A POLICY FRAMEWORK FOR THE 21st CENTURY GRID:

Enabling Our Secure Energy Future

JUNE 2011

Executive Office of the President of the United States

National Science and Technology Council

EXECUTIVE OFFICE OF THE PRESIDENT
NATIONAL SCIENCE AND TECHNOLOGY COUNCIL
WASHINGTON, D.C. 20502

June 13, 2011

Dear Colleagues:

We are pleased to transmit the report "A Policy Framework for the 21st Century Grid: Enabling Our Secure Energy Future." This report outlines policy recommendations that build upon the Energy Independence and Security Act of 2007 and the Obama Administration's smart grid investments to foster long-term investment, job growth, innovation, and help consumers save money. The report was prepared by the Subcommittee on Smart Grid of the National Science and Technology Council, Committee on Technology.

A 21st century electric system is essential to America's ability to lead the world and create jobs in the clean-energy economy of the future. The Administration has made unprecedented investments in clean-energy technologies and grid modernization. For example, as part of the Recovery Act, the Nation invested more than $4.5 billion for electricity delivery and energy reliability modernization. This report highlights further efforts that are needed to take advantage of opportunities made possible by modern information, energy, and communications technology. It also provides a policy framework that promotes cost-effective investment, fosters innovation to spur the development of new products and services, empowers consumers to make informed decisions with better energy information, and secures the grid against cyber attacks.

Facilitating a smarter and more secure grid will require sustained cooperation among the private sector, state and local governments, the Federal Government, consumer groups, and other stakeholders. Such progress is important to ensure that the United States is a world leader in the 21st century economy, is at the forefront of the clean energy revolution, and wins the future by encouraging innovation.

Sincerely,

Aneesh Chopra CoT Co-chair and Chief Technology Officer of the United States and Associate Director for Technology, Office of Science and Technology Policy	Vivek Kundra CoT Co-chair and Chief Information Officer of the United States, Office of Management and Budget	Phil Weiser CoT Co-chair and Senior Advisor for Technology and Innovation, National Economic Council

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List of Acronyms

ADEPT	Agile Delivery of Electrical Power Technology
AEP	American Electric Power
AMI	Advanced Metering Infrastructure
AMR	Automatic Meter Reading
APPA	American Public Power Association
ARPA-E	Advanced Research Projects Agency—Energy
BGE	Baltimore Gas and Electric
BPA	Bonneville Power Administration
CSWG	Cyber Security Working Group
DERs	Distributed Energy Resources
DLC	Direct Load Control
DOD	Department of Defense
DOE	Department of Energy
EEI	Edison Electric Institute
EISA	Energy Independence and Security Act
EMS	Energy Management System
EPRI	Electric Power Research Institute
EVs	Electric Vehicles
FERC	Federal Energy Regulatory Commission
FIPPs	Fair Information Practice Principles
FY	Fiscal Year
GSA	General Services Administration
GW	Gigawatt
GRIDS	Grid-Scale Rampable Intermittent Dispatchable Storage
IEA	International Energy Agency
IEC	International Electrotechnical Commission
IOUs	Investor-Owned Utilities
ISGAN	International Smart Grid Action Network

ITA	International Trade Administration
KIUC	Kaua'i Island Utility Cooperative
MDCP	Market Development Cooperator Program
MW	Megawatt
MWh	Megawatt-Hour
NAFTA	North American Free Trade Agreement
NARUC	National Association of Regulatory Utility Commissioners
NASPI	North American Synchrophasor Initiative
NASUCA	National Association of State Utility Consumer Advocates
NEI	National Export Initiative
NEMA	National Electrical Manufacturers Association
NIST	National Institute of Standards and Technology
NRC	Nuclear Regulatory Commission
NRECA	National Rural Electric Cooperative Association
NREL	National Renewable Energy Laboratory
NSF	National Science Foundation
NSGI	Naperville Smart Grid Initiative
NSTC	National Science and Technology Council
OG&E	Oklahoma Gas & Electric
PAP 10	Priority Action Plan 10
RUS	Rural Utilities Service
SEGIS	Solar Energy Grid Integration Systems
SEGIS-AC	Solar Energy Grid Integration Systems-Advanced Concepts
SETP	Solar Energy Technologies Program
SGIP	Smart Grid Interoperability Panel
SRP	Salt River Project
T&D	Transmission and Distribution
VAR	Volt-Ampere Reactive
WECC	Western Electricity Coordinating Council

Foreword

A smarter, modernized, and expanded grid will be pivotal to the United States' world leadership in a clean energy future. This policy framework focuses on the deployment of information and communications technologies in the electricity sector. As they are developed and deployed, these smart grid technologies and applications will bring new capabilities to utilities and their customers. In tandem with the development and deployment of high-capacity transmission lines, which is a topic beyond the scope of this report, smart grid technologies will play an important role in supporting the increased use of clean energy.

A 21st century clean energy economy demands a 21st century grid. Much of the traditional electricity infrastructure has changed little from the original design and form of the electric grid as envisioned by Thomas Edison and George Westinghouse at the end of the 19th century (EEI 2011, p. 6). In a 21st century grid, smart grid technologies will help integrate more variable renewable sources of electricity, including both utility scale generation systems such as large wind turbines and distributed generation systems such as rooftop solar panels, in addition to facilitating the greater use of electric vehicles and energy storage. Moreover, such technologies will help enable utilities to manage stresses on the grid, such as peak demand, and pass savings on to consumers as a result.

The evolution towards a 21st century grid is already taking place. With the Recovery Act investment of $4.5 billion for electricity delivery and energy reliability modernization efforts, the promise of a smarter grid is becoming a reality. States across the Nation are benefiting from new investments in electricity infrastructure and in consumer-facing devices that promise to vastly reduce energy waste, increase the reliability of the electric grid, and provide consumers with opportunities to save money. In addition, our current investments will enable innovation, creating jobs of the future here in the United States and giving rise to new export opportunities.

The Federal Government, building on the policy direction set forth in the Energy Independence and Security Act of 2007 and the Recovery Act's historic investments in innovation, offers this policy framework to chart a path forward on the imperative to modernize the grid to take advantage of opportunities made possible by modern information, energy, and communications technology. This framework is premised on four pillars:

1. **Enabling cost-effective smart grid investments**
2. **Unlocking the potential for innovation in the electric sector**
3. **Empowering consumers and enabling them to make informed decisions, and**
4. **Securing the grid.**

Each pillar supports a set of policy recommendations that focus on how to facilitate a smarter and more secure grid. Progress in all four areas, as part of an overall grid modernization effort, will require sustained cooperation between the private sector, state and local governments, the Federal Government, consumer groups, and other stakeholders. Such progress is important for the United States to lead the world in the 21st century economy, be at the forefront of the clean energy revolution, and to win the future by encouraging American innovation.

Chapter 1: Introduction and Overview

"Each of us has a part to play in a new future that will benefit all of us. As we recover from this recession, the transition to clean energy has the potential to grow our economy and create millions of jobs—but only if we accelerate that transition. Only if we seize the moment. And only if we rally together and act as one nation—workers and entrepreneurs; scientists and citizens; the public and private sectors."

—President Obama, June 15, 2010

The National Academy of Engineering named electrification the greatest engineering achievement of the 20th century (NAE 2003). To meet America's energy, environmental, and security needs for the 21st century, the United States should continue efforts to upgrade the electric grid. To seize the leadership position in a clean energy revolution, President Obama has set a national goal of generating 80% of our electricity from clean energy sources by 2035 and has reiterated his goal of putting one million electric vehicles on the road by 2015. These goals are part of a strategy to develop and deploy innovative energy technologies and create the energy jobs of tomorrow here in the United States (Office of Press Secretary 2011b). As President Obama has outlined, part of a secure energy future is providing "consumers with choices to reduce costs and save energy" (White House 2011b, pp. 4).

In the face of an aging grid (Chu 2010, p. 13), investing in the grid's infrastructure is crucial. Given this imperative, there is an opportunity to upgrade the grid's efficiency and effectiveness through investments in smart grid technology. Smart grid technologies and applications encompass a diverse array of modern communications, sensing, control, information, and energy technologies that are already being developed, tested, and deployed throughout the grid. In particular, these technologies can be divided into three basic categories: (1) advanced information and communications technologies (including sensors and automation capabilities) that improve the operation of transmission and distribution systems; (2) advanced metering solutions, which improve on or replace legacy metering infrastructure; and (3) technologies, devices, and services that access and leverage energy usage information, such as smart appliances that can use energy data to turn on when energy is cheaper or renewable energy is available.

These technologies and applications give rise to three cross-cutting categories of benefits:

- Facilitating and enabling a clean energy economy with significant use of renewable energy, distributed energy resources, electric vehicles, and electric storage;
- Creating an electricity infrastructure that saves consumers money through greater energy efficiency, as well as supporting the more reliable delivery of electricity; and
- Enabling technological innovation that creates jobs of the future and new opportunities for empowering consumers to use energy wisely and reduce their energy bills.

The Energy Independence and Security Act of 2007 (EISA) (U.S. Congress 2007) made it the policy of the United States to modernize the Nation's electricity transmission and distribution system. President Obama underscored that commitment in the *Blueprint for a Secure Energy Future* (White House 2011b). To advance that policy, The American Recovery and Reinvestment Act of 2009 (Recovery Act) (U.S. Congress 2009) accelerated the development of smart grid technologies, investing $4.5 billion for electricity delivery and energy reliability activities to modernize the electric grid and implement demonstration and deployment programs (as authorized under Title XIII of EISA). To date, the SGIG program has awarded grants to 99 recipients, including private companies, service providers, manufacturers, and cities, with total public-private investment amounting to over $8 billion (DOE 2009d). As these efforts are implemented, they will continue to inform utilities, regulators, and other stakeholders about the best paths toward a smarter grid.

The course and pace of smart grid deployment efforts are naturally varied. There are more than 3,000 electric utilities in the United States (EIA 2007) with diverse needs, regulatory environments, energy resources, and legacy systems. As a number of industry participants have observed, it is thus highly unlikely that a single solution will emerge as appropriate, cost-effective, and useful for all electric utilities and consumers.[1] Rather, the nature, pace, and scope of smart grid deployment efforts will vary according to the needs of different parts of the country. This diversity is a strength of the U.S. model and explains why many states and local governments are already taking leadership roles to act on the national priority to make the grid smarter. To date, 25 states have already adopted policies relating to smart grid technology (NCSL 2011), resulting in "a lot of different smart grids" (McGranaghan 2010). While there is no one-size-fits-all set of smart grid solutions, there are important unifying policy strategies that can advance U.S. leadership in the 21st century clean energy economy. This report outlines such policies and details efforts by the Federal Government and others to advance them.

The policy framework set forth in this report was developed by the National Science and Technology Council (NSTC) Subcommittee on Smart Grid.[2] To develop this framework, the Subcommittee conducted an extensive outreach and research process to identify policies that build on the Administration's smart grid investments and constitute an important part of the Administration's clean energy strategy. Notably, the policies highlighted in this document are just one part of the overall grid modernization effort. In particular, the Administration's smart grid strategy complements its efforts to spur the planning and siting of new high voltage transmission lines and to facilitate the integration of variable renewable energy. While these topics are outside the scope of this document, the Administration recognizes that overall grid modernization efforts are critical to supporting the energy needs of the 21st century.[3]

1. RFI comments from EEI, pp. 5; APPA, pp. 5; NRECA, pp. 5 (noting the varied speed of implementation likely at different rural cooperatives, and noting that a "static definition" of "the Smart Grid" would be problematic). Most RFI comments discussed in this report were submitted in connection with the Request for Information on Addressing Policy and Logistical Challenges to Smart Grid Implementation. The DOE issued the RFI in September 2010; the closing date was November 1, 2010. Comments from all respondents are collected at the URL: http://www.oe.energy.gov/Smart%20Grid%20Request%20for%20Information%20and%20Public%20Comments.htm. For cited RFI comments, readers may access the main URL, and locate the commentary and page number (agencies and individuals are listed there alphabetically).

2. See Appendix A for details on the Subcommittee's outreach and efforts.

3. Advanced information and communication technology can also be used to improve the performance of high-voltage transmission lines. In general, this report focuses on the use of advanced information and communication technologies in the local transmission and distribution sectors. In so doing, it complements the Administration's

This policy framework rests on four pillars for a smarter grid—(1) enabling cost-effective smart grid investments; (2) unlocking the potential of innovation in the electric sector; (3) empowering consumers and enabling informed decision making; and (4) securing the grid from cybersecurity threats. These pillars each support key aspects of the transition to a smarter grid and a clean energy future.

Each pillar has an associated set of key actions:

Pillar 1. Enable Cost-Effective Smart Grid Investments: Smart grid technology can drive improvements in system efficiency, resiliency, and reliability, and help enable a clean energy economy through cost-effective grid investments. Many of these technologies promise to pay for themselves in operational improvements and energy savings. The Federal Government's research, development, and demonstration projects, technical assistance, information sharing on technologies and programs, and evaluations provide valuable guidance for utilities, consumers, and regulators about what approaches are most cost-effective, thereby paving the way for the effective, ongoing upgrade of the grid.

1. **States and Federal regulators should continue to consider strategies to align market and utility incentives with the provision of cost-effective investments that improve energy efficiency.** If utilities do not have a strong incentive to sell less energy and operate more efficiently, they will not see sufficient benefits from investing in certain smart grid applications. Recognizing this issue, state commissions are increasingly confronting questions about regulatory reform options that change utility business models to, for example, make energy efficiency a more central part of their mission.
2. **The Federal Government will continue to invest in smart grid research, development, and demonstration projects.** The benefits of research and development can be shared across all utilities. If one utility performs the research by itself, however, it will bear all of the associated costs. As explained in President Obama's *A Strategy for American Innovation* (White House 2011b), the government can address this issue and facilitate innovation by supporting funding for basic research, maintaining a high-quality intellectual property rights system that offers incentives to industry and university partners, and providing pathways to commercialization.
3. **The Federal Government will continue to support information sharing from smart grid deployments to promote effective cost-benefit investments and remove information barriers.** Creating centralized public repositories for this information can encourage cost-effective investments and reduce duplicative experimentation.

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recognition that these technologies also play an important role in the improved performance of high-voltage transmission lines. For an example of the impact of smart grid technologies on long distance transmission infrastructure, consider that Bonneville Power Administration (BPA) and several leading utilities are partnering with Western Electricity Coordinating Council (WECC) in the deployment of a wide-area synchronized measurement system to monitor the high voltage transmission lines that serve many Western States. To date, the utilities, BPA, and DOE have invested $108 million to implement this system, which will provide grid operators with actionable information that will help improve power system reliability, avoid outages, improve use of transmission capacity, manage congestion, and enable reliable wind integration.

See also: The Transmission Smart Grid Imperative, September 2009 http://www.netl.doe.gov/smartgrid/referenceshelf/whitepapers/The%20Transmission%20Smart%20Grid%20Imperative_2009_09_29.pdf

Pillar 2: Unlock the Potential of Innovation in the Electricity Sector: A modernized electric grid promises to be a powerful platform for new products and services that improve grid operations and deliver convenience and savings to energy customers.

4. **The Federal Government will continue to catalyze the development and adoption of open standards.** The U.S. standards system is private-sector led and bottom-up, with the Federal Government acting as a public-sector partner and a convener. The ongoing smart grid interoperability process, led by the National Institute of Standards and Technology (NIST), is working towards flexible, uniform, and technology-neutral standards that can enable innovation, improve consumer choice, and yield economies of scale. Robust stakeholder participation in the standards process, including by utilities, is desirable to create the most effective technical standards.

5. **Federal, state, and local officials should strive to reduce the generation costs associated with providing power to consumers or wholesale providers during periods of peak demand and encourage participation in demand management programs.** Consumers generally pay time-invariant rates for electricity. Consequently, consumers generally lack the information or incentive to shift their consumption away from times when the costs of providing electricity are high. As a result, utilities spend billions of dollars a year to build, maintain, and operate peaking plants that are used only rarely, typically driven by extreme temperatures or unplanned emergencies. Studies suggest that using smart grid technologies to better manage energy use during the highest demand periods, such as a very hot day in the middle of summer, could save consumers billions of dollars a year.[4] Smoothing these expensive peaks also promises to reduce utilities' operating costs, resulting in additional savings to consumers and utilities.

6. **Federal and state officials should continue to monitor smart grid and smart energy initiatives to protect consumer options and prevent anticompetitive practices.** Facilitating a robust market for devices, energy management services, and applications that interact with the electric grid is critical to enabling innovation in smart grid technologies and applications.

Pillar 3. Empower Consumers and Enable Informed Decision Making: The success of smart grid technologies and applications depends crucially on engaging and empowering both residential and small business consumers in an effective manner. New tools and programs promise to provide consumers personalized information and enable them to make informed energy choices, while ensuring their energy consumption data is accorded privacy protections.

7. **State and Federal policymakers and regulators should evaluate the best means of ensuring that consumers receive meaningful information and education about smart grid technologies and options.** Many state regulators are already requiring education and communication programs as a condition of authorizing smart grid deployments that directly impact consumers. In rolling out such deployments, public-private collaborations, market research, and

4. See Faruqui et al. (2010) and Borenstein (2005). See also: The Brattle Group predicts that energy efficiency and demand response benefits enabled by the smart grid will save between $129 billion and $242 billion from 2010-2030 by reducing the need to invest in new electricity generation (Brattle 2008).

multichannel messaging can help develop meaningful educational materials that enable consumers to make informed choices despite their differing needs, preferences, and motivations.

8. **Building on recent efforts, state policymakers and regulators should continue to consider how to develop policies and strategies to ensure that consumers receive timely access to, and have control over, machine-readable information about their energy consumption in a standard format.** Ensuring that energy usage data are provided swiftly in predictable, automation-friendly formats can maximize consumer access to information.

9. **State and Federal regulators should, in instances where a utility deploys the relevant infrastructure, consider means of ensuring that consumer-facing devices and applications make it easier for users to manage energy consumption.** When regulators are required to be involved in decisions regarding in-home devices, they may want to consider to what degree the proposed smart grid technologies that offer consumers energy usage data and new tools to manage usage are user-friendly.

10. **State and Federal regulators should consider, as a starting point, methods to ensure that consumers' detailed energy usage data are protected in a manner consistent with Fair Information Practice Principles (FIPPs) and develop, as appropriate, approaches to address particular issues unique to energy usage.** FIPPs are widely accepted principles adopted by government agencies and intergovernmental organizations to ensure protection of personal information. The Administration supports legislation that would make FIPPs the baseline for protecting personal data in commercial sectors not currently subject to sector-specific Federal privacy statutes.

11. **State and Federal policymakers and regulators should consider appropriately updating and enhancing consumer protections for smart grid technologies.** As new issues and opportunities develop, policymakers may need to update consumer protection policies built over the last century that ensure adequate notice, the right to dispute bills, and protect health and safety issues related to disconnects, and affordability.

Pillar 4. Secure the Grid: Protecting the electric system from cyber attacks and ensuring it can recover when attacked is vital to national security and economic well-being. Developing and maintaining threat awareness and rigorous cybersecurity guidelines and standards are key to a more secure grid.

12. **The Federal Government will continue to facilitate the development of rigorous, open standards and guidelines for cybersecurity through public-private cooperation.** A critical part of such an effort is to identify and prioritize relevant cyber risks—including malware, compromised devices, insider threats, hijacked systems, etc.—and develop standards and guidelines that enable the design of effective mitigation plans for managing those risks. Consistent with the Administration's model cybersecurity legislation (Schmidt 2011), the overall goal of the effort is to develop policy and regulatory frameworks that ensure that effective and feasible security is appropriately implemented and that all stakeholders contribute to the security and reliability of the grid as a whole.

