal priorities for enhancing the security and resilience of the electricity grid.³⁶ We have previously reported that it is important for collaborating agencies to establish strategies that work in concert with those of their partners or that are joint in nature, because such strategies help align the agencies' activities to accomplish a common outcome.³⁷
 - **Maintaining a record of federal, state, and industry efforts.** DOE officials reported that the agency maintains a record of federal-, state-, and industry-critical energy sector infrastructure programs and initiatives; this record includes federal grid resiliency efforts. Officials told us that they update the record, which was created in 2013, as new programs and initiatives are identified at meetings of the Electricity Subsector Coordinating Council and the Energy Sector Government Coordinating Council. DOE officials said that they use the record as an internal tool for tracking energy-sector programs and initiatives and as a means to share information about those efforts with federal, state, and industry stakeholders, as needed. We have previously found that it is important for federal agencies engaged in collaborative efforts to create the means to monitor and evaluate their efforts.³⁸ Furthermore, we have concluded that developing and maintaining a record of federal efforts with similar goals can improve visibility over the full range of those efforts and reduce the potential for duplication.³⁹

³⁵Quadrennial Energy Review.

³⁶Energy Sector-Specific Plan, 2015.

³⁷GAO-06-15.

³⁸GAO-06-15.

³⁹GAO, *Warfighter Support: Actions Needed to Improve Visibility and Coordination of DOD's Counter-Improvised Explosive Device Efforts*, GAO-10-95 (Washington, D.C.: Oct. 29, 2009).

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- **Participating in formal joint efforts.** Some agency officials reported that their grid resiliency efforts were joint efforts with other federal agencies or industry partners. For example, DHS officials reported that both the Resilient Electric Grid Program and the Recovery Transformer Program were jointly funded by DHS and industry under formal agreements. Similarly, DOE officials reported that the Cybersecurity Risk Information Sharing Program was a formal joint effort of DOE, the federal intelligence community, and NERC. We have previously found that by leveraging partner resources, agencies can obtain additional benefits that would not be available if they worked separately.⁴⁰
 - **Soliciting input from stakeholders.** Some agency officials reported formally soliciting input on their grid resiliency efforts from federal, state, and industry stakeholders. For example, FERC officials reported that they formally seek comments on proposed reliability standards and routinely receive comments from federal, state, and industry stakeholders. FERC officials said that the agency considers these comments when determining whether to approve a reliability standard and, as a result of these comments, in some cases directs NERC to make changes in proposed standards. Similarly, DOE officials responsible for the Strategic Transformer Reserve effort reported seeking input from relevant federal agencies—including DHS, the Department of Defense (DOD), and FERC—states, industry, and others as they developed their analysis.
 - **Sponsoring and participating in conferences, webinars, and workshops.** Agency officials reported sponsoring and participating in conferences, webinars, and workshops that included discussions about grid resiliency priorities and how to address those priorities among federal, state, and industry stakeholders. For example, officials who implement DOE's Electric Distribution Grid Resilience Research and Development Program reported that they held a workshop with stakeholders to define in greater detail research and development needs related to the distribution grid's resilience. We have previously found that collaboration can help agencies define and articulate the common federal outcome.⁴¹
 - **Coordinating directly through agency staff.** Agency officials also reported that agency staff responsible for grid resiliency efforts

⁴⁰GAO-06-15.

⁴¹GAO-06-15.

pursued a number of informal activities to directly coordinate these efforts with related federal and industry efforts; these activities included periodic meetings, telephone calls, and e-mails to coordinate and share information. We have previously reported that frequent communication among collaborating agencies is a means to facilitate working across agency boundaries.⁴²

Agency Comments

We provided a draft copy of this report to DOD, DOE, DHS, and FERC for review and comment. DOE, DHS, and FERC provided technical comments, which we incorporated as appropriate. DOD indicated it had no comments on the report.

As agreed with your office, unless you publicly announce the contents of this report earlier, we plan no further distribution until 30 days from the report date. At that time, we will send copies to the appropriate congressional committees; the Secretaries of Defense, Energy, and Homeland Security; the Chairman of FERC; and other interested parties. In addition, the report will be available at no charge on the GAO website at <http://www.gao.gov>.

If you or your staff members have any questions about this report, please contact me at (202) 512-3841 or ruscof@gao.gov. Contact points for our Offices of Congressional Relations and Public Affairs are on the last page of this report. GAO staff who made key contributions to this report are listed in appendix III.

Sincerely yours,



Frank Rusco
Director, Natural Resources and Environment

⁴²[GAO-06-15](#).

Appendix I: GAO's Questionnaire for Federal Agencies with Efforts Aimed at Enhancing the Resilience of the Electricity Grid

QUESTIONS ABOUT FEDERAL GRID RESILIENCY EFFORTS – [PRE-POPULATED INFORMATION]



United States Government Accountability Office

QUESTIONS ABOUT FEDERAL GRID RESILIENCY EFFORTS: [PRE-POPULATED INFORMATION]

Introduction

GAO is evaluating federal efforts to enhance the resiliency of the U.S. electric power transmission and distribution system (the electricity grid). In April 2016, we asked your agency to identify any efforts it had that were active in fiscal year 2013 or later that aimed to enhance the resiliency of the electricity grid, either exclusively or as part of a broader effort. Through this supplemental questionnaire, we are asking you to provide additional information about one of the efforts identified by your agency. After we receive your response, we will follow up with you as needed to clarify any information about the effort.

Resilience, for the purposes of this engagement, is defined by Presidential Policy Directive 21 (PPD-21) as the ability to prepare for and adapt to changing conditions and withstand and recover rapidly from disruptions. Resilience includes the ability to withstand and recover from deliberate attacks, accidents, or naturally occurring threats or incidents. *Federal efforts to enhance grid resiliency* are programs or groups of activities serving a similar purpose or function that aim to enhance the resiliency of the electricity grid through a specific emphasis or focus, even if enhancing the resiliency of the electricity grid is only one aim of a broader effort.

Instructions

This questionnaire is divided into five sections and should be completed by agency officials involved with the [Pre-populated information]. It can be completed using MS-Word.

- 1) First, save this document to your hard drive.
- 2) Use your mouse to navigate by clicking on the field or check box ☐ you wish to answer.
- 3) To select a check box or button, click on the center of the box, and an 'X' will appear.
- 4) To deselect a check box response, click on the center of the box, and the 'X' will disappear.
- 5) To answer a question that requires a comment, click on the answer box and begin typing. The box will expand to accommodate your answer.

Please complete this questionnaire and email it back with any relevant supporting documentation to Stephanie Gaines ([Pre-populated information]) and David Marroni ([Pre-populated information]) by **July xx, 2016**. If you have any questions or comments, please email or call Stephanie at [Pre-populated information] or David at [Pre-populated information]. Thank you very much for your assistance.

Appendix I: GAO's Questionnaire for Federal Agencies with Efforts Aimed at Enhancing the Resilience of the Electricity Grid

QUESTIONS ABOUT FEDERAL GRID RESILIENCY EFFORTS – [PRE-POPULATED INFORMATION]

SECTION I: GENERAL INFORMATION ABOUT THE EFFORT

For the purposes of this engagement, we are defining a *federal grid resiliency effort* (referred to throughout this questionnaire as an “effort”) as being a program or groups of activities serving a similar purpose or function that aims to enhance the resiliency of the U.S. electric power transmission and distribution system (the electricity grid) through a specific emphasis or focus, even if enhancing the resiliency of the electricity grid is only one aim of a broader effort.

- In cases where a federal effort aims to enhance grid resiliency as part of a broader effort, we will focus on the part of the effort aimed at enhancing grid resiliency.
- We do not consider individual projects within an overall effort—such as specific grant awards, agreements, or contracts—to be efforts in themselves.
- We consider reliability standards ordered or approved by the Federal Energy Regulatory Commission to be within our scope if those standards aim exclusively or in part to enhance grid resiliency.
- We are excluding any federal efforts that may indirectly enhance grid resiliency but do not have that outcome as a specific emphasis or focus.
- We are also excluding federal efforts aimed solely at enhancing the resiliency of an agency's own electricity infrastructure assets.

Your agency provided the following information about this effort to enhance grid resiliency:

Name of Effort: [Pre-populated information]

Implementing Agency: [Pre-populated information]

Implementing Office: [Pre-populated information]

1. Is the information provided above about this effort correct?

Yes ☐

No ☐

If you answered No, what information is incorrect, and what is the correct information?
Please use the space provided below.



**Appendix I: GAO's Questionnaire for Federal
Agencies with Efforts Aimed at Enhancing the
Resilience of the Electricity Grid**

QUESTIONS ABOUT FEDERAL GRID RESILIENCY EFFORTS – [PRE-POPULATED INFORMATION]

2. What were the effort's goals, and which of those goals have a specific emphasis or focus on enhancing the resiliency of the electricity grid? Please attach a copy to your reply email, or provide weblinks in the space below, to relevant documentation, such as program plans and reports, funding opportunity announcements, or requests for proposals.

3. Your agency previously indicated to GAO that this effort was active in fiscal year 2013 or later. Was this effort active at your agency at any time during fiscal year 2013 or later? We consider an effort to be "active" if it was planned, funded, implemented, or authorized in fiscal year 2013 or later, even if the effort is now completed.

Yes ☐

No ☐



If you answered No, please explain in the space provided below.

If you would like to explain your response to this question, please use the space provided below.

Appendix I: GAO’s Questionnaire for Federal Agencies with Efforts Aimed at Enhancing the Resilience of the Electricity Grid

QUESTIONS ABOUT FEDERAL GRID RESILIENCY EFFORTS – [PRE-POPULATED INFORMATION]

4. As of June 2016, are the effort’s activities aimed at enhancing grid resiliency ongoing, planned but not started, or completed or ended? (Select one)		
Ongoing	<input type="checkbox"/>	<div>→</div> <div>If it is <u>ongoing</u>, what month and year did it start? Month Start <input type="text"/> Year Start <input type="text"/> If this ongoing effort has an estimated end date, please provide that estimate here: <input type="text"/> If this ongoing effort does not have an estimated end date, please explain why in the space provided below. <input type="text"/></div>
Planned but Not Started	<input type="checkbox"/>	<div>→</div> <div>If it is <u>planned but not started</u>, what month and year will it start? Month <input type="text"/> Year <input type="text"/></div>
Completed or Ended	<input type="checkbox"/>	<div>→</div> <div>If it <u>completed or ended</u>, what month and year did it start and end? Month Start <input type="text"/> Year Start <input type="text"/> Month End <input type="text"/> Year End <input type="text"/></div>

5. Is this a formal joint effort with other federal agencies, states, private industry, academia, or other parties?

Yes ☐

No ☐

↓

If you answered Yes, please use the space provided to list the other federal agencies, states, private industry, academia, or other parties and describe their role in the joint effort. If any of those entities are Department of Energy (DOE) national laboratories, please list each of those national laboratories and describe their role in the effort.