13. **The Federal Government will work with stakeholders to promote a rigorous, performance-based cybersecurity culture, including active risk management, performance evaluations, and ongoing monitoring.** The grid's cybersecurity protections must be tested thoroughly and regularly to ensure real-time, prioritized protection from potential threats. For this reason, the Administration's approach to electric grid cybersecurity emphasizes the importance of a performance-based culture, including active risk management, performance evaluations (i.e., exercises and simulations to determine security vulnerabilities), and ongoing monitoring.

In addition to setting forth a policy framework for smart grid efforts, this report highlights several new or important ongoing initiatives, including:

- Updated information on the impact of smart grid technology on grid performance and consumer behavior resulting from the Recovery Act funded smart grid grants and demonstration projects, available at www.SmartGrid.gov;
- A series of regional stakeholder meetings, convened by the Department of Energy (DOE)'s Office of Electricity Delivery and Energy Reliability, to stimulate high-quality, peer-to-peer dialogue on smart grid deployments, share lessons learned, and help replicate successes;
- Continuing efforts with stakeholder groups and organizations to apply data derived from Recovery Act projects to advance knowledge of the costs and benefits of smart grid technology;
- A commitment by DOE to expand cooperative relationships with the National Association of Regulatory Utility Commissioners and the National Association of State Utility Consumer Advocates, to continue providing technical assistance to their members and sharing information on consumer empowerment from Recovery Act projects;
- A Smart Grid Innovation Hub, led by DOE, as proposed in the President's Fiscal Year (FY) 2012 Budget request;
- New transformational research and design investments for the grid by the Advanced Research Projects Agency–Energy (ARPA-E);
- New challenges designed to fuel innovation and empower customers, including a Home Energy Education Challenge;
- The release of consumer behavior studies funded by the Recovery Act; and
- New investments in smart grid technologies by the Department of Agriculture's Rural Utilities Service (RUS).

Building a smarter 21st century grid is a process that will unfold over years and even decades. The objective of this report is not to prescribe particular technologies, specific smart grid deployment schedules, or even uniform policy strategies for moving this effort forward. Rather, it provides a policy framework to enable the United States to seize the opportunities available in this area and to address the challenges that will emerge as the Nation transitions to a smarter grid.

Within this framework, the Administration will continue to engage and collaborate with states, industry, consumer advocates, utilities, and other stakeholders to ensure that the grid meets consumers' needs, operates with improved efficiency, security, and resiliency, and is a platform for innovation. To that end, within six months of the release of this Report, DOE will provide the National Science and Technology Council's Committee on Technology a status report on its implementation across smart grid topic areas, including cost-benefit analysis, standards development efforts in partnership with NIST, consumer education, and cybersecurity. Similarly, DOE will continue to identify new policies and technology recommendations related to smart grid implementation.

This report begins by describing where the Nation is today. The heart of the report then discusses the key actions, presenting them within the context of the four overarching policy goals or pillars outlined above. Finally, the report describes the collaboration between various stakeholders and the Federal Government to advance the relevant opportunities for advancing these policy goals.

Chapter 2: Progress to Date

The Energy Independence and Security Act of 2007 made it "the policy of the United States to support the modernization" of the electrical grid (U.S. Congress 2007). Over the last several years, many states and utilities have already taken important steps to take advantage of smart grid technologies and programs to give rise to the potential benefits discussed herein. Typically, these upgrades enable the grid to operate more efficiently.

The Obama Administration has expanded on previous efforts to modernize the grid through the Recovery Act's $4.5 billion investment for electricity delivery and energy reliability activities to modernize the electric grid (U.S. Congress 2009). These funds are being matched by more than $5.5 billion from public and private stakeholders to fund 141 smart grid grants and cooperative agreements for smart grid and energy storage technologies across the country, with additional funding going towards workforce training (Executive Office of the President 2010a, pp. 37, Energy.gov 2011b, Energy.gov 2010c). Moreover, RUS provided a record $7.1 billion in loans in 2010 to support the modernization of the electric infrastructure serving rural America, including more than $152 million for smart meter deployments alone.[5]

Spurred by Recovery Act investments, utilities and state regulators are leading the transition to a smarter grid. In some cases, smart grid technology is being deployed on a broad scale. For example, the Vermont Transco is using Recovery Act funding to institute a statewide meter data management system and modernize the technology used in the state's electricity distribution system (SmartGrid.gov 2010). Similarly, in Texas, following legislation to encourage deployment of smart meters (PUCT 2008), all major transmission and distribution (T&D) providers have public utility commission (PUC)-approved plans in place to deploy Advanced Metering Infrastructure (AMI) in their service areas (PUCT 2011, pp. 3). These T&D service providers have already deployed 2.5 million meters and will have more than 6 million in place by 2015 (PUCT 2011, pp. 3). The new smart meters being deployed in Texas enable consumers to access their timely energy usage data online through a web portal, www.smartmetertexas.com. Consequently, Texans can use the data with third-party devices and services of their choosing to find ways to save money and energy (AEP 2011b).

Case Study:
Salt River Project (SRP), Arizona

Since 2003, SRP has installed approximately 500,000 smart meters in its service area. SRP estimates that this new equipment has enabled it to remotely respond to more than 748,000 customer service requests. As a result, SRP has saved more than 249,000 labor hours by avoiding unnecessary service calls, has avoided 1.3 million unnecessary driving miles, and has conserved 135,000 gallons of fuel. As a consequence of the energy savings, cost reductions, and operational benefits of the smart meters, SRP is now introducing an additional 500,000 meters to its service area with the help of a $56.9 million ARRA Smart Grid Investment Grant.

Source: SRP (2010)

5. $7.1 billion is found in the United States Department of Agriculture, FY 2012 USDA Budget Summary and Annual Performance Plan, http://www.obpa.usda.gov/budsum/FY12budsum.pdf, pp. 48. The $152 million for smart meter deployments is derived from an internal USDA Rural Utilities Service Electric Program analysis of lending over the year.

Case Study:
Tallahassee's Smart Grid for Electricity, Gas & Water

Tallahassee, Florida, through its municipal utility, began examining the possibility of a smart grid in 2005, and received $8.8 million in Smart Grid Investment Grant Recovery Act funds to create a comprehensive demand response program. Tallahassee is deploying smart grid technologies, including 220,000 smart meters, to improve efficiency and allow consumers to remotely control their thermostats and pay lower rates during off-peak hours. The city is using these same smart grid technologies to operate the first combined smart electric, water, and gas system in the United States. As Tallahassee Mayor Jon Marks said, the "Tallahassee consumer will be able to save energy, save water, and save money" because of this system. The city alone is expected to save $1.5 million over 15 years.

Source: Nichols (2010)

Utilities in other states are deploying advanced metering and automation equipment on the distribution infrastructure across most of their service territory to improve operational efficiency,[6] reliability, and to help provide feedback for consumers. In addition to efforts to improve operational energy efficiency, utilities in other states, such as Illinois, have already planned or instituted time-varying rates or rebate programs to take advantage of smart grid technologies that offer consumers a chance to save money by consuming less energy when demand—and the cost to respond to that demand—is at its highest (Edison Foundation 2010a, pp. 2-3; FERC 2010, pp. 4-6, B6).

The Federal commitment to modernize the grid is spurring the efforts of several Federal agencies. Notably, smart grid research programs are underway at DOE national labs (DOE n.d.) and Department of Defense (DOD) military bases (Mabus 2011). Moreover, Federal funding supports cutting-edge research, development, and demonstration of innovative smart grid technologies through DOE, the ARPA-E, the National Science Foundation (NSF), and other organizations. Finally, interoperability and cybersecurity standards are being developed with active engagement from the National Institute of Standards and Technology (NIST), the Department of Homeland Security, and other departments and agencies as appropriate.

The Administration recognizes that in addition to ongoing Federal action, continued efforts by state policymakers and regulators are necessary to ensure that our electric system evolves in a cost-effective fashion, unlocks innovation, empowers consumers, and maintains grid cybersecurity. To that end, a significant thrust of this report involves areas where the Administration can and will work with state policymakers and regulators to advance these goals.

6. Operational efficiency refers to reductions in cost and wasted energy in the production, transmission, and delivery of electricity. Such reductions can be achieved in many ways, including by employing new technologies that help distribute electricity across the grid. Sensors can also facilitate reductions in energy waste by allowing utilities to produce better calibrated amounts of electricity and monitor grid electricity levels in real time to prevent brownouts.

Advanced ("Smart") Metering Technologies

Advanced metering infrastructure (AMI) enables utilities to "collect, measure, and analyze [time-stamped] energy consumption data for grid management, outage notification, and billing purposes via two-way communications" (DOE 2010, pp. 12). AMI architectures can enable additional consumer choice and flexibility in electricity rates and energy saving programs, increase the availability of information consumers can act on, facilitate distributed energy integration and enhance utilities' ability to maintain power quality and respond to outages faster. Since advanced meters can be used to communicate data to consumers as well as to utilities, consumers can use that information to manage their energy consumption. Federal grant awards for advanced metering infrastructure (AMI) deployments under ARRA total $812.6 million to date, with total project values reaching over $2 billion (DOE 2010a). According to the Federal Energy Regulatory Commission (FERC), which defines AMI as "meters that measure and record usage data at hourly intervals or more frequently, and provide usage data to both consumers and energy companies at least once daily," advanced metering penetration increased 85% from 2007 to 2009, and further increases are expected from 31 Recovery Act grants (FERC 2010, pp. 7; FERC 2011a, pp. 6-7).

To be sure, there is no one-size-fits-all approach to deploying standards-compliant smart grid technology; utilities have made different infrastructure investments and have different generation resources and consumer needs. Accordingly, utilities may make their distribution grids smarter and engage consumers in different ways. For example, an alternative to installing AMI is to upgrade existing automatic meter reading (AMR). Another alternative is to use direct load control (DLC) capabilities. Since these systems depend on one-way communications (unlike AMI), they can be lower cost while still offering basic energy management functions.

Source: DOE (2010, pp. 12); NETL (2008, pp. 2-5); FERC (2010, pp. 7); FERC (2011a, pp. 6-7). For more information, see RFI comments from EEI, APPA, and NRECA.

Chapter 3: The Path to Enabling Cost-Effective Smart Grid Investments

"[E]ven if we reduce our oil dependency, and we're producing all these great electric cars, we're going to have to have a plan to change the way we generate electricity in America so that it's cleaner and safer and healthier. We know that ushering in a clean energy economy has the potential of creating untold numbers of new jobs and new businesses right here in the United States. But we're going to have to think about how [to] produce electricity more efficiently."

—President Obama March 30, 2011

Upgrading our nation's transmission and distribution infrastructure with greater information, communications, and control systems in a cost-effective manner is vital to realizing the potential of a smarter grid and facilitating the transition to a clean energy economy: improved reliability and resiliency, increased efficiency, greater consumer empowerment, and more opportunities for innovation. The use of real-time communications, monitoring, and control systems within the grid is a new development (NERC RFI Attachment, pp. 12, 15). New smart grid technologies in the transmission and distribution system promise to reduce the growing need for new infrastructure investments, increase the productivity and service life of existing assets, and reduce the cost of maintaining back-up power for the grid (NYISO RFI pp. 3, 6-7). Using digital technology to better manage the flow of power on the local distribution grid—the wires that deliver power to our homes—could provide as much as a 1-3% savings in energy by avoiding losses of power on the grid (R.W. Beck 2007, pp. E-1). This Chapter begins with an introduction to the role smart grid technology can play in facilitating a clean energy economy and in improving energy efficiency, before discussing several of the challenges to smart grid deployment.

3.1 Facilitate a Clean Energy Economy

In the 2011 State of the Union address, President Obama called for the Nation to build on the clean energy momentum facilitated by numerous state programs and advanced by the Recovery Act. In particular, the President set a goal of growing our Nation's share of clean electricity generation to 80% by 2035 (Office of Press Secretary 2011b). Achieving this goal requires a modernized grid infrastructure that better enables integration and expansion of clean energy sources (AARP et al. 2010, pp. 5).

- Variable Renewable Resources: Renewable resources provide a relatively small, but increasing share of America's electricity (EIA 2009, pp. 3; Wiser et al. 2010, pp. 3).[7] Wind energy has been

7. For more information, see EIA which states that 44.55% of American electricity was generated from coal, 23.33% from natural gas, 20.2% from nuclear, 6.88% from hydroelectric, 3.6% from other renewables, and 1.5% from petroleum and other sources in 2009.

the second-fastest growing segment of the United States electricity mix each year for the last 5 years (Wiser et al. 2010, p. 5) and the use of solar power is also growing quickly. Since energy generated by the wind or sunlight cannot be turned on or off as needed, and the timing of variable renewable generation and consumer demand does not always match up, smart grid technology enables utilities to more quickly recognize changes in electric power supply and access robust demand response programs to quickly adapt to those changes.[8]

Case Study:
Bonneville Power Administration and GridMobility

Working in partnership with Bonneville Power Administration and Mason County Public Utilities District (WA), technology company GridMobility has designed and is piloting an adaptive system that takes advantage of variable renewable sources when they are available, synchronizing residential water heaters with wind generation. After spending two weeks tracking a home's hot-water usage, the GridMobility solution will decrease power flow to a home's water heater if no renewable energy is available, but it will do so only if it has predicted that the family will not need hot water. The water heater will switch back on at a later time, based on real-time wind-power availability. This approach, if proven effective, will allow the utility to take advantage of clean and cheap renewable energy sources while ensuring that it does not compromise its customers' service.

Source: Newcomb (2010).

- **Distributed Energy Resources (DERs):** DERs are typically smaller electricity generation or storage units located in a community, business, or home. They can serve consumers' energy needs locally and can provide support for the grid (NREL 2009b). Distributed generation includes combined heat and power, solar photovoltaic (PV) systems, and other small generators such as microturbines and fuel cells. Distributed storage resources include batteries as well as thermal storage devices that heat or chill water to provide building services (NREL 2009b). Distributed resources may provide numerous benefits, including: delaying or avoiding investment in transmission and distribution capacity, responding to state renewable portfolio standards, and reducing exposure to volatile energy prices (DOE 2002, pp. 2-3). Enabling DER resources to provide benefits for both utilities and individual consumers, however, will require smart grid infrastructure that can integrate such systems into the electric grid.
- **Electric Vehicles (EVs):** EVs provide an opportunity to meet the Nation's transportation fuel needs with domestically generated electricity rather than oil. Significantly, EVs promise to reduce emissions from the transportation sector by an amount that is considerably larger than the emissions increase resulting from the need for more electricity generation (Sioshansi and Denholm 2009). In addition to requiring more electricity to be generated, a significant proliferation of electric vehicles has the potential to strain the distribution, generation, and transmission systems if it is not supported by smart grid technologies to facilitate the transition (White House 2011d). For example, significant numbers of electric vehicles charging at the same time on the same distribution line could overload the transformer serving their charging stations.

8. For a discussion of the planning implications of renewable generation uncertainty, see Mills et al. (2009).

- Smart grid technologies offer users and utilities the ability to manage the increased energy demand that EVs bring to local grids (Accenture 2011a; PNNL 2011).[9] In the long run, EVs may also be able to offer energy storage and other grid services, such as frequency regulation, through vehicle-to-grid interfaces. These systems conceivably could reduce the need for extra generation at times of peak demand and aid the integration of variable renewable resources by scheduling charging when excess, off-peak renewable energy is available (Letendre et al. 2006, pp. 28–37; Kempton and Tomić 2005).
- **Energy Storage:** Energy storage systems have the potential to optimize the operating capabilities of the grid and the use of renewable energy by storing power for later use. Such systems can work more effectively in tandem with smart grid technology (APS 2010, pp. 14-15), can augment demand response resources to reduce and shift peak energy loads, and can improve power quality and service reliability (APS 2010). Significantly, utility-sited energy storage can be used to avoid or delay investments in new distribution capacity and substation equipment (AEP 2009, slides 6-8). Today, only about 2.5% of U.S. electricity is provided through storage, although other countries, such as Japan, use storage for up to 15% of their energy needs (EPRI 2011b, pp. 5-22).

In addition to working toward the President's goals for a clean energy economy, smart grid technologies can enable additional energy savings through increased energy efficiency.

Case Study:
Kaua'i Island Utility Cooperative (KIUC) Purchases Battery Energy Storage System and Implements Demand Response to Support Solar Generation

The island of Kaua'i in Hawaii has no interconnections with other power systems; therefore, all demand must be met with power generated on the island. Currently, more than 90% of KIUC's electricity comes from diesel generators. To help meet its objective of generating 50% of its power from renewable sources by 2023, KIUC has planned to construct a 3-megawatt (MW) solar PV system. Because Kaua'i lacks interconnections, KIUC faces unique challenges in matching supply and demand. Demand response programs, coupled with energy storage to support variable renewables, are critical to prevent grid disruptions as Kaua'i moves closer to achieving its goal. To that end, Xtreme Power, a partner in several wind and solar integration projects on other Hawaiian islands, will provide a battery storage system capable of providing 1.5-megawatts of power flow and storing a total of 1-megawatt-hour (MWh) of charge. This combined solar PV and energy storage system will help KIUC reduce diesel consumption by millions of gallons every year.

Source: Xtreme Power (2011); KIUC (2011); Gates (2011).

9. See, e.g., PNNL (2011), working on smart charging to help control the timing of EV charging.

3.2 Provide Opportunities for Improved Energy Efficiency in Grid Operations

Losses of electricity are intrinsic to the operation of the grid and can vary substantially based on the age of the equipment, the length of the wires, the weather (which affects system efficiency), and other conditions. Typical losses from electricity transmission and distribution systems are estimated between 6% and 10% (EIA 2010b, pp. 312), but can occasionally be much higher.

Case Study:
Naperville Smart Grid Initiative Improves Reliability and Reduces Costs

In 2010, the Recovery Act Smart Grid Investment Grant Program provided $11 million in matching funds for the Naperville Smart Grid Initiative (NSGI) in Naperville, IL. NSGI will implement volt-var control and AMI to increase system efficiency, as well as complementary opt-in customer efficiency programs that include online personalized energy use data and programmable communicating thermostats. Additionally, widespread automation at the distribution and substation level, as well as resource management for their equipment and workforce, will reduce costs, increase operational efficiency, increase reliability and reduce the length of outages. The $22.6 million investment in these programs and technologies is anticipated to provide $46.2 million in benefits for Naperville and its residents.

Source: Naperville (2010)

Better measurement and more sophisticated control systems can substantially reduce these losses, supply electricity to devices more effectively, and prolong equipment life. These technologies include dynamic line rating (DOE 2009b, pp. 39)[10] and volt-var control[11] (Schneider et al. 2010). Dynamic line rating devices can be used to determine the real-time capacity of electrical lines, instead of relying on traditionally estimated capacities that lead to underutilization of transmission resources (DOE 2009b, pp. 39).

Currently, because many utilities lack real-time data about voltage levels in their distribution networks, they must determine how much power to supply based on estimates of how much voltage will decrease across lines before reaching end-users (Schneider et al. 2010). This often results in surplus voltage, which increases the amount of power used by loads (Pratt et al. 2010, pp. 57). Using volt-var control, utilities can monitor and more precisely tailor voltage to meet the needs of end users with less wasted energy (McKinsey & Co. 2010, pp. 48). A field study in the Pacific Northwest, for example, found that a 1% change in distribution line voltage provided a 0.3% to 0.86% change in energy consumption, and that voltages could be reduced from 1% to 3.5% without reducing service quality to consumers (R.W. Beck 2007, pp. 15, 25). Building on this experience, a preliminary study found that widespread investment in advanced voltage control could reduce system-wide electricity demand by up to 3% (R.W. Beck 2007, pp. 15).

10. Oncor Electric Delivery Company, LLC, for example, received $3.4 million in ARRA funds to demonstrate dynamic line rating technology.

11. Power systems may experience both over-voltage and under-voltage violations that can be overcome by volt-var control (Kundur 1994). Through controlling the production and flow of reactive power at all levels in the system, volt-var control can maintain the voltage profile within a smaller range and reduce transmission losses.

Case Study:
American Electric Power (AEP) Ohio's Integrated Volt-Var Control Reduces Distribution System Energy Waste

AEP Ohio is testing an integrated volt-var control system at six substations in its service territory. The benefits of this system include more efficient distribution of power, better use of its assets, and increased reliability during peak periods. Preliminary results support the utility's hypothesis that it can reduce system demand by 2% to 3%, and the energy needed to serve existing customer loads by 3% to 4%. AEP Ohio customers will benefit from reduced power consumption and increased longevity of their consumer electronics.

Source: AEP (2011a); ARRA Smart Grid Demonstration Program

Understanding the opportunities presented by smart grid technologies is only the foundation of grid modernization efforts. With such opportunities in mind, policymakers will increasingly confront a set of important issues related to upgrading the grid.

3.3 Supporting Investment in Smart Energy Use by the Utility Sector

A series of cross-cutting issues and needs compete for attention from utility executives. On balance, if utilities do not have a strong incentive to sell less energy and operate more efficiently, they may not see sufficient benefits to invest in technologies or grid applications that could cause them to produce, use, and sell less electricity (Pecan Street Project 2010). The issue of incentives is most apparent in the case of some investor-owned utilities (IOUs), from which roughly 65% of consumers receive electricity—16% receive electricity from publicly owned utilities, including municipal utilities, 11% from customer-owned rural cooperatives, while 7% of the Nation's energy is marketed by other organizations (EIA 2010a). Under traditional rate-of-return regulation, it is more profitable for utilities to invest more in infrastructure (including smart grid investments) and sell more electricity (Phillips 1993; Action Plan 2008, pp. 2-2)—than to help their customers become significantly more energy efficient.[12] To be sure, over the last few decades, regulators have continued to modify regulation with an eye toward promoting greater energy efficiency (IEE 2010; Action Plan 2008). As such, state commissions are increasingly confronting questions about regulatory reform options that change utility business models to, for example, make energy efficiency a more central part of their mission.

It merits emphasis that a number of IOUs are leaders in deploying smart grid technologies and that other IOUs are holding off deploying such technologies for important reasons. For cases in which utilities confront powerful incentives to accommodate variable sources of electric power or to avoid building new peaking plants, demand response technologies (including those enabled by smart grid systems)

12. See also Pecan Street Project (2010, pp. 24), calling for a "fundamental shift" to "an alternative business model that better accommodates markedly more end-use efficiency and significant amounts of new distributed generation" that is "of paramount importance if the utility is to thrive in a future electricity market that will have many new technologies, more customer control, and carbon constraints."

may be particularly attractive investments.[13] In other cases, where the incentive to sell more power is dominant, smart grid technologies that enable increased energy efficiency may be viewed less favorably. For these and other reasons, approaches to a smarter grid vary considerably among states and utilities (FERC 2010, App. B; ACEEE 2010; APPA 2010).[14]

Case Study:
The Pacific Northwest Smart Grid Demonstration Project Business Case

Bonneville Power Administration, in partnership with Battelle and in consultation with national experts, is validating the value of smart grid technologies in the Pacific Northwest through the creation of a regional business case. Assessing the costs and benefits of smart grid technologies is one of the four goals of the regional demonstration project. The business case is being built on methods to quantify the costs and benefits of smart grid investments for wholesale power providers, transmission providers, distribution utilities, and consumers. The business case will be shared throughout the five-state region to inform investment decision makers on the technologies tested and can potentially serve as a model for other parts of the country.

Source: Smartgrid.gov (2010); ARRA Smart Grid Demonstration Program

Due to their ownership, governance, and consumer orientation, municipally-owned utilities and rural cooperatives may have direct incentives to pursue cost-effective energy efficiency opportunities. For example, cooperative members directly benefit when energy is procured at lower prices (NRECA RFI, pp. 1-2). Accordingly, in their low-density service areas, cooperatives have significant penetrations of demand response initiatives and load control programs aimed at reducing their exposure to price volatility during peak times, and significant investment in advanced metering to save costs (FERC 2011d, pp. 25–29, 37; NRECA RFI, pp. 3-4, 30).

New learning from experience as to what constitutes a cost-effective investment will guide the transition to a smarter grid. For utilities, state utility commissions, and consumers alike, rapidly changing technologies can lead to concerns about stranded assets (AARP 2010, pp. 13). Notably, because technology is changing swiftly throughout the smart grid ecosystem, utilities may be understandably reluctant to invest in infrastructure that may soon be out of date. Similarly, regulators and ratepayers may be justifiably reluctant to compensate them for it.

The following sections discuss the challenges facing utilities and Federal and state regulators in the context of key actions intended to facilitate the transition to a smarter grid.

13. Baltimore Gas and Electric (BGE), for example, has taken an aggressive posture on demand response. Before its effort to invest in smart grid technologies (which can enable more effective demand response), it has had success smoothing expensive demand peaks through a Peak Rewards Program, that used "smart thermostats." In exchange for the right to cycle a home or business' air conditioning compressor off and on—at levels the utility suggests consumers will not even notice—BGE gives consumers varying levels of incentive credits on their summer bills (BGE n.d.). The program has been so successful that BGE used it as a substitute for the equivalent of a "power plant's worth of . . . new generation" (Maryland PSC 2008, pp. 23).

14. See Edison Foundation (2010) for a State-by-State summary of provisions; see APPA (2010) for a compendium of public power programs.

Case Study:
Bluebonnet Electric Cooperative's Cost-Effective Upgraded AMR

In 2003, Bluebonnet Electric Cooperative, headquartered in Bastrop, Texas, invested in AMR equipment. More than 80,000 AMR meters were deployed over Bluebonnet's large service territory. At the time, AMR was the most technologically advanced choice, and it removed the need to drive along the 11,000-miles of line to check meter readings in person. In 2009, with the benefit of advanced technology, Bluebonnet chose to deploy cost-effective upgrades to their existing AMR technology. This upgraded AMR technology allows Bluebonnet Cooperative's members to log on to the Cooperative's web portal and access previous-day updates on their accounts, day-by-day energy consumption, patterns of consumption, current billing cycle costs, and a projected bill based on current usage.

Source: Johnson (2010)

3.4 Align Utility Incentives

The Administration is committed to supporting state efforts to improve incentives for deploying cost-effective energy efficiency and harnessing the technologies that enable utilities and consumers to decrease energy waste and save money. As previously described, smart grid technologies and applications can enable additional energy efficiency through a variety of ways, including empowering consumers to take action based on timely access to their energy usage data. To focus on ways to save energy through energy efficiency, the 2008 National Action Plan for Energy Efficiency (Action Plan) brought together more than 60 diverse organizations and developed a plan to pursue cost-effective energy efficiency (Action Plan 2008, pp. ES-10, ES-11). The Administration is continuing to work to achieve the Action Plan goals through the State Energy Efficiency Action Network (SEE Action), which is a joint DOE-Environmental Protection Agency effort to help the nation achieve all cost-effective energy efficiency by 2020 through assisting state and local governments in their implementation of energy efficiency policies and programs (energy.gov 2010). Similarly, in the 2010 National Action Plan on Demand Response, the FERC staff recommended the formation of a public-private coalition to help states, localities and regions develop and deploy successful and cost-effective electric demand response programs. FERC staff are currently working with DOE and developing an implementation proposal for the Plan.

Key Action	**1. States and federal regulators should continue to consider strategies to align market and utility incentives with the provision of cost-effective investments that improve energy efficiency.**

States will need to, as they have on their own and pursuant to EISA, continue to pursue policies to better align utility incentives to sell less energy and implement cost-effective energy efficiency investments that fit the needs of their consumers (ACEEE 2010, pp. 23; McKinsey & Co. 2010, pp. 101–104; Action Plan 2008, pp. 44–53; Verizon RFI, pp. 7-8). For example, utilities in several states, including Arizona, Florida, California, Texas, and New York have already planned or instituted programs that strengthen incentives to use less energy and are utilizing new technologies to improve energy and operational efficiency

(Edison Foundation 2010).[15] In that respect, the development of new regulatory strategies surrounding utility incentives, coupled with measures that hold utilities accountable for implementing actions to spur energy efficiency, is a promising development. To support that effort, the Federal Government will continue to work with states to ensure that the strategies are in place to cost-effectively utilize smart grid technologies to improve the energy and operational efficiency of the electric system and to help consumers save money.[16]

> "[E]very institution and every household has to start thinking about how are we reducing the amount of energy that we're using and doing it in more efficient ways."
>
> —President Obama, March 20, 2011

3.5 Research and Development

While better aligning utility incentives with the deployment and use of cost-effective smart grid investments will help consumers save money through the proliferation of energy efficiency programs, ongoing innovation in smart grid technologies can create additional value for consumers and utilities. The benefits of research and development can be shared across all utilities, but if one utility performs the research by itself, it will bear all of the associated costs. For this reason, and because electric utilities typically cannot charge premium prices or recruit new customers when they improve their services, individual utilities often under-invest in research and development for grid operations and communications. To be sure, some investments along these lines are being made, such as those led by the Electric Power Research Institute and the Cooperative Research Network. Nonetheless, private sector equipment vendors and technology firms sometimes cannot or will not research creative "out-of-the-box" transformational energy technologies that pose high risk but could provide dramatic benefits for the nation.

Federal support can be particularly important to developing and evaluating new technologies, particularly in cases of transformational opportunities requiring a long-term horizon (CenterPoint RFI, pp. 11; EEI RFI, pp. 65). As explained in President Obama's *A Strategy for American Innovation* (2011), the Federal Government can address this need and facilitate innovation by supporting funding for basic research, maintaining a high-quality intellectual property rights system that offers appropriate incentives to

15. Information about these programs is available at: Docket RE-00000C-09-0427, Before the Arizona Corporation Commission, March 5, 2010, http://images.edocket.azcc.gov/docketpdf/0000116125.pdf (Arizona); "Separating Means and Ends: Reorienting Energy Efficiency Programs and Policy Toward Reducing Energy Consumption in California." http://www.cpuc.ca.gov/NR/rdonlyres/D5CFAD3F-A4EC-4721-BD79-D4BD6AC72257/0/EDWhitePaper_MeansAndEnds_090402.pdf (California); "Report to the Legislature on Utility Revenue Decoupling." http://www.psc.state.fl.us/publications/pdf/electricgas/DecouplingReport_To_Legislature.pdf (Florida); "Energy Efficiency Accomplishments of Texas Investor Owned Utilities, Calendar Year 2009." http://www.texasefficiency.com/media/files/eummot%20results%20summary%202009.pdf (Texas); 07-M-0548: Energy Efficiency Portfolio Standard http://www3.dps.state.ny.us/W/PSCWeb.nsf/All/06F2FEE55575BD8A852576E4006F9AF7?OpenDocument (New York).

16. For example, the willingness and ability of demand response providers to participate in the energy market is affected by the level of compensation provided to those resources. FERC acted recently to ensure that demand response resources participating in the organized wholesale energy markets are appropriately compensated for the service they provide, at the market price for energy (FERC 2011, pp. 2, 41, 47).

industry and university partners, and providing pathways to commercialization and markets for new technologies. As reflected in the President's Budget, the Administration is committed to continue to support the research, development, and deployment of new smart grid technologies.

Key Action	**2. The Federal Government will continue to invest in smart grid research, development, and demonstration projects. Federal funding can drive innovative technologies to commercialization.**

The Administration has catalyzed a wide range of investments in research and design for smart grid technologies. In particular, the Recovery Act invested $685 million in smart grid regional and energy storage demonstration projects and was matched by more than $1 billion from utilities and industry (DOE OE 2011d). DOE's Office of Electricity Delivery and Energy Reliability conducts research and development that accelerates discovery and innovation of smart grid technologies and creates "next generation" devices, software, tools and techniques to help modernize the electric grid. Priorities include renewable and distributed systems integration, energy storage and power electronics, advanced system monitoring and visualization, and development of control systems. The Office also conducts analysis of the structure and makeup of the electricity sector and related issues, and provides technical assistance to States and regions. DOE's ARPA-E focuses specifically on transformational technologies in the early stages of development. Finally, the President's 2012 Budget calls for an Energy Innovation Hub focused on smart grid technology, and DOD is investing in smart grid research and development with a particular focus on micro-grid applications (U.S. ACE 2010; Lopez 2010).

The Recovery Act's ability to catalyze the rollout of new demonstration projects is important for three main reasons. In short, Recovery Act investments are:

- Enabling the development of new technologies that have not yet been fully proven out;
- Providing direct benefits to our electricity grid today; and
- Demonstrating how new smart grid technologies can be applied to benefit the electric system, spurring a growing market for these technologies.[17]

Current investments in smart grid technologies and programs are helping to illustrate which smart grid technologies are cost-effective in different situations, and to drive innovation in new technologies. Significantly, American investment in smart grid technology innovation promises to create new jobs of the future here in the U.S., benefit U.S. consumers, and allow U.S. businesses to export their innovations to foreign markets (National Export Initiative 2011; U.S. Trade and Development Agency 2011). Although these demonstration projects and investments have inherent value widely, to ensure the country captures their full value, the lessons learned from them must be analyzed and shared.

17. GridWise Alliance RFI, pp. 7, notes that Recovery Act spending, in addition to creating jobs, can help share the lessons of smart grid deployments.

Case Study:
DOD Pilots Smart Micro-Grid Technology

DOD is piloting micro-grid technology at the Marine Corps' Twentynine Palms installation in California, a base in the Mojave Desert serving a population of more than 27,000 military and civilian personnel. The micro-grid is a power distribution system that both manages and optimizes the flow of electricity around the base. It also allows the military base to improve energy security by managing backup power operation for critical loads in the event the micro-grid is disconnected from the utility grid. The technology promises to improve the base's control over power quality and reliability. Deploying the technology in the real-world test bed of Twentynine Palms will allow DOD to assess the true costs, benefits, and security of the system to determine if the Department should use the micro-grid technology at other DOD installations.

Source: DOD (2011, pp. 4)

3.6 Information Sharing

Although many recent studies concerning smart grid technologies are encouraging (R.W. Beck 2007; EPRI 2011b), more research and analysis could help inform industry, regulators, utilities, and consumers about what technologies and approaches are most effective in different contexts.[18] Overseeing utility investments and operations is primarily a state responsibility, and states will continue to make critical decisions about smart grid investments. The lack of information about successes and lessons learned can create a challenge for utilities as they develop business cases for smart grid deployments and for regulators as they weigh the proposed costs and benefits.[19] Accordingly, there is an opportunity to better catalog and share best practices and information about the benefits of smart grid technologies.

Key Action	**3. The Federal Government will continue to support information sharing from smart grid deployments to promote effective cost-benefit investments and remove information barriers. Creating centralized public repositories for this information can encourage cost-effective investments and reduce duplicative experimentation.**

The Federal Government will support and coordinate improved information sharing efforts through SmartGrid.gov and the Smart Grid Information Clearinghouse.[20] These sites will help regulators, utilities, and policymakers make informed decisions concerning smart grid technologies.[21] In particular, these efforts will focus on gathering and making available to the public accurate, verifiable metrics that will help regulators and utilities determine the cost-effectiveness of smart grid deployments.

18. NRECA RFI, pp. 19, suggests that it is "premature" to suggest that cost-effectiveness studies have discovered the "secret sauce" of smart grid technologies.

19. EPRI (2011b, pp. 2-13) states: "What is critical today is reliable data on benefits from smart grid demonstrations." See also WEF (2010, pp. 38–40); EEI RFI, pp. 59, NRECA RFI, pp. 25, and New York State Smart Grid Consortium RFI, pp. 24.

20. See RFI comments from NARUC, pp. 3, suggesting that a clearinghouse "could be helpful"; NRECA, pp. 25, noting that decisions about smart grid technologies and demand response "are too important to be made in a vacuum"; and Oregon PUC, pp. 5, noting that an information clearinghouse on smart grid activities is an "important role the Federal Government can play."

21. See APPA RFI, pp. 3; BGE RFI, pp. 8; and Demand Response & Smart Grid Coalition RFI, pp. 27.

Opportunities to Share Information from Recovery Act Investments

Utilities are making new smart grid investments across the Country, and their experiences can help build a repository of best practices as others move to make cost-effective investments in the smart grid. Such lessons may come from smart grid infrastructure funded by the Recovery Act Smart Grid Investment Grant Program, including:

By the end of 2012, Cobb Electric Membership Corporation, in Georgia, will have installed more than 192,000 smart meters, paired with 3,800 in home displays, and 5,000 direct load control devices for customers who choose to authorize Cobb to cycle their air conditioning units during peak periods.

Florida Power and Light Company is installing 3 million smart meters, deploying 45 phasor measurement units on transmission lines, and upgrading sensors on 270 substations to improve service, offer time-varying rates, and support the integration of renewable and distributed resources.

By the end of 2013, the Western Electricity Coordinating Council will have deployed 250 to 300 phasor measurement units and 20 phasor data concentrators to allow previously unavailable levels of monitoring, visualization, and control of the Western bulk electricity system. The Western Electricity Coordinating Council spans several states, including Arizona, California, Colorado, Idaho, Montana, New Mexico, Nevada, Oregon, South Dakota, Utah, and Washington.

The facilitation of cost-effective smart grid investments is only the first step. As the next Chapter explains, states and the Federal Government can also play important roles to catalyze innovation in the electricity sector.

Chapter 4: The Path to Unlocking Innovation in the Electricity Sector

There is significant potential for innovation and the use of advanced information and communication technologies within the electric grid (EnerNOC RFI, pp. 5; EEI RFI, pp. 34). Many of the smart grid technologies being deployed today are focused on improving sensing and measurement capabilities, and providing grid operators with better system awareness and access to operational efficiency gains. These technologies are necessary—for example, better sensors could have helped avert the 2003 Northeast Blackout (Chu 2009, slide 27)—but are only the beginning of the opportunities for improvement created by a smarter grid. Continuing research and development can thus improve existing technologies and unlock new opportunities in smart grid development. Much like the telephone network evolved very slowly for most of the 20th century and then changed rapidly in recent decades, the grid has the potential to experience slow evolutionary improvements and periods of faster transformation.[22]

Case Study:
Averting Widespread Power Failures Using Smart Grid Technology

Managing the stability of the electric grid is a constant challenge. This is especially true in the West, where population centers and generation sources are often far apart and thus small power oscillations are frequent. Severe oscillations can cause potentially damaging voltages or power flows that trigger automatic shutdown systems to protect equipment. These oscillations are typically managed by a variety of monitoring and automatic response systems. Despite these measures, in the summer of 1996, a combination of disabled monitoring and control systems, power lines short-circuited by trees, inappropriate emergency procedures, and insufficient regional oversight twice led to uncontrolled system instability and blackouts, affecting 2 million and 7.5 million customers. The problem spread across several Western states because grid operators, who at the time had little awareness of conditions beyond their control areas, learned of the problem too late to take action to prevent blackouts in their regions. Similar root causes, including lack of wide area situational awareness, contributed to the August 14, 2003 northeastern blackout that affected 50 million people.