QUESTIONS ABOUT FEDERAL GRID RESILIENCY EFFORTS – [PRE-POPULATED INFORMATION]

6. The PPLD-21 definition of resilience includes three aspects of resilience: (1) the ability to prepare for and adapt to changing conditions; (2) the ability to withstand disruptions; and (3) the ability to recover rapidly from disruptions. Which of these aspects of resilience are addressed by this effort?

	Yes	No
a) Ability to prepare for and adapt to changing conditions? <i>We consider the ability to prepare for and adapt to changing conditions to include preparedness activities taken to define the hazard environment and mitigation activities taken prior to an event to reduce the severity or consequences of a hazard.</i>	<input type="checkbox"/>	<input type="checkbox"/>
b) Ability to withstand disruptions? <i>We consider the ability to withstand disruptions to include response activities taken to manage the adverse effects of an event.</i>	<input type="checkbox"/>	<input type="checkbox"/>
c) Ability to recover rapidly from disruptions? <i>We consider the ability to recover rapidly from disruptions to include activities designed to effectively and efficiently return conditions to a level that is acceptable after a disruption.</i>	<input type="checkbox"/>	<input type="checkbox"/>

If you would like to explain your response to this question, please use the space provided below.

7. Which type(s) of threat or hazard is addressed by this effort?

	Yes	No
a) Cyber Attack?	<input type="checkbox"/>	<input type="checkbox"/>
b) Natural Hazard?	<input type="checkbox"/>	<input type="checkbox"/>
c) Operational Accident?	<input type="checkbox"/>	<input type="checkbox"/>
d) Physical Attack?	<input type="checkbox"/>	<input type="checkbox"/>
e) Other?	<input type="checkbox"/>	<input type="checkbox"/>



If you answered Other, please use the space provided to describe the type of threat or hazard addressed by this effort.

Appendix I: GAO’s Questionnaire for Federal Agencies with Efforts Aimed at Enhancing the Resilience of the Electricity Grid

QUESTIONS ABOUT FEDERAL GRID RESILIENCY EFFORTS – [PRE-POPULATED INFORMATION]

8. The federal government’s 2015 Energy Sector-Specific Plan identified three key priorities for the electricity subsector that contribute to national and energy sector critical infrastructure security and resilience goals: (1) Tools and Technology; (2) Information Flow; and (3) Incident Response. Which electricity subsector priorities identified in the 2015 Energy Sector-Specific Plan are addressed by this effort, if any?

	Yes	No
a) Tools and Technology? <i>Deploying tools and technologies to enhance situational awareness and security of critical infrastructure.</i>	<input type="checkbox"/>	<input type="checkbox"/>
b) Information Flow? <i>Making sure actionable intelligence and threat indicators are communicated between the government and industry in a time-sensitive manner.</i>	<input type="checkbox"/>	<input type="checkbox"/>
c) Incident Response? <i>Planning and exercising coordinated responses to an attack.</i>	<input type="checkbox"/>	<input type="checkbox"/>

If you would like to explain your response to this question, please use the space provided below.

9. Does this effort address the bulk power system? The bulk power system refers to facilities and control systems necessary for operating the electric transmission network and generation facilities needed for reliability.

Yes☐
No☐

10. Does this effort address the distribution system? The distribution system refers to all the facilities and equipment connecting a transmission system to a customer’s equipment.

Yes☐
No☐

Appendix I: GAO's Questionnaire for Federal Agencies with Efforts Aimed at Enhancing the Resiliency of the Electricity Grid

QUESTIONS ABOUT FEDERAL GRID RESILIENCY EFFORTS – [PRE-POPULATED INFORMATION]

11. What types of activities does the part of this effort that is focused on enhancing the resiliency of the electricity grid include?

	Yes	No
a) Emergency Preparedness and Response? <i>Emergency preparedness includes activities such as coordination, planning, training, and exercise programs conducted to prepare for potential disaster response operations. Emergency response includes activities such as providing situational awareness during an event; coordinating response efforts; and helping facilitate system restoration.</i>	<input type="checkbox"/>	<input type="checkbox"/>
b) Information Sharing? <i>Information sharing includes activities that facilitate the timely sharing of threat information between federal agencies and the energy sector.</i>	<input type="checkbox"/>	<input type="checkbox"/>
c) Institutional Support and Technical Assistance? <i>Institutional support and technical assistance includes activities such as building capacity in the industry; convening stakeholders to coordinate efforts; and providing technical assistance to improve policies and programs.</i>	<input type="checkbox"/>	<input type="checkbox"/>
d) Modeling, Analytics, and Risk Assessment? <i>Modeling, analytics, and risk assessment include activities such as modeling, simulation, and analysis of electricity grid risks, vulnerabilities, interdependencies, and event consequences.</i>	<input type="checkbox"/>	<input type="checkbox"/>
e) Research and Development? <i>Research and development includes activities that pursue tools, technologies, and demonstrations aimed at bringing new and innovative technologies to maturity and helping them transition to industry.</i>	<input type="checkbox"/>	<input type="checkbox"/>
f) Standard Setting? <i>Standard setting include activities such as the development or approval of legally-binding or voluntary standards for industry, the adoption of which are expected to, at least in part, lead to actions that enhance the resiliency of the electricity grid.</i>	<input type="checkbox"/>	<input type="checkbox"/>
g) Other?	<input type="checkbox"/>	<input type="checkbox"/>

↓
If you checked other, please describe the types of activities in the space below:

If you would like to explain your response to this question, please use the space provided below.