Current transmission network monitoring systems gather measurements every four seconds, which is too slow to observe the aforementioned oscillations. Thus, operators set limits on transmission lines conservatively to allow a margin of safety. Time-synchronized phasor measurement units (PMUs) can measure power system parameters much faster, allowing grid operators to better observe, model, and manage system stability. Such measurements allow operators to move more energy on existing transmission lines and, as a result, tap low-cost and renewable power that might otherwise be inaccessible because of transmission constraints. The sharing of PMU data makes grid operators aware of wide-area conditions throughout their transmission interconnection, enabling them to respond more quickly to stability problems. Smart grid technologies that can selectively reduce demand, such as controls on water heaters or air conditioners, give grid operators another tool to respond to problems identified by PMU data, reducing the need for rolling blackouts during emergencies. ARRA funded the deployment of 877 phasor measurement units (PMUs), expanding the prior nationwide network of 200 by more than 400 percent (Overholt 2010).

Source: NERC (2002); NERC (2009); WECC (2010); EPRI (2011); Hart et al. (2001); U.S. Canada Power System Outage Task Force (2004).

22. See EEI RFI, pp. 37, noting that smart grid "technologies are evolving and will continue to evolve" rapidly.

History has shown that the states and Federal Government have important roles in catalyzing innovation. In the electricity sector, this role can include facilitating the creation and use of standards, developing new energy efficiency programs, investigating the impact of different consumer incentive programs, and monitoring markets to prevent anticompetitive behavior.

> "[O]ur best opportunities to enhance our energy security can be found in our own backyard because we boast one critical, renewable resource that the rest of the world can't match: American ingenuity."
>
> —President Obama, March 20, 2011

4.1 Standards

Recognizing that standards play a critical role in enabling a 21st century grid, EISA called for NIST and FERC to facilitate the development and adoption of interoperability standards (U.S. Congress 2007). The ongoing smart grid interoperability process, led by NIST, promises to lead to flexible, uniform, and technology-neutral standards that can enable innovation, improve consumer choice, and yield economies of scale. In the smart grid arena, the Federal Government is operating in the tradition it has followed previously in promoting the development of standards in a wide array of fields, including public health (NIST 2011a), national security (NIST 2011b), and the environment (NIST 2010a). Interoperability standards[23]—standards that ensure "equipment or software from different vendors [can] work together or communicate" and allow "new, innovative creations to work with older, established services" (PCAST 2010, pp. 15)—serve to support the development and deployment of emerging technologies like the smart grid.

Key Action	**4. The Federal Government will continue to catalyze the development and adoption of open standards.**

The benefits of smart grid interoperability standards include:

- **Standards help ensure that today's investments will still be valuable in the future.** Because smart grid technology is changing swiftly, utilities and vendors may be reluctant to invest in infrastructure that may soon be out of date, and regulators and ratepayers may be justifiably reluctant to compensate them for it. Standards can ensure that smart grid investments made today will be compatible with advancing technology (Arnold 2011, pp. 1; Honeywell RFI, pp. 9).[24] Likewise, standards can ensure that smart grid devices installed today are installed with proper consideration of the security required to enable and protect the grid of tomorrow (Arnold 2011, pp. 1).
- **Standards help catalyze innovation.** Shared standards and protocols provide some assurance that new technologies can be used throughout the grid and reduce investment uncertainty by lowering transaction costs and increasing compatibility. Standards demonstrate to entre-

23. For examples of such standards, see footnote 30.
24. See EEI RFI submission pp. 54, which notes that standards should allow continued use of legacy equipment.

preneurs that a significant market will exist for their work (NSSF, n.d., pp. 3; DRSG RFI, pp. 8). Standards also help consumers trust and adopt new technologies and products in their homes and businesses (NSSF, n.d., pp. 3).

- **Standards support consumer choice.** In the absence of smart grid interoperability standards, companies may attempt to "lock-in" consumers by using proprietary technologies that make their products (and, therefore, their consumers' assets) incompatible with other suppliers' products or services. Open standards, developed in a consensus-based, collaborative, and balanced process (ANSI 2005, pp. 1), can alleviate those concerns and ensure that consumers have choices (AT&T RFI, pp. 10; NEMA RFI, pp. 8).
- **Standards help keep prices lower.** Standards can reduce market fragmentation and help create economies of scale, providing consumers greater choice and lower costs (Marks & Hebner 2004, pp. 1). For example, computer manufacturers' adoption of the Universal Serial Bus specification (USB Implementers Forum 2011) has enabled significant and affordable innovations in connectivity for a broad range of consumer devices. Standards can do the same for smart grid technologies (CEA RFI, pp. 3).
- **Standards can highlight best practices as utilities face new and difficult choices.** Standards can facilitate the transition to a smarter grid by guiding utilities as they face novel cybersecurity, interoperability, and privacy concerns (Arnold 2011, pp. 4; APPA RFI, pp. 3).
- **Standards can help open markets.** In addition to being developed in America, smart grid interoperability standards should be coordinated internationally. International engagement helps to open global markets, create export opportunities for U.S. companies, and achieve greater economies of scale and vendor competition that will result in lower costs for utilities and ultimately consumers (Honeywell RFI, pp. 10).

4.1.1 Standards Process Overview

The U.S. standards system is private-sector led and bottom-up, with the Federal Government acting as the public-sector partner and sometimes as a convener (Marks and Hebner 2004). Notably, the National Technology Transfer and Advancement Act requires Federal agencies to use voluntary consensus standards developed by private-sector bodies in lieu of standards developed by government agencies for regulatory and procurement purposes, whenever feasible.[25] The Act is reinforced by Office of Management and Budget Circular A-119, which calls for use of voluntary consensus standards whenever possible in the government's procurement and regulatory activities (OMB 1998). Consistent with the primary role of the private sector, strategic Federal involvement is sensible and appropriate where necessary to convene key stakeholders and enable standard-setting efforts to succeed (ASTM International 2011, pp. 1-2).

To be successful, smart grid interoperability standards should be open and accessible. In the standards context, "open" means that the process for developing the standards is collaborative and consensus-based (Purcell 2009, pp. 29). In this context, "open" also suggests that standards will be made available on fair, reasonable, and nondiscriminatory terms and conditions, which can include monetary com-

25. U.S. Congress (1995). A copy of the law is available at http://standards.gov/standards_gov/nttaa.cfm.

pensation where appropriate. Indeed the ability to monetize innovation via patents is often critical to driving companies and entrepreneurs to develop and commercialize new technologies, and a balanced and effective intellectual property system must provide appropriate incentives to innovate and protect intellectual property from theft and abuse.[26]

EISA, recognizing the importance of standards in the development of smart grid technologies, provided that:

> The Director of the National Institute of Standards and Technology shall have primary responsibility to coordinate the development of a framework that includes protocols and model standards for information management to achieve interoperability of smart grid devices and systems. Such protocols and standards shall further align policy, business, and technology approaches in a manner that would enable all electric resources, including demand-side resources, to contribute to an efficient, reliable electricity network (U.S. Congress 2007).

The EISA framework is designed to be "flexible, uniform, and technology neutral" to facilitate innovation, accommodate existing technology, and allow for regional and organizational differences (U.S. Congress 2007). Once there is, in the judgment of the FERC, "sufficient consensus" concerning the standards developed under NIST's oversight, FERC is directed to "adopt such standards and protocols as may be necessary to ensure smart-grid functionality and interoperability in interstate transmission of electric power, and regional and wholesale electricity markets" (U.S. Congress 2007). The law delegates to FERC the responsibility of defining what "sufficient consensus" and "adopt" means in the context of the standards.

The NIST Smart Grid Standard-Setting Process[27]

To implement EISA, NIST developed a three-phase system to facilitate the development of standards that would both achieve a consensus and continue to encourage innovation and growth.[28] That process began with a May 2009 meeting in which U.S. Secretary of Commerce Gary Locke and U.S. Secretary of Energy Steven Chu hosted nearly 70 top executives from the electric power, information technology, and other industries to establish their organizations' commitment to support the standards process.

The first phase engaged stakeholders through a participatory public process designed to identify applicable standards and overall requirements, gaps in currently available standards, and priorities for additional standardization activities. In so doing, NIST hosted three public workshops with 1500 participants, published three separate Federal Register notices, and utilized a web-based collaboration site (i.e. a "wiki"). Phase I resulted in the *NIST Framework and Roadmap for Smart Grid Interoperability Standards, Release 1.0*, published in January 2010. The release describes a high-level reference model for the standards and identifies 25 protocols and standards relevant to the smart grid's interoperability, in addition to noting 50 standards for future consideration.

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26. The connection between standards and intellectual property rights is, among other topics, being explored by a different NSTC Subcommittee. See the NIST Standards RFI at http://www.federalregister.gov/articles/2010/12/08/2010-30864/effectiveness-of-federal-agency-participation-in-standardization-in-select-technology-sectors-for.
27. Unless otherwise noted, the description of NIST's process is based on Arnold (2011).
28. See also APPA RFI, pp. 25, "APPA generally supports the current NIST smart grid standard-setting process."

NIST created the Smart Grid Interoperability Panel (SGIP) in Phase II. The SGIP is developing important structural supports for standards, including a Catalog of Standards to hold descriptive information about smart grid standards. In Phase III, NIST and SGIP have developed and are implementing a testing and certification framework.

FERC's Role in the Standards Process

NIST notified FERC in October 2010 that it had identified five families of standards as ready for consideration by regulators.[29] To invite public discussion of whether there is sufficient consensus to adopt these standards, FERC hosted a Technical Conference on January 31, 2011 and solicited written comments from interested parties (FERC 2011a). FERC is currently evaluating how to proceed (FERC 2011b). To the extent any of the standards are adopted under EISA, FERC previously found in a 2009 Smart Grid Policy Statement that EISA "does not make any standards mandatory and does not give [FERC] authority to make or enforce any such standards" (FERC 2009b, pp. 15).

4.1.2 Next Steps in the Standards Process

NIST will continue to develop and update the standards from the *NIST Framework and Roadmap for Smart Grid Interoperability Standards, Release 1.0*,[30] recognizing that the continued development and adoption of standards is an important driver for ensuring maximum value from ongoing smart grid investments.[31] To enable the development and implementation of smart grid standards, merely embracing the standards as best practices in the field—rather than as mandatory ones—is sufficient. As such, "sufficient consensus," need not mean unanimity, particularly as the standards will not be mandatory. In short, regulators should publicly embrace the interoperability standards with the understanding that they will continue to develop with the ongoing evolution in smart grid technology.[32] Federal and state

29. The five standards, which will continue to evolve with smart grid technology include:

- **IEC 61970 and IEC 61986: Providing a Common Information Model (CIM) necessary for exchanges of data between devices and networks, primarily in the transmission (IEC 61970) and distribution (IEC 61968) domains.** These standards facilitate the exchange of data between utilities, and allow the exchange of data between applications within a single company.
- **IEC 61850: Facilitating substation automation and communication as well as interoperability through a common data format.** The standard specifies the requirements for how applications interact with and control devices, in addition to the standards for testing for conformity. It also creates common language for devices, results in fewer errors and greater capabilities, and implements modern networking technology in substations.
- **IEC 60870-6: Facilitating exchanges of information between control centers.** It specifies the method of exchanging time-critical data between utilities, improving reliability and interoperability.
- **IEC 62351: Addressing the cyber security of the communication protocols defined by the other IEC standards**.

See Arnold (2010), pp. 3, NIST (2010c)

30. The release is available at http://www.nist.gov/public_affairs/releases/upload/smartgrid_interoperability_final.pdf.

31. See AT&T RFI, pp. 1, 11, noting that "NIST working groups developing Smart Grid interoperability standards have been productive endeavors with excellent output that will foster innovation in connection with the Smart Grid." See also Cisco RFI, pp. 2-4; EEI RFI, pp. 60; Ingersoll-Rand RFI, pp. 5; Toshiba RFI, pp. 3.

32. Some stakeholders have urged that FERC take a larger role in the standards process. See, e.g., Joint Comments of the Public Utility Commission of Texas and the California Public Utilities Commission, Response to the NIST RFI, March 7, 2011 (http://www.puc.state.tx.us/electric/projects/34610/CPUC_PUCT_Comments_NIST_030711.pdf). In particular, while the soft form of adoption recommended herein may be appropriate for interoperability standards that primarily address the functionality of the smart grid, it may be appropriate to mandate compliance with some standards to the extent they are necessary to ensure cybersecurity or reliability of the grid. Further discussion of cybersecurity issues is contained in Chapter 6.

regulators should take appropriate action regarding the development and implementation of smart grid standards and encourage the adoption of best practices in regard to standards.

In embracing smart grid standards, FERC can look to the Nuclear Regulatory Commission's (NRC's) model of facilitating standards development for guidance.[33] Under that model, interested parties are allowed an opportunity to be heard when the NRC crafts a decision. At the end of the process, the NRC sets forth desired performance objectives, leaving it up to licensees to determine how to achieve those objectives. In the smart grid context, FERC's embrace of the NIST Interoperability Framework could encourage utility companies looking for smart grid solutions to rely on the framework for guidance, but leave it to individual utilities to decide how to best comply.

4.2 Demand Management

While interoperability standards can play an important role in technology and application innovation, the electricity sector can also benefit from innovation in demand response programs and rate design. In particular, a more effective management of peak demand holds considerable promise to improve grid efficiency and reliability. To be sure, the challenge of meeting peak energy demand varies throughout the country, with innovative programs and smart grid technologies promising to help utilities and individuals better manage energy demand as appropriate given individual circumstances. In addition, smart meters and sensors promise to provide more frequent, detailed, and reliable data that allows improved evaluation, measurement, and verification of savings from energy efficiency programs.

Smart grid technologies can facilitate a broad range of actions to manage electricity usage during periods when peak demand, rapid changes in supply or demand, or problems with generation or transmission equipment threaten the system's reliability or impose high costs (Cappers et al. 2009, pp. 7). Demand for electricity peaks when people are using a lot of energy at once. In warmer climates, peak demand tends to be highest on summer afternoons, when residential customers and businesses turn on their air conditioners and cooling devices at once. In other regions, demand peaks on the coldest winter mornings. Peak demand adds cost to the system because it requires the construction, maintenance, and use of additional peaking plants that are only used a few times a year and are usually more expensive to run than base load plants. According to a study by The Brattle Group, investing in technologies that better manage energy use during the highest demand periods and increase energy efficiency could alleviate the need to build 90 gigawatts (GW) or more of power plants by 2030 (Brattle Group 2008). This is equivalent to avoiding the construction and use of approximately 90 large power plants, which in many states would burn fossil fuels. In addition, a recent study in New York State found that:

> In an average year, the top 1% of hours (roughly 90 hours) of electric demand in New York State accounts for more than 10% of system peak demand. Due to the cost of acquiring and maintaining capacity that is seldom needed, the cost to serve peak load is much greater than the average cost over the year (Newell & Faruqui 2009, pp. 5).

Peak demand can be managed through demand response, which includes pricing programs that create incentives for consumers to choose to reschedule or reduce their energy use on critically hot days or

33. For more information on that process, see "Guidance Development" at the NRC, at http://www.nrc.gov/about-nrc/regulatory/guidance-dev.html.

times of day with high demand. Demand response programs can take a number of forms. One model is for utilities or third parties to compensate consumers for the ability to curtail, shift, or adjust their electricity use during periods of high prices or system emergencies.

Demand response has the potential to reduce costs for all ratepayers—not just the participants in a particular demand response program. Notably, tapping demand response resources to reduce the hours that expensive peaking plants operate promises to reduce generation costs to serve peak load. In some circumstances, demand response programs also allow utilities to defer construction of additional electricity generation, transmission, or delivery resources.[34] Savings from these activities can be provided back to ratepayers (FERC 2011c, pp.3-5). Recognizing its tremendous potential to reduce costs and increase reliability, FERC Chairman Jon Wellinghoff has called demand response the "killer app" for smart grid technology (Morgan 2009, pp. 39; Wellinghoff and Morenoff 2007, pp. 389, 393–396).[35]

Key Action	**5. Federal, state, and local officials should strive to reduce the generation costs associated with providing power to consumers or wholesale providers during periods of peak demand and encourage participation in demand management programs. Innovative rate designs will be more feasible as smart grid technologies become more widely available.**

Consumers generally pay time-invariant rates for electricity. In many parts of the U.S., for example, consumers pay the same retail price for electricity when demand is low, such as during the middle of the night, as when demand is high, such as in the afternoon of a hot summer day. Consequently, consumers generally lack the information or incentive to shift their consumption away from times when the costs of providing electricity are high. As a result, utilities spend billions of dollars a year to build, maintain, and operate peaking plants that are used only rarely, typically driven by extreme temperatures or unplanned emergencies. Smoothing these expensive peaks promises to reduce utilities' operating costs, resulting in savings to consumers and utilities.[36]

State regulators may wish to consider, as some already have, offering time-varying rates that more accurately capture the hour-to-hour variations in the cost of supplying electricity. A successful approach to this form of rate design was implemented in Washington, DC and California pilot projects. In particular, these pilot projects designed rates intended to provide the average customer who made no changes to their consumption patterns with no change in their bill (eMeter 2010 pp. 4; Charles River Associates 2005 pp. 18). They also found that many customers rescheduled or reduced consumption during high cost periods and cut their energy bills.[37]

34. For an economic analysis of the issues presented by demand response efforts, see generally Borenstein and Holland (2005).

35. In one example of how such programs can work (where authorized by state programs or regional market rules), some commercial and industrial consumers can participate in organized wholesale markets, receiving payment in return for their willingness to reduce electricity use at peak times, either individually or in the aggregate. In 2008, FERC issued Order No. 719 (Wholesale Competition in Regions with Organized Electric Markets), which, among other items, requires Regional Transmission Organizations and Independent System Operators to amend their market rules to permit aggregators of demand response to bid into organized electric markets.

36. "Moreover, both [participating customers] and all other Cooperative consumers share in the energy and capacity savings that accrue from the demand response programs. All cost savings are necessarily returned to consumers" (NRECA RFI, pp. 53).

37. See eMeter (2010, pp. 3-4, 29-36); Charles River Associates (2005, pp. 5-14, 44-125). See also Faruqui & Sergici (2009) for a review of similar studies.

Smart grid technologies can empower consumers to better manage their energy use, including opportunities to reduce peaks and share in any savings (Borenstein & Holland 2005, pp. 11-12). These technologies may also give consumers more predictable bills, with the information and control they need to target specific electricity costs or bill totals. Demand response includes a diverse set of programs (FERC 2010, pp. 5), such as:

- Direct load control (DLC) programs in which consumers can choose to allow a program administrator to remotely turn off their appliances or equipment (FERC 2011d, pp. 23);
- Demand-bidding and buyback programs that provide customers the opportunity to reduce their electric consumption in exchange for a payment;
- Rate programs that create an opportunity for consumers to directly save money by reducing peak energy consumption;
- Programs including real-time pricing (Borenstein 2005; Goldman 2006) and critical peak pricing (Faruqui and Sergici, 2009) that vary rates over time to better reflect actual production costs; and
- Emergency programs in which large commercial and industrial consumers curtail their electric consumption in case of a grid emergency (NERC 2011 pp. 11, 45, 73).

Smart grid technologies make options like DLC and various rate programs more flexible and accessible to consumers with different levels of energy use.[38] Many new DLC programs, for example, remotely adjust settings such the temperature settings on a programmable communicating thermostat. Smart thermostats and other enabling technologies can make responding to price changes easy and automatic (e.g., through "set it and forget it" controls), helping consumers reduce peak energy use by as much as 57% and save money as a result.[39] Moreover, consumers participating in such programs also report very high levels of satisfaction.[40]

Large commercial and industrial consumers frequently have more options than residential and small- to medium-size business consumers to participate in demand response programs. Some states place large commercial and industrial consumers on dynamic rates by default (Goldman 2006, pp. xii-xiii), and such pricing structures are frequently only available to large power consumers because they typically have the resources to shift large amounts of power off-peak, rely on back-up generators, or purchase building energy management tools (Barbose et al. 2004, pp. ES-5; Goldman 2006, pp. 28; Samad 2010, slide 10). Out of the approximately 58 GW of estimated potential peak reduction in 2009, commercial and industrial consumers enrolled in demand response programs provided nearly 85%, with residential consumers providing the remainder (FERC 2011d, pp. 102-103).[41] Commercial and industrial demand response is the source for almost all demand response bid into wholesale demand response programs (FERC 2011d).

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38. See AARP RFI, p. 4, noting that DLC programs yield demand reductions that "tend to be persistent and reliable," and that real-time or variable pricing pilot programs have also achieved significant peak demand reductions.

39. OG&E (2011) reports up to a 57% peak reduction for consumers with smart thermostats. Other studies (Faruqui & Sergici 2009, pp. 43) have found that critical peak pricing coupled with enabling technologies can reduce peak energy usage by a median of 36% and a 95% confidence interval of 27 to 44%.

40. See Faruqui et al. (2010, pp. 33), stating that 99% of participants in a Maryland pilot would like to continue with the program; White (2006, slide 2), reporting 96% satisfaction among participants in the Good Cents SELECT Advanced Energy Management Program (now called Energy Select). See also eMeter (2010, pp. 5), reporting 74% satisfaction and 6% dissatisfaction among participants.

41. Programs directly targeting commercial and industrial customers make up 42%, and wholesale and other programs comprise the remaining 43%. (FERC 2011d, pp. 102-103).

Demand Response in Commercial and Industrial Customers: A Success Story

Commercial and industrial customers have decades of experience with demand response programs. Across the Nation, utility-run demand response programs have enrolled more than 21 GW of commercial and industrial energy demand that can be reduced or rescheduled to manage peaks. This is equivalent to controlling more than three quarters of the peak load in New England. Commercial and industrial demand response capacity in utility-run programs increased 7 GW, or approximately 50%, between 2006 and 2010 and accounts for 75% of the capacity in utility-run demand response programs.

Source: FERC (2011, pp. 30-31); ISO NE (2011).

Smart grid technologies present an opportunity to develop demand response programs that are attractive to customers,[42] fit their lifestyle, reduce peak energy demand, and make it easier to reduce the cost of providing electricity. Programs may include rebate options, bill protection, or enabling technologies that, coupled with effective education, help consumers make informed choices about participation. In considering such programs, it is important for regulators to consider how they affect low-income and vulnerable consumers.[43]

The National Action Plan on Demand Response released by FERC staff consists of strategies and activities in three primary areas: technical assistance to states; development of a national communications program on demand response; and the development and enhancement of tools and materials that support demand response (FERC 2010). As explained above, FERC and DOE will continue to work with state regulators and others on these issues.

In an effort to help stakeholders design demand response programs, the Administration is committed to supporting research and sharing with all stakeholders suggestions on key issues related to customer behavior, customer options, and ways to save energy.[44] To that end, several Recovery Act projects are developing studies that will examine how consumers respond to demand response programs (including programs with and without variable pricing) and other complementary enabling technologies. When complete, DOE will publish an analysis of the results.

42. This can be achieved, for example, by considering the size of incentives (FERC 2009a, pp. 192-193, 196-197) and by streamlining the enrollment process like with Cash for Clunkers (Vandenbergh et al. 2010, pp. 10552). A recent survey suggests that the opportunity to save money would "most encourage" consumers to use electricity management programs (Accenture 2011b, pp. 17).

43. There are studies indicating that low-income consumers respond to dynamic prices (NIST 2010a). See also Brockway (2008, pp. 56–65), finding, based on existing studies, that lower-income customers can reduce peak load, but by a smaller percentage than higher-income customers. Indeed, in the PowerCentsDC project, low-income consumers volunteered at a higher rate than other residential consumers (eMeter 2010, pp. 2). Moreover, as NRECA reported, its demand response programs "have saved Cooperative members, including those within vulnerable populations, hundreds of millions of dollars. There has been no suggestion that those traditional energy efficiency, load control, and voluntary conservation programs pose any risk to vulnerable populations" (NRECA RFI, pp. 41). It merits note, however, that, AARP et al. (2010, pp. 11), have expressed some concern about the literature surrounding low-income households, calling for continuing attention to this issue.

44. See FPL RFI, pp. 13, "The wide variations in consumer response to different demand response and energy conservation programs suggest, among other things, that policymakers should continue to encourage a wide array of pilots and tests, as long as they are thoughtfully constructed and generate data susceptible to sound analysis."

> **"Consumers and society will benefit most from a smart grid marketplace characterized by competition, innovation, and experimentation. Policymakers should support regulations that foster these characteristics."**
>
> Source: Consumer Electronics Alliance RFI, pp. 15.

4.3 Preventing Anticompetitive Behavior

To provide further benefits from smart grid technologies that best fit an individual's or business' needs, it is important that consumers have choices on what smart grid technologies they are able to install and utilize in their home or business.

Key Action	**6. Federal and state officials should continue to monitor smart grid and smart energy initiatives to protect consumer options and prevent anticompetitive practices.**

Policymakers and regulators should consider, where appropriate, how to ensure a robust, competitive market for devices, energy management services, and applications that interact with the electric grid. In particular, policies should protect the emerging marketplace for smart appliances and consumer facing smart grid devices and applications. In a competitive environment, market participants (utilities and consumers alike) can compare the value of numerous smart grid devices and energy management applications and make purchasing decisions based on the merits of each. In evaluating the relevant market dynamics, both state utility regulators and antitrust enforcement agencies (i.e., States' Attorneys General, the Department of Justice, and the Federal Trade Commission) should continue to consider and address the possibility that some firms with substantial market power are in a position to impede the market entry of new products and energy management applications (FTC 2010a, pp. 2).

In the context of infrastructure modernization, policymakers should be sensitive to the following possibilities (FTC 2010a, pp. 9):

- Attempts to convince regulatory bodies to force unreasonable costs for connection and modernization onto new entrants, including smart grid application providers;
- System designs that make it impossible for third parties to match the utility's service level; and
- A dominant firm's use of proprietary standards that locks out competition from rival products and services.

In the context of smart technology deployments more generally, state regulators should be mindful of attempts by utilities (FTC 2010a, pp. 9) to:

- Support imposition of utility-type regulation on new entrants that raises entrants' costs and thus discourages their entry;
- Make access to consumer usage information expensive or impossible; and

- Enact authorization practices that create barriers to consumer control and use of energy usage data, thereby preventing the offering of new enabling products and services.

Ensuring options for consumers can catalyze innovation and helps to empower them. In being mindful of the concerns outlined above, regulators will confront questions on how to facilitate the transition to a smarter grid. Among other things, regulators will need to evaluate and manage transitional costs and address what steps are necessary to achieve a smarter grid. The next Chapter picks up this issue, discussing additional mechanisms for empowering consumers.

Chapter 5: The Path to Empowering Consumers and Enabling Informed Decision Making

Residential and small business consumers should have access to a portfolio of smart grid programs, technologies, and policies that empower them to manage their energy use effectively.[45] These programs support the Administration's commitment to "provide customers with choices to reduce costs and save energy" as highlighted in the *Blueprint for a Secure Energy Future* (White House 2011b, pp. 25). To be sure, there is no one-size-fits-all approach for how smart grid technologies can help consumers. Rather, there are many tools that offer diverse consumers attractive new opportunities to manage their energy usage more effectively and to share in system-wide savings. Providing simple information—via websites, smart phones, or even kitchen-counter displays—about how much energy a house is using, along with simple tips to help reduce unnecessary energy use, can lead to 5 to 15% in energy savings (Darby 2006, pp.3).

The development of appliances that can connect to and communicate with the grid and modify their energy use is an example of rapid innovation that provides benefits to consumers and society (AT&T RFI, pp. 9; CEA RFI, pp. 5). Beyond alerting consumers to opportunities to use energy more efficiently, smart appliances could communicate with the electric grid to recognize the source and cost of electricity, and provide and adjust services accordingly. Smart appliances could be programmed to respond to authorized commands from the utility to help regulate demand (Hammerstrom et al. 2007a, pp. vii). A smart refrigerator, for example, can delay a defrost cycle until it can draw the necessary power at the day's lowest rate (GE 2011); a smart dryer can shut down its heating element during brownouts (Hammerstrom et al. 2007b, pp. 3.11); a smart water heater can "learn" to schedule its heating in a way that supplies adequate hot water but only draws off-peak or renewable electricity (BPA 2010). Some reports detailing the emergence of smart appliances as a burgeoning industry suggest that with several policy changes the market for such devices could be as large as $26 billion by 2019 (Pike Research 2011).

By themselves, smart appliances can help homeowners reduce their energy use, but with a home energy management system (EMS), they can give rise to greater savings. An EMS, for example, promises to allow homeowners to access and operate networked appliances remotely providing them with the ability to turn on a heater or air conditioner from work. Additionally, a home EMS promises to allow users to see their energy use in detail, including the energy use of specific appliances or equipment, such as their pool pump. For some consumers, an EMS may also provide real-time price information that they can use to change their energy use when prices are high, or send automatic directions to specific appliances to turn off during high priced periods or when high demand threatens system stability.

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45. Commercial and industrial (C&I) consumers enjoy powerful opportunities for energy efficiency and demand response, but generally experience fewer of the information and access barriers that affect residential consumers and small businesses. See, among others, EnerNOC RFI, pp. 2, 5; EEI RFI, pp. 15-16; ASHRAE RFI, pp. 4; NRECA RFI, pp. 27; and DRSG RFI, pp. 17–18. Additionally, while this report uses the broader term "consumers," in some instances, "customer" (the individual or entity responsible for paying the electricity bill) may be more appropriate. NASUCA (2009b) made this distinction in its smart grid resolution, and it is particularly relevant in discussions about data access and privacy.

The following sections discuss five important considerations that can help ensure consumers receive the most benefits from these technologies.

5.1 Consumer Education

As new opportunities for energy management emerge,[46] regulators and policymakers should update and enhance consumer education efforts. The number of new choices and options may initially prove daunting for some consumers, but to ensure a successful transition to a smarter grid, consumers will need to understand the transition and the new choices they confront.

Key Action	**7. State and federal policymakers and regulators should evaluate the best means of ensuring that consumers receive meaningful information and education about smart grid technologies and options. Ideally, these efforts will create a track record of transparency and responsiveness (New America Foundation, RFI, p.5), address consumer concerns including data privacy, and clearly explain the opportunities and safeguards that characterize smart grid projects to help consumers make informed decisions.**

Education and communication about consumer devices and applications can empower consumers to make choices that reflect their cost, comfort, and environmental preferences. Surveys consistently indicate that while people are largely unaware of smart grid technologies (SGCC 2011, pp. 6–7; CEA RFI, p. 9), they are increasingly open to the possibilities smart grid technologies offer and want to know more about them (SGCC 2011, pp. 8–10; CEA RFI, pp. 9).[47] Accordingly, utilities (CenterPoint Energy RFI, pp. 3–4; Pepco RFI, pp. 6–7; APPA RFI, pp. 9–10; FPL RFI, pp. 14; Progress Energy RFI, pp. 5),[48] consumer advocates (AARP et al. RFI, pp. 11; Office of Ohio Consumers' Counsel RFI, pp. 11), regulators (Michigan PSC staff RFI, pp. 7–8; Oregon PUC RFI, pp. 1; Stanton 2011, pp. 53-55), and Federal agencies (FERC 2009a, pp. 70) all have emphasized the need for improved education efforts about smart grid technologies. In many cases, creating a dialogue with consumers also reduces conflict and provides the foundation for a good working relationship between utilities and the communities they serve (Ling 2010; EEI RFI, pp. 10-11).[49]

Many state regulators already require education and outreach programs as a condition for authorizing smart grid deployments that directly impact consumers (DC Office of People's Counsel RFI, pp. 5–8; Maryland PSC 2010, pp. 42-44). In rolling out such deployments, public-private collaborations,[50] market

46. In its RFI comment (pp. 32), the New York State Smart Grid Consortium said, "Customers want choices, so allowing them to select among different paths for adjusting their usage . . . will be a major benefit of smart grid."

47. See Pike Research (2010), noting that 67% of those who were "extremely familiar" with the smart grid had a "very favorable" (or better) opinion of it. According to GE (2010), 80% of those familiar with the term "smart grid" are willing to learn more about its benefits.

48. American Electric Power reported (AEP 2010, pp. 1), "When we asked those who didn't enroll [in a TOU pilot] why . . . a surprising number indicated they weren't aware of the new services. This indicates a need to better educate our customers."

49. APPA RFI, pp. 10 ("Some utilities have found that smart grid deployment without strong community involvement or good education programs can undermine the program").

50. See, e.g., CenterPoint RFI, pp. 4 (describing the PUCT's Advanced Metering Implementation Team); Office of Ohio Consumers' Counsel RFI, pp. 12, 15; National Action Plan Coalition 2011, pp. 4, 7; Pecan Street Project 2010, pp. 11–12. For additional statements of the need for consumer education, see CEA RFI, pp. 8-11; DRSG Coalition RFI, pp. 14;

research (Daniels & Flora 2010, slides 24, 25), and multichannel messaging[51] can help develop meaningful educational materials that enable consumers to make informed choices despite their differing needs, preferences, and motivations.[52] To date, a number of states, including California, Colorado, Illinois, and Maryland, have required utilities to develop education and information programs as a condition of approval of smart grid deployments (Stanton 2011, pp. 59; Maryland PSC 2011, pp. 50).

One innovator in the consumer education area is the District of Columbia. The PowerCentsDC pilot emerged from a five-person board that included representatives from the District of Columbia Public Service Commission, the Office of People's Counsel, Pepco (the local utility), the Consumer Utility Board, and the local chapter of the field personnel's union. This board recognized "that improved communication among the pilot board members was leading to better communication with consumers" (National Action Plan Coalition 2011, pp. 7). In 2010, the District of Columbia Public Service Commission approved a request by the DC Office of People's Counsel's to form a collaborative AMI Task Force that will develop educational materials for use during smart meter deployment and will report back to the Commission (DC PSC 2010). As other states move forward, this model provides a valuable roadmap to consider (D.C. Office of People's Counsel RFI, pp. 4; Pepco Holdings RFI, pp. 6).

The Federal Government will support consumer education efforts by sharing case studies and developing best practices for smart grid deployment.[53] As explained in Chapter 7, DOE, through its ongoing work with the National Association of Regulatory Utility Commissioners (NARUC) and the National Association of State Utility Consumer Advocates (NASUCA), will make this information available at SmartGrid.gov. Moreover, the FERC-NARUC Collaborative on Smart Response will continue disseminating useful information on consumer engagement.

An important step in educating consumers is to ensure timely access to their energy usage data and enable consumers to control how it is used.

Honeywell RFI, pp. 10-11; Ingersoll-Rand RFI, pp. 2; New America Foundation RFI, pp. 5; Toshiba RFI, pp. 1.

51. See, e.g., Pepco RFI, pp. 6; DRSG Coalition RFI, pp. 15; EEI RFI, pp. 12 (highlighting Oncor's communication efforts); DC Consumer Counsel RFI, pp. 8; APPA RFI, pp. 5–8. Also see Doan (2011).

52. Ohio Consumers' Counsel RFI, pp. 6; DC Office of People's Counsel RFI, pp. 7; NRECA RFI, pp. 19, noting that consumer education is likely necessary, in conjunction with appropriate tools, to change consumer behavior; Pepco Holdings RFI, pp. 1, suggesting that utilities "will have failed in their mission" if consumers are not given a proper understanding of "how to interface and gain value from the smart grid."

53. Several commenters remarked on the importance of such education and efforts. See, e.g., EEI RFI, pp. 11, suggesting that consumer education is important to prevent a "negative impact on consumer perceptions of Smart Grid benefits"; NRECA RFI, pp. 22; and Pepco Holdings RFI, pp. 2, suggesting that consumers should be educated in a fashion that allows them to understand time-variant pricing "in a way that allows for them to understand it without penalty."

Case Study:
Networks of Sensors and Data Systems Make Commercial Buildings More Efficient

Building commissioning is a process of verifying the performance of all building systems in new construction. The functioning of these systems often decline over time as building conditions change and building system components wear out. Monitoring-based commissioning uses networked sensors to continuously monitor building performance. This monitoring can help identify and correct design and operational deficiencies and degradations in performance, as well as identify new energy-saving measures. The effect of monitoring-based commissioning is substantial, persistent reduction of wasted energy in commercial buildings. A test implementation of monitoring-based commissioning in 24 buildings identified and corrected more than 1,100 deficiencies, reducing electricity use by 9%, peak electrical demand by 4%, and hot water use by 25%. Cost savings from the efforts paid back the commissioning costs—including the installation of new sensors and information systems—in a median of 2.5 years.

Source: Mills and Mathew (2009)

5.2 Timely Access to Data

In addition to ensuring information and education are components of smart grid deployments, significant opportunities exist to ensure consumers have timely access to the information that can help them save money.[54]

Key Action	**8. Building on recent efforts, state policymakers should continue to consider how to develop policies and strategies to ensure that consumers receive timely access to, and have control over, machine-readable information about their energy consumption in a standard format.**

Energy usage data can help consumers detect malfunctioning appliances, provide input to smart grid devices and applications, improve home or building energy efficiency, and help consumers lower their bills. DOE found that organizations that responded to an RFI focused on this topic[55] displayed "almost universal consensus" that consumers should have access to and control over their own detailed energy usage data.[56] In particular, consumer access involves access to, and control over, energy consumption

54. See generally Attari et al. (2010)

55. As part of DOE's efforts to facilitate the adoption and deployment of smart grid technologies, it initiated a public process to gain valuable input about data access and privacy issues related to the smart grid. DOE published a "Request for Information" (RFI) in the Federal Register on these topics on May 11, 2010, and held a public meeting to discuss the issues presented in the RFI on June 29, 2010. After considering the information received in response to the RFI and at the public meeting, DOE issued the "Data Access and Privacy Issues Related to Smart Grid Technologies" report on October 5, 2010. The report is available at http://www.gc.energy.gov/documents/Broadband_Report_Data_Privacy_10_5.pdf and focused on the issues where there is broad consensus among smart grid participants.