Appendix I: GAO’s Questionnaire for Federal Agencies with Efforts Aimed at Enhancing the Resilience of the Electricity Grid

QUESTIONS ABOUT FEDERAL GRID RESILIENCY EFFORTS – [PRE-POPULATED INFORMATION]

12. How important are each of the following activities for the federal government to pursue to enhance the resiliency of the electricity grid? Please see the previous question for the definitions of each activity.				
	Not at all important	Somewhat important	Moderately important	Very important
a) Emergency Preparedness and Response?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
b) Information Sharing?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
c) Institutional Support and Technical Assistance?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
d) Modeling, Analytics, and Risk Assessment?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
e) Research and Development?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
f) Standard Setting?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
g) Other?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

↓
If you checked other, please describe the types of activities in the space below:

If you would like to provide any detail or explanation of your ratings in question 12, please use the space provided below.

Appendix I: GAO's Questionnaire for Federal Agencies with Efforts Aimed at Enhancing the Resilience of the Electricity Grid

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13. If your effort includes Research and Development activities, please indicate which of the R&D priorities for Energy Sector resilience identified in the 2015 Energy Sector-Specific Plan are addressed by your effort, if any.

	Yes	No
a) Enhance System Design for Resiliency? <i>According to the 2015 Energy Sector-Specific Plan, innovative R&D is needed for cost-effective hardening measures (e.g., new materials and higher design and construction standards), as well as for resilient design tools to enable energy infrastructure designers to prioritize cost-effective system upgrades and expansions to minimize social consequences.</i>	<input type="checkbox"/>	<input type="checkbox"/>
b) Improve Preparedness and Mitigation Measures? <i>According to the 2015 Energy Sector-Specific Plan, this includes new tools for resilience assessment, monitoring of predictive failure modes of energy equipment and systems (such as synchrophasors and frequency disturbance recorders for monitoring conditions of power delivery networks), and damage prediction models. Improved flexibility and robustness measures such as power electronic-based controllers, energy storage, and microgrids have also been identified.</i>	<input type="checkbox"/>	<input type="checkbox"/>
c) Improve System Response and Recovery? <i>According to the 2015 Energy Sector-Specific Plan, improved situational awareness and its prerequisite of a resilient communications infrastructure are two key areas needed for strengthening Energy Sector resilience over the next ten years. Other R&D areas include new energy management systems and optimization tools for restoration prioritization.</i>	<input type="checkbox"/>	<input type="checkbox"/>
d) Analyze and Manage Interdependencies? <i>According to the 2015 Energy Sector-Specific Plan, a comprehensive framework for interdependency modeling and simulation can support the integration of multiple disparate models and simulations to conduct cross infrastructure analysis to address the threat assessment, preparedness, mitigation, response, and recovery issues. This type of framework can build on models and simulation tools already available to address aspects of individual infrastructure.</i>	<input type="checkbox"/>	<input type="checkbox"/>

If you would like to explain your response to this question, please use the space provided below.

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QUESTIONS ABOUT FEDERAL GRID RESILIENCY EFFORTS – [PRE-POPULATED INFORMATION]

SECTION II: FUNDING FOR THE EFFORT

We're interested in how much money goes toward the grid resiliency activities your effort supports so we can report obligations data across all federal efforts that were active in fiscal year 2013 or later. If necessary, please consult with staff in your agency's budget office to answer these funding-related questions.

Note: Please provide copies of supporting documentation for the numbers you provide below.

For questions in this section, please use the following definition of a federal obligation:

An obligation is a definite commitment that creates a legal liability of the government for the payment of goods and services ordered or received, or a legal duty on the part of the United States that could mature into a legal liability. Payment may be made immediately or in the future. An agency incurs an obligation, for example, when it places an order, signs a contract, awards a grant, purchases a service, or takes other actions that require the government to make payments to the public or from one government account to another.

What were the total federal obligations for your effort's grid resiliency activities in the following fiscal years? Enter \$0 if there were no federal obligations in a given fiscal year.

	14. Total federal obligations for the effort's grid resiliency activities	15. Did this data come from a data system?	16. Check if you are unable to provide obligations data
a) Total for fiscal years prior to FY2013:	\$ <input type="text"/>	Yes <input type="checkbox"/> No <input type="checkbox"/>	<input type="checkbox"/>
b) FY2013:	\$ <input type="text"/>	Yes <input type="checkbox"/> No <input type="checkbox"/>	<input type="checkbox"/>
c) FY2014:	\$ <input type="text"/>	Yes <input type="checkbox"/> No <input type="checkbox"/>	<input type="checkbox"/>
d) FY2015:	\$ <input type="text"/>	Yes <input type="checkbox"/> No <input type="checkbox"/>	<input type="checkbox"/>
e) FY2016: (as of the end of the first quarter)	\$ <input type="text"/>	Yes <input type="checkbox"/> No <input type="checkbox"/>	<input type="checkbox"/>

17. If you were unable to provide federal obligations data for any of the years (i.e. you checked the box in the last column in the table above for one of the years), please explain why in the space below.

Total for fiscal years prior to FY2013:
FY2013:
FY2014:
FY2015:
FY2016 (as of the end of the first quarter):

QUESTIONS ABOUT FEDERAL GRID RESILIENCY EFFORTS – [PRE-POPULATED INFORMATION]

18. In addition to federal obligations, some efforts may receive funding from non-federal sources. If your effort received funding from non-federal sources, please identify the amount of that funding and the source(s) of that funding in the space below. Enter \$0 if there was no funding from non-federal sources in a given fiscal year.

Total for fiscal years prior to FY 2013: \$

FY 2013: \$

FY 2014: \$

FY 2015: \$

FY 2016 (as of the end of the first quarter): \$

19. What was the total funding for this effort over its lifecycle, taking into account all funding sources? If the effort is not complete, please provide the current estimate of its expected total funding.