56. DOE Data Access (2010). The Energy Independence and Security Act (EISA) of 2007 requires states to consider whether electricity purchasers should be provided access to price, usage, intervals and projections, and source information from their utilities. Consumers' access to their own data is consistent with provisions of the National Broadband Plan and EISA. Recommendation 12.7 of the National Broadband Plan says: "States should require electric utilities to provide consumers access to, and control of, their own digital energy information, including real-time information from smart meters and historical consumption, price and bill data over the Internet. If states fail to develop reasonable policies over the next 18 months, Congress should consider national legislation to cover consumer privacy and the accessibility of energy data" (FCC 2010, pp. 256). See also Tendril RFI, pp. 3.

data (including at least usage and pricing data) and the ability to authorize data access for the third-party applications of their choice.[57] For example, the Fair Credit Reporting Act protects sensitive information at the same time as it authorizes individuals to share that information with third parties.[58]

States considering how to make energy usage data accessible to consumers should consider the following principles:

- **Internet Accessibility:** Consumers should have options for how to receive their energy consumption data, including through traditional channels such as over the phone. Where appropriate, consumers should also have the opportunity to securely access their energy consumption data over the internet. Given the innovation potential from making standardized energy data available over the internet, and the opportunity to potentially help the most consumers in the shortest period of time, all states and utilities should consider how to make progress on this principle.[59] As previously noted, Texas has already implemented this principle, enabling a number of innovators to take advantage of resulting opportunities.
- **Timely Access to Data:** Energy usage data and price information that is available with minimal delay supports the development of a variety of interactive applications, such as demand response.[60] Some innovative consumer technologies being deployed today utilize near real-time usage data and price information—such as kitchen counter in-home displays that show the current month's electricity bill-to-date.[61] Utilities vary in their progress toward resolving technical, cost allocation, and policy hurdles to activate "home area networks"[62] and other technologies that can provide near real-time data direct from the meter. Where feasible, states should encourage utilities to make near real-time data from meters accessible to consumers via open interfaces and nationally recognized standards, in a secure and non-discriminatory fashion. In that spirit, the California Public Utilities Commission took an important step in ordering its major investor-owned utilities to provide consumers with smart meters the ability to access their usage information in near real-time by the end of 2011 (CPUC 2009, pp. 3).
- **Machine-Readable Data in Standard Formats:** Ensuring that energy usage data are provided in standardized, machine-readable formats can maximize consumer access to information by allowing them to select the energy management system that best meets their needs (McQuade

57. DOE Data Access (2010, pp. 11), says, "Consumers should decide whether and for what purposes any third-party should be authorized to access or receive" consumer energy usage data. APPA (RFI, pp. 26) notes, "any interaction between the utility and third party energy service providers on data access must start with the customer's authorization." Also see TIA RFI, pp. 8–9; NRECA RFI on data privacy, p. 5, which notes that "NRECA believes it should be the consumer's choice regarding whether or not consumption data is provided to . . . third parties."

58. For the text of the Fair Credit Reporting Act, 15 U.S.C. § 1681 et seq., see http://www.ftc.gov/os/statutes/031224fcra.pdf

59. See, e.g., Sunstein (2010, pp. 6), suggesting that the internet is an ideal source to make information "as accessible as possible"; EISA (U.S. Congress 2007); FCC (2010, pp. 256).

60. EnerNOC RFI, pp. 4 ["monitoring the customers' usage in near real-time . . . makes demand response more predictable and consistent for our utility and ISO customers. Getting this same data with even an hour delay (much less a 24 hour delay) would severely hamper our ability to ensure performance"]. See also Honeywell RFI, pp. 4.

61. See, e.g., TIA RFI, pp. 3. The Toyota Prius provides an example of such real-time feedback, using onboard displays to provide real-time mileage approximations that may help people drive more efficiently.

62. A "home area network" is a network of home appliances and devices that enables consumers to interact with the grid and better control the appliances in their home—even remotely. See GAO (2011, pp. 7).

& Booe 2010, pp. 14; EnerNOC RFI, pp. 5). The Priority Action Plan 10 (PAP 10) of the NIST-initiated Smart Grid Interoperability Panel (SGIP 2011) provides a standardized model for exchanging energy usage and cost information between different parties and devices and is the basis for information exchange directly from the meter to household devices, as well as from utility back office systems to authorized third parties.

- **Authorizing Third-Party Access:** Permitting consumers to affirmatively authorize non-utility third-parties to access their data enables innovation among vendors and gives consumers options to select applications that meet their needs.[63] Online portals, for example, can provide secure ways for consumers to authorize the disclosure of their energy usage data and can streamline authentication.[64]

Case Study:
Smart Grid Investments in Texas

Texas' competitive marketplace and the state's aggressive build-out of quality infrastructure are the keys to making Texas's smart grid a reality, with tangible benefits to customers and market participants. Texas is moving forward with broad-scope smart grid development: already deploying smart meters and devices in customer homes, utilizing real-time data, and constructing new transmission. Two of Texas's efforts are:

The Public Utility Commission of Texas (PUCT) authorized over $2.5 billion in smart meter investment. Over 6 million smart meters will be deployed; before the end of 2012 there will be nearly-full deployment (PUCT 2011b, pp. 3). The web portal, www.smartmetertexas.com, is used by consumers, competitive Retail Electric Providers, and utilities to track and manage energy use.

Increasingly diverse products are being offered to customers by competitive Retail Electric Providers to help them better manage their energy usage through smart grid technologies and applications. Products include home energy service packages, prepaid products, in-home devices, and real-time pricing.

Source: Public Utility Commission of Texas

The above principles provide valuable guidance as to how state regulators can support consumers' efforts to direct the secure transfer of data from utilities to third-parties, while recommendations below discuss how to do so in a manner that protects privacy. The establishment of this data transfer process may result in a one-time set-up cost and minimal maintenance, which may be considered for recovery in a reasonable fashion. Consequently, as regulators face continuing challenges as to how best to work with utilities, customers, and third parties to manage access to data for third parties, the Federal Government will be available to provide technical assistance, and to relate lessons learned on an array of matters, including who pays for the costs to enable data transfer (e.g., utilities, ratepayers, third parties). The Federal Government will also continue to explore and discuss issues that arise when energy usage data are collected and shared from a source other than the meter.

63. See, e.g., the Pecan Street Project (2010, pp. 25) calling for a "third party electric services market." See also AT&T RFI, pp. 10; EnerNOC RFI, pp. 4.

64. See DOE Data Access (2010, pp. 17): "DOE recognizes the obvious efficiencies of an online process and the expanding range of sensitive e-commerce and other transactions strongly suggest the long-term advantages of online authorization processes."

Case Study:
Smart Grid Innovation by America's Youth

Shreya Indukuri and Daniela Lapidous, students at the Harker Upper School in San Jose, California, convinced their school to measure its energy usage with off-the-shelf sub-metering technology. That data provided the school with valuable guidance about energy saving opportunities, including the fact that the air conditioning switched on in the gym every night. As a result of this effort, the Harker Upper School was able to realize a 13% energy reduction and a 250% return on its investment.

Source: White House (2011e)

In addition to educating consumers, energy usage data can play a pivotal role in smart grid devices and applications. Those products, however, are only as valuable as they are useful.

5.3 Device Usability

Improved consumer data access provides the opportunity for improved and tailored energy management. To ensure that consumers receive the benefits from smart grid technologies, they must both be able to use the device and understand and act upon the feedback they receive.

Key Action	**9. State and Federal regulators should, in instances where a utility deploys the relevant infrastructure, consider means of ensuring that consumer-facing devices and applications make it easier for users to manage their energy consumption. The types of information and options that smart grid technologies can offer may not be familiar to all consumers, meaning that a simple and usable design may well be crucial to helping consumers realize the promised benefits.**

As experience with programmable thermostats has demonstrated that consumers find it difficult to conserve energy when energy-saving devices are difficult to use (EPA 2010, pp. 2; Meier et al. 2010, pp. 4-9; Consumer Reports 2007).[65] When they are required to be involved in decisions that involve in-home devices, regulators of consumer-facing devices and applications may therefore want to consider whether smart grid technologies that offer consumers energy usage data and new tools to manage it are user-friendly. Usability becomes a particular factor when consumers are unable to choose the devices and appliances they use. For example, because neither landlords nor tenants have significant incentives to invest in energy-saving devices, renters are 5.5% less likely to have energy efficient appliances than homeowners.[66] And for the generation of consumers to whom the "flashing 12:00" problem on the VCR

65. For updates on the EPA's new product specifications for climate controls, see http://www.energystar.gov/index.cfm?c=new_specs.climate_controls.

66. This difference may result in up to 2 million MWh of wasted electricity each year (Davis 2009, pp. 1, 4–5). For a review of the issue, see Murtishaw & Sathaye (2006). See also NRECA RFI (p. 22): "Moreover, many low and fixed income Americans, particularly renters, are not able to replace inefficient (but still functional) appliances or make building improvements that would result in marked efficiency gains."

was a constant reminder of the failings of products that were too difficult to use, the importance of not repeating this mistake should be self-evident.

Since consumers may self-install products like smart thermostats, incorporating plug-and-play installation can give consumers quick access to energy management tools (Ehrhardt-Martinez et al. 2010, pp. 27; Public Sector Institute 2011; Alliance to Save Energy RFI, pp. 6; Honeywell RFI, pp. 10). With regard to such tools, effective automation measures that allow people to "set and forget" their preferences can enable continous energy savings when consumers do not want (or do not remember) to interact with their energy usage settings (Hammerstrom et al. 2007a, pp. 9.3).[67]

Case Study:
Draft ENERGY STAR Specification for Climate Controls Incorporate Smart Grid Features

The Environmental Protection Agency (EPA) is developing the ENERGY STAR specification for Climate Controls that will help consumers stay comfortable and save energy. Climate Controls are consumer-facing devices, such as programmable thermostats, that provide advanced user interfaces to control heating and air conditioning systems. The draft ENERGY STAR Climate Control specification incorporates smart grid features.

The draft ENERGY STAR specification shares this report's emphasis on interoperability and features that make it easy to manage energy consumption. It requires qualifying Climate Controls to be able to communicate with smart grid or other internet-enabled devices such as smart phones. The draft requires qualifying, communicating Climate Controls to display time-varying price information if utilities provide it. It also requires Climate Controls to offer energy-efficient, consumer-friendly default settings and to meet ease-of-use requirements. Finally, the draft specification addresses compliance with NIST Smart Grid Interoperability Panel standards and avoids mandating interface designs by giving manufacturers the option to make products comply with ease-of-use standards through testing that demonstrates that users can perform common tasks quickly and accurately.

ENERGY STAR is one of several complementary programs that help consumers identify and purchase energy efficient products. These programs are in a position to enable the energy efficiency, emissions reductions, and consumer savings from smart grid compatible features. ENERGY STAR recognizes products that realize significant energy savings, allow purchasers to recover their efficiency investments in a reasonable time, and perform as well or better than other products. Federal, state and utility energy efficiency programs often make ENERGY STAR products eligible for rebates and favorable tax treatment. EPA is currently considering the inclusion of smart grid functionality as it reviews ENERGY STAR specification for other product categories.

For more information about the draft specifications: http://www.energystar.gov/index.cfm?c=new_specs.climate_controls/Draft2_CC_spec_FINAL.pdf

After ensuring the device is usable, the next step in enabling energy savings from smart grid technologies is offering consumers personalized suggestions about specific energy-saving measures (Pratt et al. 2010, pp. A.1-A.4).[68] Consequently, even relatively small changes can make information significantly

67. A recent study suggests that consumers are most concerned about whether an electricity management program is customizable, but also simple and easy to use (Accenture 2011b, pp. 29). See also DRSG RFI (pp. 12) and Honeywell RFI (pp. 4, "let automation provide complete, consistent, and persistent energy savings").

68. See Alliance to Save Energy RFI Submission at 3, 5, November 1, 2010; Pepco Holdings RFI Submission at 4-5, November 1, 2010, Addressing Policy and Logistical Challenges to Smart Grid Implementation.

more useful. Consider, for example, that many consumers find dollars rather than kilowatt-hours a more meaningful measurement of energy savings opportunities (Frankish & Darby 2009, pp. 24-26).[69] Similarly, many people are more motivated to avoid losses than to achieve gains, meaning that consumers are more inclined to replace appliances to "stop wasting money" than to buy a new appliance to "start saving money" (Fuller et al. 2010, pp. 29; Tversky & Kahneman 1981, pp. 453-53; Carrico et al. 2010, pp. 8; Letzler 2010).

Three decades of research (Darby 2006) show that feedback, including feedback that taps into social norms and compares consumers' electrical use to local averages, can help consumers effectively reduce energy costs (Ayres et al. 2009; Allcott 2010). A recent study involving the Sacramento Municipal Utility District suggests that its customers could collectively save more than $15 million over ten years if the utility were to expand a pilot project that mailed consumers more detailed information about their electricity use, and compared their usage to their peers' usage (Ayres et al. 2009, pp. 10). Similar studies suggest that simply providing effective feedback on energy consumption to residential consumers can reduce their overall electricity use by 4% to 15%.[70] Offering feedback in as granular a form as it is collected and stored, and making it available in standard, machine-readable formats, will give consumers an array of options for how they want to receive and interpret energy use information.[71]

Effective feedback also provides consumers a broader context that helps them make decisions, such as comparing their present consumption to their historical consumption or showing that an old appliance uses far more energy than a new one.[72] One form of effective feedback is to provide consumers with comparisons of their energy usage against similar users or neighborhood averages.[73] A promising example is efforts that send personalized bills that help consumers reduce their energy use by up to 2.5% (Ehrhardt-Martinez et al. 2010, pp. 51). As Recovery Act investments provide additional experience with such opportunities, utilities will be able to evaluate different approaches to energy management and develop refinements for customer feedback mechanisms (Fuller et al. 2010, pp. 28–35; DOE Smart Grid Investment Grant 2010).

While providing consumers timely access to energy usage data in an understandable form can be a valuable tool for achieving energy savings, the data needs to be protected to safeguard consumers' privacy.

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69. See also Harris Interactive (2007), pp. 123-124. http://www.ftc.gov/os/2007/01R511994EnergyLabelingEffectivenessFRNConsResBkgrdInfo.pdf.

70. See Ehrhardt-Martinez et al. (2010,p. iii), which finds 4–12% reductions across different types of feedback; see Darby (2006, p. 3), which finds 5–15% reductions for direct feedback. EPRI (2011b, pp. 7-5) also reports 5-15% reductions.

71. The collection of energy use data, anonymized for privacy protection, can also aid a range of entities, such as building code drafters and makers of electric appliances. See, e.g., DOE EERE (2010, pp. 81), discussing prospects for more precise and specific guidance in future versions of American Society of Heating, Refrigerating and Air-Conditioning Engineers and The International Energy Conservation Code building energy codes.

72. See Alliance to Save Energy, RFI pp. 3, 5, Pepco Holdings, RFI pp. 4–5, OPOWER, RFI, pp. 2, stating "data alone will not help consumers manage their energy usage. Behavior-based messaging is necessary to translate this new data into new insights that motivate customers to use energy differently." Furthermore, small changes in the presentation of information can help consumers better understand what is at stake and what their options are (Tversky and Kahneman 1981, pp. 453–454). See also Carrico et al. (2010 pp. 8-9).

73. See, e.g., Pepco Holdings, Inc. RFI, pp. 6–7; NRECA RFI, pp. 21 ("As noted above, the Touchstone Energy Study found that many consumers were particularly interested in getting a report that compared their home's energy use to that of similar homes in the area, suggesting that social norms also play a role"); Ehrhardt-Martinez et al. (2010, pp. 19); Thaler & Sunstein (2008, pp. 66-70); Ayres et al. (2009, pp. 3).

5.4 Data Privacy

It is important to be mindful of consumer privacy concerns when sharing consumer energy usage data (DOE Data Access 2010, pp. 2; NIST SGIP-CSWG 2010, pp. 11–15). Energy usage information can and should be protected like other sensitive information.

Key Action	**10. State and Federal regulators should consider, as a starting point, methods to ensure that consumers' detailed energy usage data are protected in a manner consistent with Fair Information Practice Principles and develop, as appropriate, approaches to address particular issues unique to energy usage. Consumer trust is essential to the success of smart grid technologies, and protecting the privacy of smart grid related data is one crucial component of strengthening this trust.**

Though energy usage data likely does not fall within the scope of existing, sector-specific Federal privacy statutes,[74] this data should nonetheless be collected and used only in ways that are appropriate and subject to legally enforceable privacy protections. In general, a company's public commitment to follow a code of conduct, as well as existing requirements for taking reasonable measures to safeguard consumer data, are likely to be enforceable by the Federal Trade Commission and State Attorneys General under their authority to address unfair and deceptive practices. Additionally, the Administration is considering broad online data privacy regimes that could be applicable to smart grid data that is shared or accessed online (FTC 2010b, pp. ix; DOC 2010, pp. 1-2). Furthermore, at the state level, public utility commissions may set privacy rules for regulated utilities; their jurisdiction over third parties, however, varies.

At present, there is not in place a comprehensive and broadly-accepted application of Fair Information Practice Principles (FIPPs) in the smart grid context. Nonetheless, FIPPs can provide a common framework for protecting energy usage data and consumer privacy. To that end, the Administration has called on Congress to enact a "consumer privacy bill of rights" that provides baseline protections based on FIPPs, which are widely accepted principles adopted by government agencies and intergovernmental organizations to ensure protection of personal information (Strickling 2011, pp. 6-7).[75] The Administration supports legislation that would make FIPPs the baseline for protecting personal data in commercial sectors that are not currently subject to sector-specific Federal privacy statutes,[76] which could include energy usage data. The Administration also supports an approach in which numerous entities—governmental agencies, utilities, energy industry organizations, consumer groups, and researchers—would share the responsibility for implementing FIPPs through privacy rules that are specific to the smart grid context.

74. For example, the Health Insurance Portability and Accountability Act (HIPAA) (U.S. Congress 1996) protects the privacy of personal health information; the Fair Credit Reporting Act (U.S. Congress 1970), Gramm-Leach-Bliley Act (U.S. Congress 1999), and other laws protect the privacy of financial information; etc.

75. FIPPs were first comprehensively discussed in the US Department of Health, Education, & Welfare's *Records, Computers, and the Rights of Citizens* report (HEW 1973) (HEW Report). Subsequently, FIPPs have been developed by numerous governmental and intergovernmental agencies. FIPPs may be procedural or substantive. See FTC Privacy Online (1998, endnotes 27, 28).

76. From congressional testimony by Lawrence E. Strickling: "The Administration urges Congress to enact a 'consumer privacy bill of rights' to provide baseline consumer data privacy protections. Legislation should consider statutory baseline protections for consumer data privacy that are enforceable at law and are based on a comprehensive set of FIPPs" (Strickling 2011, pp. 6).

This approach would protect consumers' privacy in a manner that is compatible with broader energy management policies. Grounding such discussions in comprehensive FIPPs could also create greater consistency in privacy policies across industry sectors and would build on several states' policies that are already under development.[77]

FIPPs provide a general and comprehensive, yet flexible, set of considerations to take into account when designing systems that generate, collect, use, and disclose personal data (as well as setting rules concerning the use of this data).[78] Using FIPPs as a framework for smart grid privacy will still require that industries, consumer advocates, and regulators collaborate to develop enforceable codes of conduct for different smart grid deployment contexts. The rules or guidelines will likely differ depending on whether energy usage data are confined to utilities, or shared with third parties. State regulators may consider requiring utilities and other firms to provide customers clear information regarding how their data may be used, if consumers authorize such use, and guaranteeing that customers have the ability to select the purposes for which their data may be used.[79] Finally, consumer default settings can be influential, and FIPPs do not lead to categorical rules about whether utilities (or other entities that collect or process smart grid data) should set default opt-in or opt-out regimes.[80]

5.5 Consumer Protection

Key Action	**11. State and federal policymakers and regulators should consider appropriately updating and enhancing consumer protections for smart grid technologies. Concerns about data-sharing, new rate structures, and involuntary remote disconnection—namely the impact on privacy, fairness, due process, and costs—raise policy challenges that consumer protection laws and policies may need to address.**

Privacy protections are a critical aspect of consumer protection, yet other important consumer protection issues should also be considered. As new issues and opportunities related to smart grid deployment arise, policymakers may need to update consumer protections built up over the last century of utility regulation—protections that ensure adequate notice, the right to dispute bills, health and safety issues related to disconnection, and affordability. Significantly, smart meter capabilities may help utilities develop novel approaches to better address these points. At the same time, regulators may well need to revisit existing protections to ensure that consumers in a smart grid system maintain due process rights

77. See, e.g., California Public Utilities Commission (forthcoming decision adopting privacy rules for energy usage data based on FIPPs), to be published at http://docs.cpuc.ca.gov/published/proceedings/R0812009_doc.htm.

78. This echoes the conclusion of NIST's Cyber Security Working Group (CSWG), which recommends that entities draw on these existing principles to inform privacy practices specific to the smart grid. See NIST-SGIP-CSWG (2010 pp. 36).

79. It bears notice that the purpose of smart meter data collection is often not only to support utility billing and grid operations, but also to empower consumers to better manage energy use with things like personalized feedback and access to their own detailed data.

80. CDT/EFF RFI, pp. 3; BGE RFI, pp. 4 ("We believe it is important to proactively 'push' information to customers initially. Over time, as their understanding and interest grows, we expect customers to begin to seek information themselves and utilize self-service tools. To support this evolution, we suggest that policymakers do not necessarily require proactive customer consent for this type of program. Instead, in situations where utilities establish contractual privacy protections with business partners, policy should support data being provided to such energy efficiency service providers by default").

and protections at least as strong as those traditionally offered.[81] Regulators should further consider deriving enhanced protections from advanced features, rethinking opportunities based upon desired outcomes rather than solely strengthening traditional solutions.

State regulators and legislators should consider taking steps to ensure that smart grid technologies and programs are implemented in a manner that protects all consumers, particularly vulnerable populations. For example, as smart meters with remote disconnection capability are being deployed, states have begun to consider what consumer protection measures should be in place.[82] Conversely, that same remote disconnection capability is now often accompanied by load limiting functionality that can lead to alternatives to full disconnection, the potential for low- to no-cost reconnections, consumption data that can identify money-saving alternative rates, and can proactively identify candidates for state and Federal assistance programs, assistive technologies, and other energy saving programs. The Federal Government can support states through information sharing efforts as they make decisions about if and how to reexamine existing protections for consumers.[83] For example, Recovery Act projects may provide data on low-income participation in demand response programs that can be used by states, consumer advocates, utilities, and other stakeholders to better assess whether consumers' concerns about fairness and costs are being addressed by measures used in those contexts.

As the next Chapter explains, ensuring robust cybersecurity will provide the foundation for consumers to utilize a portfolio of smart grid programs and technologies to manage their energy use effectively.

81. See, e.g., AARP et al. RFI, pp. 5; AARP et al. RFI, Attachment, pp. 16–19; DC Office of People's Counsel RFI, pp. 4; Ohio Consumer's Counsel RFI, pp. 3-4; NASUCA Resolution 2009-03 says, "States and utilities should not be permitted to use Smart Grid deployment as a means for reducing consumer protections with regard to electric service in general and termination procedures in particular" (NASUCA 2009b, pp. 4).

82. See AARP et al. RFI, attachment, pp. 18–19.

83. See GridWise Alliance RFI, pp. 5, noting Federal role of providing tools for state policymakers but not forcing states to act in a proscribed manner.

Chapter 6: The Path to Secure the Grid

The greatest strength of a 21st century grid—evolving technology—may also present opportunities for additional vulnerabilities. Networks of computers, intelligent electronic devices, software, and communication technologies present greater infrastructure protection challenges than those of the traditional infrastructure. Notably, a smarter grid includes more devices and connections that may become avenues for intrusions, error-caused disruptions, malicious attacks, destruction, and other threats (DOE 2009c, pp. v). Ultimately, smart grid technologies will involve integrated suites of open standards, specifications, and requirements to assure the interoperability, privacy, and security that will enable operations, ensure resilience, and provide consumer benefits.

Cybersecurity practices must address not only the threats and vulnerabilities of traditional information systems, but also issues unique to electric grid technology. These include the lengthy life expectancy of energy control systems, low-latency communications needed for real-time control, and differing requirements and regulatory frameworks among grid stakeholders. Ensuring that cybersecurity practices are effective will require the ongoing development of existing standards and completing those still under development (GAO 2011, pp. 26-27). Although the government has improved and is continuing to improve the processes for sharing information about risks and threats to the electricity sector, more can be done (National Infrastructure Advisory Council 2010, pp. 6-7). To that end, and as reflected in the Administration's proposed cybersecurity legislation,[84] the Federal Government will seek to ensure that grid operators have access to actionable threat information; support research, development, and demonstration of cybersecurity systems and develop human capital; and work with private-sector stakeholders to establish accountability for meeting standards and performance expectations.

6.1 Cybersecurity Standards

Key Action	**12. The Federal Government will continue to facilitate the development of rigorous, open standards and guidelines for cybersecurity through public-private cooperation. Cooperation between stakeholders can help identify and address the diversity of cyber risks the electric power sector faces. The Federal Government will support the continuing evolution of those standards and guidelines to keep pace with the threat.**

The Administration's approach to a secure grid is to pursue a thoughtful, cost-effective strategy that ensures the largest improvement in security and the greatest return on investment.[85] The Administration recognizes that collaboration between government agencies, industry, and utilities is necessary to sustain the long-term evolution of smart grid technology. A critical part of such an effort is to identify and

84. "The Administration Unveils its Cybersecurity Legislative Proposal" Howard A. Schmidt, May 12, 2011. http://www.whitehouse.gov/blog/2011/05/12/administration-unveils-its-cybersecurity-legislative-proposal

85. See EEI RFI, pp. 53–54 ("[T]he industry embraces a cooperative relationship with Federal authorities to protect against situations that threaten national security or public welfare, and to prioritize the assets that need enhanced security"); Pepco Holdings RFI, pp. 24, ("Cyber security is an area of policy in which the Federal Government must have the authority to set threshold policy standards for state compliance"). See also Honeywell RFI, pp. 6.

prioritize relevant cyber risks—including malware, compromised devices, insider threats, and hijacked systems—and develop standards and guidelines that enable the design of effective plans for mitigating those risks. The overall goal of the effort is to develop policy and regulatory frameworks that ensure that effective and feasible security is appropriately implemented and that all stakeholders contribute to the security and reliability of the grid as a whole.

At present, stakeholders have varying levels of awareness and understanding of current threats and specific vulnerabilities. To fully engage in a risk-based approach to cybersecurity, state regulators, industry participants, and electric utilities must receive timely and actionable cyber threat and vulnerability information from Federal and industry partners. In this respect, it is important to leverage current threat-sharing activities, such as the Electricity Sector—Information Sharing and Analysis Center, the United States Computer Emergency Readiness Team, and the National Electric Sector Cybersecurity Organization. Finally, the Administration supports efforts to improve the ability of companies to voluntarily provide the government with actionable information, so as to facilitate joint responses to cyber threats.

6.2 Cybersecurity Culture

Key Action	**13. The Federal Government will work with stakeholders to promote a rigorous, performance-based cybersecurity culture, including active risk management, performance evaluations, and ongoing monitoring.**

Smart grid cybersecurity must transition from compliance-based approaches that emphasize checklists and inventories to performance-based strategies that utilize risk management, situational awareness, and vulnerability assessment and testing (Kundra 2010, pp. 3-6). Consequently, the grid's cybersecurity protections must be tested thoroughly and regularly to ensure real-time, prioritized protections from potential threats. For this reason, the Administration's approach to electric grid cybersecurity emphasizes shifting to a performance-based culture, including active risk management, performance evaluations (i.e., exercises and simulations to determine security vulnerabilities), and ongoing monitoring. As such strategies are further developed and deployed, the DOE-NARUC cooperation on technical assistance (described in Chapter 7, below) will make a focus on cybersecurity a top priority.

Chapter 7: Continuing Cooperation with States and Other Key Stakeholders

For America to lead in developing and deploying the next generation of electricity networks, widespread, sustained collaboration will continue to be necessary. The Federal Government, state and local governments, regulators, policymakers, utilities, product developers, and consumer organizations all have roles to play in the development of the Nation's electric grid. This reflects both that there are a number of key actors and that circumstances vary across the country. For example, utilities have different incentives regarding smart grid deployment based on variations in corporate structure, the laws under which they operate, their customer demographics, their generation resources, and the condition of their distribution networks. While stakeholders generally agree that cost-effective upgrades to the electricity system will increase reliability, concerns remain about the allocation of investment risks between utilities and ratepayers and among ratepayer classes.

To implement the recommendations and key actions set forth in this policy framework, the Administration will work with a diverse set of stakeholders to build on earlier successes and enable future innovation.

7.1 Building on Progress

7.1.1 Learning from the Recovery Act Investments

The historic scale of investment under the Recovery Act is jumpstarting smart grid research, demonstration, and deployment,[86] as well as supporting technology development and system integration, demonstrations, testing and evaluation, and education and training. Under the Recovery Act, DOE invested over $4 billion, matched by more than $5 billion from utilities and industry, to deploy and demonstrate smart grid technologies in 141 projects across the country (DOE OE 2011a). These projects involve the application of sensors, smart switches, and control and communications technologies within the grid's transmission and distribution systems, as well as devices that enable the participation of consumers in energy management. For example, the Los Angeles Department of Water and Power was awarded more than $60 million in Recovery Act funds to deploy smart grid systems at partner university campuses and technology transfer laboratories. This demonstration project also includes demand response technologies, next-generation cybersecurity technologies, and demonstrations of novel approaches to integrate a significant number of electric vehicles onto the grid (DOE OE 2011a).

Building on these Recovery Act programs, DOE is working with stakeholders in three key areas:

1. **Gathering empirical data from Recovery Act projects to quantify the costs and benefits of smart grid technology to better inform investment decision making;**
2. **Understanding how advanced metering infrastructure coupled with dynamic rates and associated practices influence customer behavior; and**
3. **Developing and implementing improved cybersecurity practices.**

86. See TIA RFI, pp. 12, stating that Recovery Act funding "has played and will continue to play a critical role as a catalyst for the smart grid market."

DOE has been working for several years to develop an analytical framework for quantifying benefits associated with the deployment of smart grid projects that addresses all aspects of power system planning and operations. The framework has been developed collaboratively with the Electric Power Research Institute, national laboratories, various utilities, and consulting firms. Through the Recovery Act activity, DOE is engaging key stakeholder groups to further elucidate and advance this framework for defining and quantifying the costs and benefits of investments in smart grid projects.[87]

DOE is currently working with several grant recipients to undertake studies to examine the response of consumers to variable electricity prices in conjunction with the deployment of AMI and associated technology, such as web portals, in-home displays, and programmable communicating thermostats. These studies will evaluate consumer acceptance of and response to time-based rate programs, control and information technologies, and enhanced education efforts. An example of the DOE-sponsored effort is a consumer behavior study being undertaken by Oklahoma Gas & Electric (OG&E); that study will focus on reducing system peak load and assessing whether customers respond to a rate that varies depending on the time of day and grid conditions and whether customers enabling technologies to actively manage their consumption and bills.

Case Study:
Oklahoma Gas & Electric (OG&E) Decreases Outages Using Smart Grid Technologies

Over the past four years, OG&E has installed several pilot distribution automation systems in its operating area. In the first three years of operation, one such system provided a 60-70% reduction in outage time on the affected circuits. OG&E estimates that installing similar equipment on just 20% of its distribution network would avoid 35 million outage minutes every year, a 30% reduction in average system outage time. To that end, within this decade, OG&E plans to implement a distribution management system that will monitor conditions in the distribution system and interface with customer smart meters. This promises to reduce outages and protect valuable equipment from overload damage. From avoided outage time alone, yearly benefits in excess of $300 million are expected to accrue to customers.

Source: Perkins (2010)

Finally, DOE is leading public-private sector collaboration to develop the cybersecurity risk management guidance for the electric sector. DOE is working on the activity with NIST and FERC as well as many other organizations, including the North American Electric Reliability Corporation, the Institute of Electrical and Electronics Engineers, the National Electrical Manufacturers Association, and the GridWise Architecture Council. To support the Recovery Act projects, DOE led an interagency team to develop the cybersecurity requirements and maintains a website (https://www.arrasmartgridcyber.net/) to

87. DOE is already engaging with stakeholders including:
- The National Association of Regulatory Utility Commissioners (NARUC) and state commissioners and staffers.
- The Edison Electric Institute (EEI) and its members.
- The Electric Power Research Institute (EPRI).
- The American Public Power Association (APPA) and its members.
- The National Rural Electric Cooperative Association (NRECA), the Cooperative Research Network, and their members.
- The North American Synchrophasor Initiative (NASPI) and its members; and
- The National Association of State Utility Consumer Advocates (NASUCA), its members, and other consumer advocate organizations.

assist grant recipients in obtaining a greater technical understanding of the cybersecurity requirements. Additionally, in August 2010, the Cyber Security Working Group (CSWG) led by NIST, a subgroup of the Smart Grid Interoperability Panel, produced the NIST Interagency Report 7628 (NISTIR 7628) which provides guidelines that can be used by utilities to institute secure practices, including driving vendor requirements.

7.1.2 United States Department of Agriculture Rural Utilities Service and Rural Development Electric and Energy Programs

RUS is a major source of infrastructure financing for more than 600 rural electric cooperative utilities and other systems, thereby advancing the Administration's commitment to modernizing the electric grid by providing affordable service and advanced utility infrastructure across rural America.[88] In FY 2010, RUS approved significant loan support to finance transmission and distribution system improvements, including $152 million for smart meter deployment and installations. As such, RUS continues to be actively involved in Administration efforts to promote grid modernization, smart grid policy, and investments and standards implementation.

7.1.3 Workforce Development

The challenges of the transition to a smarter grid will require not only the oversight by utility regulators, but also a sustained effort by many stakeholders to develop and prepare a workforce to implement and manage a changing grid. Maintaining a sufficiently large, skilled workforce is a significant challenge currently facing the power sector. Pursuant to the Energy Policy Act of 2005, DOE's Office of Electricity Delivery and Energy Reliability has investigated workforce trends within the energy and power industry and identified significant emerging challenges due to an aging workforce and a reduced focus on power engineering education (U.S. Congress; 2005 DOE 2006b, pp. 20–21). Some estimates suggest that roughly half of the electric power industry's engineers may retire or leave the field between 2009 and 2014 (U.S. Power and Energy Engineering Workforce Collaborative 2009, pp. 4).

At the same time that utility employees are poised to retire in increasing numbers, the number of university-sponsored power engineering programs and vocational training programs has decreased, meaning fewer qualified recruits are graduating prepared to fill the growing number of open positions (NERC 2007, p. 20; U.S. Power and Energy Engineering Workforce Collaborative 2009, pp. 4).[89] The North American Electric Reliability Corporation has identified the potential loss of experienced workers as a "serious threat to the bulk power system reliability" (NERC 2007, pp. 20). While industry programs are emerging to meet short-term demand, long-term workforce development is "necessary for sustaining scientific advancement to maintain our competitive position in the world" (DOE 2006b, pp. 21).

Workforce development programs will help not only to transfer knowledge from retiring to incoming workers but can also train workers in emerging smart grid technologies. To support that effort, Recovery Act funding is supporting partnerships between industry and academia to create interdisciplinary programs at universities and community colleges around the Country. As recently reported by *The New York Times*, educators, government officials, and utilities are collaborating to develop educational programs

88. Program information available at http://www.usda.gov/rus/electric.
89. DOE (2006b, pp. 7) notes that it can take as much as 12 years to train a highly skilled line worker.

that will prepare younger generations for the transition to a smarter grid (Zeller 2010).[90] Recovery Act efforts include curriculum development, training activities, and the development of interdisciplinary programs at the university and college level.

In the spring of 2010, DOE awarded nearly $100 million to 52 workforce training and development projects.[91] This support will help to train an estimated 30,000 workers and bring industry and academia together to develop cutting-edge power systems and smart grid education programs. More than $95 million of this funding will be leveraged by community colleges, universities, utilities, and manufacturers to develop and implement programs to train skilled workers—including our veterans—to modernize the Nation's electrical grid and implement smart grid technologies in local communities across the country.

Additionally, the Department of Labor's Employment and Training Administration has partnered with the Center for Energy Workforce Development to identify technical competencies that will influence talent development for the utility sector (CEWD 2009). The center is now leveraging this understanding to establish programs that can fill gaps in the workforce pipeline.

7.1.4 Supporting Information Sharing on Cost-Effectiveness and Best Practices

The DOE Office of Electricity Delivery and Energy Reliability supports two complementary and cross-linked web sites that offer comprehensive information on smart grid technologies, tools, techniques, policies, and programs. SmartGrid.gov[92] is the Nation's resource for all Federal smart grid activities. The SmartGrid.Gov website, in conjunction with the Smart Grid Information Clearinghouse(www.SGIClearinghouse.org), will help disseminate best practices and information on smart grid programs and technologies to utilities, legislators, state regulators, consumers, and industry.

7.2 Innovative Research and Development

Research and development are keys to advancing new smart grid technologies (CenterPoint RFI, p. 11). Important existing smart grid research and development efforts include:

- **DOE Office of Electricity Delivery and Energy Reliability:** DOE's Office of Electricity and Energy Reliability conducts a Smart Grid research and development that accelerates discovery and innovation. The Office collaborates with the electric power industry, states, universities, national laboratories, and other stakeholders to develop a shared vision of the future for the Nation's electric delivery system and the technical challenges it faces in the decades ahead. DOE will continue to work with the public and private sector alike in many of the most critical grid modernization areas.[93]
- **DOE Building Technologies Program:** DOE's Building Technologies Program is designed to develop "technologies, techniques, and tools for making buildings more efficient, productive, and affordable." The Program will continue to pursue the research and design of innovative

90. A sample smart grid curriculum is available at www.asmartenergyfuture.com.
91. For a listing of these programs see: http://www.oe.energy.gov/recovery/1308.htm.
92. SmartGrid.gov is managed for DOE by the National Renewable Energy Laboratory (NREL).
93. See DRSG RFI, pp. 24; eMeter RFI, pp. 14 (noting the benefits of considering existing documentation from pilots and other sources in building a cost-effective grid).

smart grid technologies related to buildings for consumers, such as the Building-Wide, Proactive Energy Management Systems for High-Performance Buildings project, which maximizes the operational efficiency, comfort, and economy of the building based on external conditions such as electricity prices and grid constraints (DOE-BTP 2011).