\$

20. If you provided federal obligations data, did all of the data come from a data system (i.e., you answered ‘yes’ to all the questions in question 15 for each year relevant to your effort)?

Yes ☐

No ☐

↓
If you answered No, which year’s data did come from a data system?

If you answered No, what is the source of the data if it did not come from a data system?

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QUESTIONS ABOUT FEDERAL GRID RESILIENCY EFFORTS – [PRE-POPULATED INFORMATION]

Government auditing standards require us to assess the reliability of any computer-processed data we plan to report. If any of the federal obligations data you reported in question 14 came from a data system, please answer the following questions about the data system and the steps you take to ensure the data are accurate and complete.

If necessary, please consult with staff in your agency's budget office to answer these funding-related questions.

21. What procedures ensure that the data system consistently captures all data occurrences (records, observations) and all data elements?

22. Is there written documentation of these procedures?

23. Does the system have any edit checks or controls to help ensure the data are entered accurately?

24. Are there other procedures for ensuring data are accurate and complete?

25. What are the procedures for follow-up if any errors are found, and who is responsible for correcting them?

26. What is your opinion of the quality of the data, specifically its completeness and accuracy? For example, are there any data limitations, such as data elements that are often incomplete or incorrect?

27. If needed, please use the space provided below to provide further details about your answers in Section II of this questionnaire.

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QUESTIONS ABOUT FEDERAL GRID RESILIENCY EFFORTS – [PRE-POPULATED INFORMATION]

SECTION III: RESULTS OF THE EFFORT

We're interested in the results of your effort as they relate to enhancing the resiliency of the electricity grid.

Note: Please provide copies of supporting documentation for the results you describe below, including any relevant performance reports, lessons learned reports, or other documents.

28. Please use the space below to describe the goals or objectives of your effort related to enhancing the resiliency of the electricity grid.

29. Does your effort aim to achieve specific targets or outcomes related to enhancing the resiliency of the electricity grid?

Yes ☐ → If you answered Yes, what are the specific targets or outcomes?

No..... ☐ → If you answered No, please use the space provided to describe in broad terms what your effort aims to achieve related to enhancing the resiliency of the electricity grid.

30. To what extent has your effort achieved the specific targets or outcomes identified in question 29? If your effort will not be able to achieve a specific target or outcome, please briefly explain why and the impact of that on accomplishing the effort's goals and objectives identified in question 28.

31. Outside of the specific targets or outcomes we asked about in questions 29 and 30, can you describe any other results of your effort?

32. Are there specific areas where additional federal investment is needed to enhance grid resiliency?

QUESTIONS ABOUT FEDERAL GRID RESILIENCY EFFORTS – [PRE-POPULATED INFORMATION]

SECTION IV: COORDINATION OF THE EFFORT

The Congress and GAO are interested in understanding how agencies coordinate internally and with other federal agencies, states, and private industry to enhance grid resiliency and to avoid duplication of effort.

Some examples of coordination activities include the following:

- Working groups that cross organizational boundaries and meet regularly to coordinate and establish mutually reinforcing or joint strategies for related efforts;
- Mechanisms that monitor, evaluate, and report results across related efforts; and
- Processes that identify and address needs in a related area by leveraging resources across organizational boundaries.

33. Do you or staff from this effort coordinate with other grid resiliency efforts within your agency or with other federal agencies? For the purposes of this engagement, we consider DOE national laboratories to be organizations within DOE.

Yes ☐

No ☐

↓

If you answered Yes to the above question, please provide up to three examples in the table below of how you coordinate within your agency or with other federal agencies.

Description of Coordination Activities	Name of agency(s) coordinating with
a. <div></div>	<div></div>
b. <div></div>	<div></div>
c. <div></div>	<div></div>

QUESTIONS ABOUT FEDERAL GRID RESILIENCY EFFORTS – [PRE-POPULATED INFORMATION]

34. Do you or staff from this effort coordinate with states on your grid resiliency activities?

Yes☐
No☐

If you answered Yes to the above question, please provide up to three examples in the table below of how you coordinate with states.

Description of Coordination Activities	Name of state(s) coordinating with
a. <input type="text"/>	<input type="text"/>
b. <input type="text"/>	<input type="text"/>
c. <input type="text"/>	<input type="text"/>

35. Do you or staff from this effort coordinate with industry on your grid resiliency activities?

Yes☐
No☐

If you answered Yes to the above question, please provide up to three examples in the table below of how you coordinate with industry.

Description of Coordination Activities	Name of industry entity(s) coordinating with
a. <input type="text"/>	<input type="text"/>
b. <input type="text"/>	<input type="text"/>
c. <input type="text"/>	<input type="text"/>

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QUESTIONS ABOUT FEDERAL GRID RESILIENCY EFFORTS – [PRE-POPULATED INFORMATION]

36. Does your office or agency collect information on other grid resiliency efforts that are active within your agency, in other federal agencies, or in private industry, to ensure your effort does not duplicate another effort?

- Yes ☐
No ☐
Don't Know... ☐

If you answered Yes, please explain how your office or agency collects the information and how your agency assesses the information.

37. What other federal efforts, if any, are you aware of that are similar to your effort in terms of what they aim to achieve to enhance grid resiliency? Please provide the names of the effort(s) and the agency implementing the effort(s) in the space below, and describe how you coordinate with officials responsible for the effort(s), if at all.

38. What industry efforts, if any, are you aware of that are similar to your effort in terms of what they aim to achieve to enhance grid resiliency? Please provide the names of the initiative(s) and the entity(s) implementing them in the space below and describe how you coordinate with the entity(s) responsible for that effort, if at all.

39. Is there additional coordination related to federal grid resiliency efforts that you believe is important but is not being done? If so, please describe in the space below.

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QUESTIONS ABOUT FEDERAL GRID RESILIENCY EFFORTS – [PRE-POPULATED INFORMATION]

SECTION V: OTHER INFORMATION

- 40.** We have reviewed the description of your effort on the agency's website. **If there is additional programmatic information you would like to provide, please use the space below or attach documentation to the email transmitting your responses to this questionnaire.**

- 41.** Please list in the space below the supporting documents you are emailing us in addition to your completed questionnaire.

- 42.** Please provide the contact information for a representative from your agency for any follow-up questions we may have about this questionnaire:

Name:
Title:
Agency:
Office/Division:
Email:
Phone:

- 43.** Please use the space below for any additional information on our topic or any additional explanation of your answers you want to provide that was not covered earlier in the questionnaire. Alternatively, you can suggest that further discussion about this effort be conducted through follow-up conversations with GAO.

Please remember to attach the completed questionnaire and any other supporting documentation to your reply email to [Pre-populated information] and [Pre-populated information].

Thank you for your time!

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Appendix II: Characteristics of Efforts to Enhance the Resilience of the Electricity Grid at Three Federal Agencies

We identified 27 efforts across three agencies—the Department of Energy (DOE), the Department of Homeland Security (DHS), and the Federal Energy Regulatory Commission (FERC)—that aimed to enhance the resilience of the electricity grid. Tables 6, 7, and 8 provide descriptions of the efforts at each agency as agency officials reported in their responses to our questionnaire and as we identified in agency documents.

Table 6: Department of Energy (DOE) Reported Grid Resiliency Efforts

Effort name and implementing office	Description	Results	Total obligations for grid resiliency activities, fiscal years 2013-2015 (dollars)
Advanced Research Projects Agency—Energy			
Grid-Scale Rampable Intermittent Dispatchable Storage (GRIDS) Program	According to DOE officials, the GRIDS Program focuses on developing new grid-scale energystorage technologies—such as batteries, flow batteries, and flywheels—to balance short-duration variability in renewable generation. The GRIDS Program aims to develop new, low-cost storage technologies that will allow the electricity grid to adapt to changing conditions created by renewable generation	According to DOE officials, the GRIDS Program has led to the development of several batteries that have been turned into products and deployed on the electricity grid. The program also has led to the formation of new U.S.-based companies that produce and market advanced energy storage devices, which are expected to better ensure that replacement equipment is available if needed.	2,980,705
Office of Electricity Delivery and Energy Reliability			
Cybersecurity for Energy Delivery Systems (CEDS) Program	According to DOE officials, the CEDS Program helps the energy sector by developing cybersecurity solutions for energy delivery systems through integrated planning and a focused research and development effort.	According to DOE officials, the CEDS Program has supported more than 30 research and development projects that have led to the deployment of tools and advanced technologies that enhance the security of the nation's energy delivery systems.	114,866,205
Cybersecurity Risk Information Sharing Program (CRISP)	According to DOE officials, CRISP uses advanced technologies and innovative analytical capabilities to facilitate collaboration within the energy sector through robust two-way information sharing that provides energy sector partners with targeted, actionable information to facilitate requirement setting, detection, prevention, mitigation, and rapid response to emerging cyber threats.	According to DOE officials, energy sector participation in CRISP has increased, which has led to greater information sharing and enhanced resilience of the electricity grid.	38,742,000

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Effort name and implementing office	Description	Results	Total obligations for grid resiliency activities, fiscal years 2013-2015 (dollars)
Electric Distribution Grid Resilience Research and Development Program	According to DOE officials, the Electric Distribution Grid Resilience Research and Development Program aims to meet the research and development needs for a resilient electric distribution grid, with the goal of contributing to a 10 percent reduction in the economic costs of power outages by 2025.	According to DOE officials, the program has demonstrated a grid design decision support tool that is intended to enhance the resilience of a distribution feeder against wind and flood hazards.	4,150,000
Electricity Subsector Cybersecurity Capability Maturity Model (ES- C2M2)	According to DOE officials, the ES-C2M2 effort is a public-private partnership that is designed to facilitate improvements in the cybersecurity capabilities of the electricity subsector and to enhance understanding of the cybersecurity posture of the electricity grid. The effort helps organizations evaluate, prioritize, and improve their own cybersecurity capabilities.	According to DOE officials, DOE has provided ES-C2M2 tool kits to companies since 2012. Owners and operators of the electricity grid are using ES-C2M2 assessments to prioritize security actions and investments, monitor their progress, and quantify cyber risks for insurance purposes.	3,602,346
Energy Storage Program	According to DOE officials, the Energy Storage Program has a number of projects that are relevant to grid resilience, including analyses to enhance the stability and resilience of island grids; improve dynamic instabilities in large area grids; improve the security and resilience of military microgrids; and improve the stability, reliability, and resilience of networks to accommodate increasing renewable portfolio standards.	According to DOE officials, the Energy Storage Program has supported the deployment of energy storage technologies that provide enhanced grid stability and resilience.	6,691,000
Infrastructure Security and Restoration Program (ISER)	According to DOE officials, ISER implements DOE's efforts to enhance energy sector preparedness, response, and recovery. ISER serves as a point of entry for energy sector security and resiliency stakeholders, including other federal agencies, state, local, tribal, and territorial partners, and the private sector. Through the ISER programs, stakeholders are able to develop a common understanding of threats and hazards, enhance mitigation strategies, build and validate response capabilities, and improve access to recovery capabilities.	According to DOE officials, ISER provides continuous monitoring of the nation's energy infrastructure and analysis of historical and real-time situations affecting the infrastructure; ISER conducts this monitoring through the development and use of capabilities such as a real-time monitoring system, a collaboration tool, developing analysis reports, and publishing an annual energy incident report.	18,924,408

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Effort name and implementing office	Description	Results	Total obligations for grid resiliency activities, fiscal years 2013-2015 (dollars)
Microgrid Research and Development Program	According to DOE officials, the Microgrid Research and Development Program aims to develop commercial-scale microgrid systems capable of reducing outage time of required loads at a cost comparable to non-integrated baseline solutions while reducing emissions and improving system energy efficiencies by 2020.	According to DOE officials, simulated and/or emulated testing of microgrid system designs with advanced controllers will be completed in fiscal year 2017. Field demonstrations of microgrid system designs with advanced controllers will begin in fiscal year 2017. In addition, a design support tool for off-grid microgrids will be transferred for use by at least one microgrid designer for a remote community application in fiscal year 2017.	26,853,350
State and Regional Energy Risk Assessment Initiative	According to DOE officials, the State and Regional Energy Risk Assessment Initiative aims to help states better understand risks to their energy infrastructure so they can make informed decisions about their investments, resilience and hardening strategies, and asset management. The initiative is a collaborative effort with the National Association of State Energy Officials, the National Association of Regulatory Utility Commissioners, the National Conference of State Legislatures, and the National Governors Association.	According to DOE officials, DOE has collaborated with Argonne National Laboratory to create energy risk profiles for each state. These profiles address the electricity, petroleum, and natural gas sectors and highlight the most common threats to energy infrastructure. Fifty state energy risk assessments and 5 regional energy risk assessments have been produced and are currently in use by states and other partners, as well as the general public.	225,000
Strategic Transformer Reserve	According to DOE officials, the Strategic Transformer Reserve effort aims to assess the adequacy of the current inventory of spare large, high-power transformers and alternative approaches to increasing the availability of spare transformers, and to develop a plan for Congress on establishing a strategic transformer reserve.	According to DOE officials, DOE has convened meetings with stakeholders to solicit their input and has increased stakeholder understanding of the challenges related to large, high-power transformers. DOE officials told us in January 2017 that they expected to submit their report to Congress in the near future.	750,000

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Effort name and implementing office	Description	Results	Total obligations for grid resiliency activities, fiscal years 2013-2015 (dollars)
Transformer Resilience and Advanced Components (TRAC) Program	According to DOE officials, the TRAC Program aims to ensure the resilience of aging assets; identify new requirements for future grid components; and accelerate the development, demonstration, and deployment of next-generation components to enhance the resilience of the electricity grid.	According to DOE officials, the TRAC Program started in January 2016 and has made technical progress. Several projects have been awarded to national laboratories and a funding opportunity announcement was released in June 2016. These activities are aligned with the goals of the TRAC Program and will produce insights and technical advances that can be used to increase grid resilience.	0 ^a
Total			217,785,014

Source: GAO analysis of DOE-reported data. | GAO-17-153

^aThe Transformer Resilience and Advanced Components Program did not start until fiscal year 2016 and therefore had no obligations from fiscal year 2013 through fiscal year 2015.

Table 7: Department of Homeland Security (DHS) Reported Grid Resiliency Efforts

Effort name and implementing office	Description	Results	Total obligations for grid resiliency activities, fiscal years 2013-2015 (dollars)
Science and Technology Directorate			
Recovery Transformer (RecX) Program	According to DHS officials, the goal of the RecX Program was to design and demonstrate a rapidly deployable large, high-power transformer that could be used to enable rapid recovery of the grid in the event of multiple transformer failures.	According to a DHS document, the RecX transformer was successfully field tested in March 2012. The field test demonstrated RecX's rapid deployment speed by reducing from the typical 8 to 12 weeks to less than 6 days the time needed to transport, install, and energize the transformer.	0 ^a
Resilient Electric Grid Program	According to DHS officials, the Resilient Electric Grid Program uses advanced technologies to increase the reliability, flexibility, and resilience of the nation's grid. For example, officials are developing a new cable that will allow distribution networks to interconnect and share power while eliminating the risk of cascading fault currents.	According to DHS officials, the effort has proven the technology and its capabilities in a laboratory setting and is currently working to install the solution within a host utility's grid for an operational demonstration.	19,594,457

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Effort name and implementing office	Description	Results	Total obligations for grid resiliency activities, fiscal years 2013-2015 (dollars)
Solar Storm Mitigation	According to DHS officials, the Solar Storm Mitigation effort aims to provide owners and operators of the electricity grid with advanced and actionable information about anticipated geomagnetically induced current levels in the event of a solar storm.	According to DHS officials, the effort has developed a forecasting capability that is currently undergoing verification and validation testing. Lack of significant solar storms creates a lack of data against which to test the forecasting capability; historical data is being used where applicable.	2,217,089
Total			21,811,546

Source: GAO analysis of DHS-reported data. | GAO-17-153

^aDHS reported that no funds were obligated for the Recovery Transformer program from fiscal year 2013 through fiscal year 2015. However, the agency also reported that a total of \$6,794,050 had been obligated for the program in fiscal years prior to fiscal year 2013.

Table 8: Federal Energy Regulatory Commission (FERC) Reported Grid Resiliency Efforts

Effort name	Description	Results
Grid Assurance LLC, Spare Transmission Equipment Service Petition	According to FERC officials and documents, the effort's goal was to act on a private company's petition for regulatory findings related to the company's plan to establish a subscription service for spare critical transmission equipment, including transformers.	FERC acted on Grid Assurance's petition related to the company's proposed spare critical transmission equipment service.
Reliability Standard CIP-003-6 (Security Management Control)	According to FERC officials, the purpose of the CIP-003-6 reliability standard is to specify consistent and sustainable security management controls that establish responsibility and accountability to protect bulk electric system cybersystems against compromise that could lead to the misoperation of or instability in the bulk electric system.	FERC has approved the proposed reliability standard so that it is mandatory and enforceable.
Reliability Standard CIP-004-6 (Personnel and Training)	According to FERC officials, the purpose of the CIP-004-6 reliability standard is to minimize the risk against compromise that could lead to the misoperation of or instability in the bulk electric system from individuals accessing bulk electric system cybersystems; this standard aims to do so by requiring an appropriate level of personnel risk assessment, training, and security awareness in support of protecting bulk electric system cybersystems.	FERC has approved the proposed reliability standard so that it is mandatory and enforceable.

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Effort name	Description	Results
Reliability Standard CIP-005-5 (Electronic Security Perimeters)	According to FERC officials, the purpose of the CIP-005-5 reliability standard is to manage electronic access to bulk electric system cybersystems by specifying a controlled electronic security perimeter in support of protecting these cybersystems against compromise that could lead to the misoperation of or instability in the bulk electric system.	FERC has approved the proposed reliability standard so that it is mandatory and enforceable.
Reliability Standard CIP-006-6 (Physical Security of Bulk Electric System Cyber Systems)	According to FERC officials, the purpose of the CIP-006-6 reliability standard is to manage physical access to bulk electric system cybersystems by specifying a physical security plan in support of protecting these cybersystems against compromise that could lead to the misoperation of or instability in the bulk electric system.	FERC has approved the proposed reliability standard so that it is mandatory and enforceable.
Reliability Standard CIP-007-6 (Systems Security Management)	According to FERC officials, the purpose of the CIP-007-6 reliability standard is to manage system security by specifying select technical, operational, and procedural requirements in support of protecting bulk electric system cybersystems against compromise that could lead to the misoperation of or instability in the bulk electric system.	FERC has approved the proposed reliability standard so that it is mandatory and enforceable.
Reliability Standard CIP-008-5 (Incident Reporting and Response Planning)	According to FERC officials, the purpose of the CIP-008-5 reliability standard is to mitigate the risk to the reliable operation of the bulk electric system as a result of a cybersecurity incident; this standard aims to do so by specifying incident response requirements.	FERC has approved the proposed reliability standard so that it is mandatory and enforceable.
Reliability Standard CIP-009-6 (Recovery Plans for Bulk Electric System Cyber Systems)	According to FERC officials, the purpose of the CIP-009-6 reliability standard is to recover reliability functions performed by bulk electric system cybersystems by specifying recovery plan requirements in support of the continued stability, operability, and reliability of the bulk electric system.	FERC has approved the proposed reliability standard so that it is mandatory and enforceable.
Reliability Standard CIP-010-2 (Configuration Change Management and Vulnerability Assessments)	According to FERC officials, the purpose of the CIP-010-2 reliability standard is to prevent and detect unauthorized changes to bulk electric system cybersystems by specifying configuration change management and vulnerability assessment requirements in support of protecting bulk electric system cybersystems from compromise that could lead to the misoperation of or instability in the bulk electric system.	FERC has approved the proposed reliability standard so that it is mandatory and enforceable.
Reliability Standard CIP-011-2 (Information Protection)	According to FERC officials, the purpose of the CIP-011-2 reliability standard is to prevent unauthorized access to bulk electric system cybersystem information by specifying information protection requirements in support of protecting bulk electric system cybersystems against compromise that could lead to the misoperation of or instability in the bulk electric system.	FERC has approved the proposed reliability standard so that it is mandatory and enforceable.

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Effort name	Description	Results
Reliability Standard CIP-014-2 (Physical Security)	According to a FERC document, the purpose of the CIP-014-2 reliability standard is to identify and protect transmission stations and transmission substations, and their associated primary control centers that, if rendered inoperable or damaged as a result of a physical attack, could result in instability, uncontrolled separation, or cascading within an interconnection.	FERC has approved the proposed reliability standard so that it is mandatory and enforceable.
Reliability Standard EOP-010-1 (Geomagnetic Disturbance Operations)	According to a FERC document, the purpose of the EOP-010-1 reliability standard is to mitigate the effects of geomagnetic disturbance events by implementing operating plans, processes, and procedures.	FERC has approved the proposed reliability standard so that it is mandatory and enforceable.
Reliability Standard TPL-007-1 (Transmission System Planned Performance for Geomagnetic Disturbance Events)	According to a FERC document, the purpose of the TPL-007-1 reliability standard is to establish requirements for transmission system planned performance during geomagnetic disturbance events.	FERC has approved the proposed reliability standard, but it is not yet being enforced.

Source: GAO analysis of FERC-reported data. | GAO-17-153

Note: FERC officials reported that the agency could not provide obligation data for its grid resiliency efforts because FERC could not break down by individual reliability standard the costs associated with reviewing and approving reliability standards.

Appendix III: GAO Contact and Staff Acknowledgments

GAO Contact

Frank Rusco, (202) 512-3841 or ruscof@gao.gov

Staff Acknowledgments

Other key contributors to this report were Jon Ludwigson, Assistant Director; Stephanie Gaines; and David Marroni. Important contributions were also made by Ben Atwater, Antoinette Capaccio, Nancy Crothers, Laura Durland, Philip Farah, Cindy Gilbert, Brian Lepore, Dan Royer, Stephen Sanford, Marylynn Sergent, Maria Stattel, Barbara Timmerman, and Greg Wilshusen.

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