- **DOE Solar Energy Technologies Program:** The Solar Energy Technologies Program (SETP), through the Solar Energy Grid Integration Systems (SEGIS), awarded financial assistance to four companies in 2011 that are developing smarter and more interactive inverters that will enhance grid reliability and power quality while optimizing the delivery of solar power. The Program is continuing its activities in this area through the April 2011 release of the Solar Energy Grid Integration Systems-Advanced Concepts (SEGIS-AC) funding opportunity. SEGIS-AC will address the variable quality of solar power (such as when there is cloud cover), utility grid support, and system optimization for intelligent grid integration (DOE-SETP 2011) through continued research and development with a greater focus on deployment.
- **Advanced Research Projects Agency—Energy:** ARPA-E was created to invest in and manage the development of transformational energy technologies. Because most projects funded by ARPA-E are at the high-risk stage between concept and prototype, ARPA-E is specifically designed to provide crucial financial, technical, and commercialization assistance to shepherd new projects to market. ARPA-E proposed in FY 2012 to use $100 million from the President's Wireless Innovation Fund for wireless-related smart grid technologies and more. Further, in FY 2012, ARPA-E proposes to launch programs to develop advanced control architectures (network algorithms and supporting hardware) that are resilient, reliable, and capable of managing distributed resources in response to widespread deployment of intermittent, non-dispatchable generation. In March 2010, ARPA-E announced its third round of funding opportunities, which included programs designed to fund next-generation smart grid technologies:
  - The Grid-Scale Rampable Intermittent Dispatchable Storage (GRIDS) program is developing cost-effective, rampable energy storage that works like pumped hydroelectric storage, but is deployable in parts of the country where hydroelectric resources are scarce.
  - The Agile Delivery of Electrical Power Technology (ADEPT) program is developing smart electronic transformers that can allow the grid to better utilize existing transmission capacity.

Case Study:
DOE, National Lab, Industry, and Academia Collaborate to Develop and Use GridLAB-D™ Simulation Tool to Assess Grid Options

GridLAB-D is a flexible simulation environment that examines the interplay of every part of a distribution system. It allows modeling of the impacts of distribution-level smart grid applications to identify synergies and conflicts, and model their impacts on the operation of the entire grid. GridLAB-D has an advanced algorithm that simultaneously calculates the state of millions of independent devices. Its approach reduces the danger that flawed assumptions could yield inaccurate results and predicts behavior in unusual situations with significantly more accuracy. It can simulate the interactions of smart grid technologies and energy markets and inform decisions about managing load growth and ensuring system reliability. GridLAB-D will help researchers better understand smart grid technologies that can be deployed in the next 5 to 10 years.

GridLAB-D is also a useful tool for industry. For example, when American Electric Power (AEP) was considering the deployment of a new voltage control system on its distribution system, GridLAB-D was used to simulate the system and quantify the expected benefits of its use. After analyzing the results of a field trial, GridLAB-D was able to extrapolate those results to the entire AEP system, allowing AEP to build a business case for the wide-scale deployment of the technology.

Source: GridLAB-D (2010)

- **National Science Foundation:** In 2010, NSF expanded its emphasis on electric power by creating the Energy, Power and Adaptive Systems Program. This program supports work in areas such as:
  - Energy conversion chips that change, for example, heat and light to electricity;
  - Grid components such as solid state transformers and generators that use renewable energy; and
  - The electric power system as a whole.

  This program also supports development of mathematical tools to improve grid operation and design better devices. NSF is supporting research to develop a "fourth generation intelligent grid" that would use intelligent system-wide optimization to better allow renewable sources and pluggable electric vehicles without compromising reliability or affordability (Werbos 2011, pp. 57).
- **National Institute of Standards and Technology:** NIST collaborates with industry, academia, and other government agencies to promote U.S. innovation and industrial competitiveness by advancing measurement science, standards, and technology in ways that enhance economic security and improve quality of life. Within this mission, the NIST laboratories carry out research and development programs supporting the electric grid and its modernization in several major areas, including measurement research, and support for the development of interoperability and cybersecurity standards.
- **Department of Defense:** Military forces continue to face significant challenges in ensuring sufficient supply and efficient use of energy across their operations. Accordingly, the armed

services are investing in a variety of grid-based technologies that improve power generation, energy storage, power distribution, and power management for operational needs. In particular, micro-grid technologies show considerable potential for reducing the use of fuel and integrating resources into more efficient energy networks, enabling real-time optimization of power supply, demand, and energy storage for deployed Army operations. Notably, the Air Force is pursuing grid or networked power for remote and deployed air bases though similar investments, focusing specifically on providing uninterruptible power for radar and communications equipment.

7.3 Government as a Model User of Demand Response Technology

The General Services Administration (GSA), which buys much of the Federal Government's power, has already implemented four Government Accountability Office recommendations to increase participation in demand response programs (GAO 2004, pp. 45–46) and has issued guidance requiring buildings to offer demand response during system emergencies.[94] GSA plans to further consider efforts to automate demand response, utilize national interoperability standards, develop demand response contracting best practices, and encourage agencies to adopt dynamic rate alternatives.

The Federal Government will look for opportunities to save money, use open standards, and improve grid operations by expanding its participation in formal and informal demand response programs. GSA and the Department of Defense are moving ahead with the following:

- Increasing capacity to handle accounts on real-time pricing with, for example, software that accepts billing data in formats developed through NIST's Smart Grid Interoperability Panel. If this software is custom built, GSA will explore the possibility of putting it in the public domain;
- Adding automated demand response capabilities that use demand response communications standards developed through NIST's Smart Grid Interoperability Panel during building upgrades;
- Shifting appropriate Federal customers to real-time pricing or other arrangements that give them an incentive to respond to the real-time price of electricity;
- Enrolling appropriate Federal customers in demand response programs that complement their pricing plan and facility's capabilities and that help to integrate renewable resources; and
- Developing and sharing demand response and contracting best practices.

7.4 New and Ongoing Opportunities for Cooperation

7.4.1 The Smart Grid Innovation Hub

The Department of Energy has proposed the creation of a Smart Grid Innovation Hub as outlined in the President's FY 2012 Budget request. DOE envisions this Hub as bringing together a multi-disciplinary group of researchers, innovators, industries, utilities, labs, and governments to support research, development, and demonstration of smart grid technologies and systems. In so doing, the Hub will focus on grid transformation, evolution, and modernization. In particular, it will address existing concerns and

94. The requirement can be found at 10 C.F.R. 436.105 (GSA 2011). http://www.gsa.gov/portal/content/100861

work to accelerate discoveries, integrate new components into the grid in a manner that can be scaled-up into a system, and create the tools, models, and systems to further the smart grid. Each stage—technology development, simulations and analyses, and integration and demonstration—will inform the others to create a smooth process to create and deploy new technologies. In short, the Hub will provide scientific support to new technologies as well as an avenue to bring those innovations to market.

7.4.2 New DOE Efforts

DOE is announcing a nationwide contest to challenge America's students and their families to save energy in their homes—America's Home Energy Education Challenge. After learning about energy efficiency at school, students will use their new skills to compete—as a classroom or as a school—in a national head-to-head competition to reduce energy usage in their homes. DOE will award three grand prizes and ten regional prizes to the teams that save the most energy and mobilize the highest percentage of students to compete. Moreover, every student that participates will be recognized for different tasks, such as completing a basic energy audit or figuring out how to access their home energy usage data.

DOE is continuing efforts to advance the deployment and commercialization of smart grid technologies and accelerate America's shift to an information-enabled electricity grid. In June 2011, DOE plans to issue a solicitation to demonstrate innovative applications that provide consumers with access to new information about their energy usage so that they can make more informed decisions about their energy consumption.

7.4.3 Technical Assistance to State Regulators

As a number of utilities consider implementing smart grid programs, state regulators are facing challenges about how to assess proposed smart grid investments. To provide support, DOE will work with NARUC to assess their members' needs for additional technical assistance,[95] which could include creating an evolving repository of technical and policy analyses, expert testimony, and major regulatory decisions from state proceedings on smart grid technology implementation issues. Such a repository, for example, could include case studies of state experiences with implementing smart grid technologies, as well as relevant PUC decisions of both pilots and full-scale deployments.

This coordination and support will build on the existing DOE technical assistance provided to state electricity officials, the NARUC-FERC Collaborative on Smart Response and its predecessors, the $44.2 million of Recovery Act funds provided to states to hire and retain staff to review proposed Recovery Act electricity projects, and the $4 million Recovery Act grants to NARUC to develop the State Electricity Regulators Capacity Assistance and Training Program, which also includes smart grid as one of its subject areas. This funding is building important intellectual capital that will help state regulatory utility commissions address electricity challenges that may include deployment of smart grid technologies.

95. The potential for leadership by DOE and NARUC was highlighted by responses to the Request for Information. See AT&T RFI, pp. 8, urging DOE to identify best practices for states; BGE RFI, pp. 8, suggesting DOE is an a "unique position" to provide guidance for utilities, customers, regulators, and legislators; APPA RFI, pp. 21–22, suggesting NARUC and the Administration should cooperate to disseminate the results of smart grid pilots.

7.4.4 NARUC—NASUCA—DOE Cooperation on Consumer Empowerment

Recognizing that many benefits enabled by smart grid technologies rely on consumer action or engagement, it is imperative that the technology options and application choices available to the consumer be clear, simple, and offer benefits within a reasonable period of time. By cooperating with one another as they work to ensure consumers have the opportunity to receive information about smart grid technologies and programs, DOE, the regulatory community, and consumer groups can be more effective.[96] Additionally, such cooperation can provide a framework for better understanding consumers' experiences with smart grid technologies, and how Federal and state policies can continue to evolve and ensure that consumers are able to fully benefit from the transition to a smarter grid.[97]

7.4.5 Implementing the Roadmap to Secure Control Systems in the Energy Sector

An unsecure grid creates risks for consumers and utilities, hampers investment, and exposes the nation's critical infrastructure. In recognition of the fact that securing the electric grid against cyber threats cannot be achieved by private or governmental entities working alone, the Federal Government has taken numerous steps to form partnerships and working relationships between government and private entities. Homeland Security Presidential Directive 7[98] and the National Infrastructure Protection Plan[99] established the initial framework for public-private partnerships for 18 critical infrastructure sectors and designated DOE as the sector-specific agency to work collaboratively with all stakeholders in the energy sector.[100] The strategy to ensure the overall security of the electricity sector is outlined in the *Energy Sector-Specific Plan*,[101] initially published in 2007 and updated in 2010.

To specifically address the unique cybersecurity challenges in the electric sector, DOE in 2006 joined with utilities, vendors, researchers and other energy sector stakeholders to develop the *Roadmap to Secure Control Systems in the Energy Sector*.[102] This roadmap identified concrete steps to secure control systems over 10 years. In 2010, DOE once again joined with industry stakeholders to update the roadmap to specifically address an evolving threat environment and the new challenges introduced by smart grid technologies. The draft *Roadmap to Secure Energy Delivery Systems* provides specific milestones industry and government can work toward to achieve an energy infrastructure that is resilient in the presence of cyber assaults. The Energy Sector Control Systems Working Group is a public-private working group formed to track progress toward the Roadmap goals. Since 2006, more than 65 initiatives have been launched by DOE, universities, and private sector entities to develop and commercialize advanced cybersecurity solutions to improve cybersecurity across the energy sector.

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96. Many commenters noted the importance of a Federal role in sharing best practices for consumer education. See, e.g., APPA RFI, pp. 10-12, 24; CEA RFI, pp. 10-11; EEI RFI, pp. 5.

97. APPA RFI, pp. 10: "DOE could help utilities develop effective education campaigns by compiling best practices and lessons learned from the SGIG projects."

98. This document is available at http://www.dhs.gov/xabout/laws/gc_1214597989952.shtm.

99. The plan is available at http://www.dhs.gov/xlibrary/assets/NIPP_Plan.pdf.

100. Cybersecurity encompasses all aspects of the electric grid. Smart grid technologies and applications are merely one subset of the grid.

101. The plan is available at http://www.oe.energy.gov/DocumentsandMedia/Energy_SSP_2010.pdf.

102. The document is available at http://www.oe.energy.gov/DocumentsandMedia/roadmap.pdf.

7.4.6 Smart Grid Interoperability Panel—NIST-supported venue for public/private cooperation

SGIP[103] engages stakeholders from the entire smart grid community in a participatory public process to identify applicable standards, gaps in currently available standards, and priorities for new standardization activities for the evolving smart grid. SGIP supports NIST in fulfilling its responsibilities under the 2007 Energy Independence and Security Act.

7.5 Working with International Partners

Around the world, governments, businesses, and citizens are beginning to understand the potential of a smart grid and are actively investing in smart grid technologies. The U.S. electrical grid is connected to other nations' grids across borders, and the interoperable, networked nature of smart technologies may enable certain applications to connect across the internet. Therefore, the Administration is committed to working with international partners to ensure the development, coordination, and security of our connected grid.

7.5.1 International Smart Grid Action Network

At the Clean Energy Ministerial held in Washington, DC, in July 2010, hosted by U.S. Secretary of Energy Steven Chu, ministers announced the launch of the International Smart Grid Action Network (ISGAN). ISGAN is an international partnership that was created to be a mechanism for multilateral, government-to-government collaboration to advance the development and deployment of smarter electric grid technologies, practices, and systems. ISGAN activities are focused on those aspects of smart grid where governments have regulatory authority, expertise, convening power, or other leverage, with a focus on six principal areas: policy, standards and regulation, finance and business models, technology and systems development, user and consumer engagement, and workforce skills and knowledge. Currently, 19 countries and the European Commission participate in ISGAN. In April 2011, ISGAN was formally established as an Implementing Agreement under the International Energy Agency's *Framework for International Technology Co-Operation*. The ISGAN Implementing Agreement provides a proven model for cooperation among ISGAN participants and with other relevant smart grid-related initiatives.[104]

7.5.2 International Cooperation in Standards Development

NIST has adopted a policy to utilize international standards wherever possible. This provides a double benefit. First, by minimizing unnecessary modifications from country to country, equipment and systems suppliers can realize greater economies of scale, which can, in turn, reduce costs for utilities and consumers. Second, harmonized international standards facilitate global market access for suppliers, leading to increased exports and jobs for U.S. suppliers. To that end, NIST is working closely with many international standards development organizations, including the International Electrotechnical Commission; International Organization for Standardization; International Telecommunication Union

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103. For more information on the SGIP, see http://collaborate.nist.gov/twiki-sggrid/bin/view/SmartGrid/SGIP.

104. Participants include the European Commission and the governments of Australia, Belgium, Canada, China, France, Germany, India, Italy, Japan, Korea, Mexico, Netherlands, Norway, Russia, Sweden, Switzerland, the United Kingdom, and the United States. For information, see http://www.cleanenergyministerial.org/pdfs/factsheets/CEM2_Fact_Sheet_ISGAN_07April2011.pdf.

Telecommunication Standardization Sector; Institute of Electrical and Electronics Engineers; Society of Automotive Engineers International; Internet Engineering Task Force; and others, so that their standards can be incorporated where appropriate in the U.S. smart grid standards framework. Nearly 80% of the standards identified in the initial release of the NIST Smart Grid Framework and Roadmap are international standards.

NIST is devoting considerable attention to bilateral and multilateral engagement with other countries to ensure the continued development of international standards for smart grid technologies and encourage global participation in the work of the SGIP. Both NIST and the International Trade Administration (ITA) are engaging foreign governments and promoting transparency and coordination in the development of smart grid standards. This work will promote international trade and investments that further the modernization of national electric grids and reduce barriers to trade in smart grid technologies and services around the world.

The ITA also manages the Market Development and Cooperator Program (MDCP), which supports projects that enhance the global competitiveness of U.S. manufacturing and service industries. One of the five MDCP projects awarded in 2009 was a partnership with the National Electrical Manufacturers Association (NEMA) for the *Development of a Secure, Robust, and Reliable North American Smart Electrical Grid.* The objective of this program is to increase coordination on the development of smart grid standards and technology between the U.S., Canada, and Mexico. The harmonization of smart grid standards among these North American Free Trade Agreement (NAFTA) countries will facilitate trade of smart grid products and technologies, which will become increasingly important as an integrated smart grid system is implemented throughout North America.

7.5.3 International Cooperation for Better Export Opportunities

In his 2010 State of the Union address, President Obama announced the National Export Initiative (NEI) and set the ambitious goal of doubling U.S. exports in the next 5 years to support millions of jobs here at home. The President's Export Promotion Cabinet has since identified smart grid technology as an important sector of the economy with export potential. The Administration is now using the NEI to concentrate Federal agency attention on trade promotion, market development, and trade enforcement and to highlight opportunities for U.S. exporters, including the smart grid industry. The NEI is focused on (1) improving trade advocacy and export promotion efforts; (2) increasing access to credit, especially for small and midsize businesses; (3) removing barriers to the sale of U.S. goods and services abroad; (4) enforcing trade rules; and (5) pursuing policies at the global level to promote strong, sustainable, and balanced growth.

The International Trade Administration is working with partners around the world to promote U.S. products and services in markets where smart grid investment is growing. Through U.S. Commercial Service offices in nearly 80 countries, the ITA is quickly identifying market opportunities abroad and engaging the smart grid industry at home to connect exporters to buyers abroad. The ITA will utilize specific trade promotion mechanisms in these efforts, including official trade missions and the International Buyer Program, which is a government-industry partnership that recruits foreign buyers and business partners to attend industry trade shows in the U.S.

Chapter 8: Conclusion

Smart grid technologies and programs represent an evolution in how our electricity system operates. As this report highlights, this transition offers significant promise for utilities, innovators, consumers, and society at large. This document has outlined four essential pillars that will enable the United States to transition to a smarter grid:

1. **Enable Cost-Effective Smart Grid Investments:** Smart grid technology can drive improvements in system efficiency, resiliency, and reliability, and help enable a clean energy economy through cost-effective grid investments. Many of these technologies promise to pay for themselves in operational improvements, and energy savings. The Federal Government's research, development and demonstration projects, technical assistance, information sharing on technologies and programs, and evaluations provide valuable guidance for utilities, consumers, and regulators about what approaches are the most cost-effective, thereby paving the way for the effective, ongoing upgrade of the grid.
2. **Unlock the Potential of Innovation in the Electricity Sector:** A modernized electric grid promises to be a powerful platform for new products and services that improve grid operations and deliver comfort, convenience, and savings to energy customers.
3. **Empower Consumers and Enable Informed Decision Making:** The success of smart grid technologies and applications depends on engaging and empowering both residential and small business consumers. New tools and programs promise to provide consumers personalized information and equip them to make informed energy choices, while ensuring their energy consumption data is accorded privacy protections.
4. **Secure the Grid:** Protecting the electric system from cyber attacks and ensuring it can recover when attacked is vital to national security and prosperity. Developing and maintaining threat awareness and rigorous cybersecurity guidelines and standards are keys to a more secure grid.

The smart grid policies and activities discussed in this document complement the Administration's efforts to spur the planning and siting of new high voltage transmission lines and other methods to better integrate variable renewable energy. While these topics are outside the scope of this document, the Administration recognizes that overall grid modernization is critical to supporting the energy needs of the 21st century.

There are significant benefits that will flow from making the grid smarter. This grid modernization effort, however, will require sustained cooperation between the States, local governments, the Federal Government, the private sector, and other stakeholders. The Recovery Act provided support for a number of important steps in this direction, but there is still much to be done. To provide a path forward, the Administration's smart grid policy framework will enable U.S. leadership in clean energy solutions and provide a foundation of energy innovation more generally.

The Administration recognizes that this report is only one step in an ongoing effort. To that end, within six months of the release of this report DOE will provide the National Science and Technology Council's Committee on Technology with a status report on its implementation across topic areas, including cost-benefit analysis, standards development efforts in partnership with NIST, consumer education, and cybersecurity. Similarly, DOE will continue to identify new policy and technology recommendations related to smart grid implementation. DOE will continue to identify new policy and technology recommendations related to smart grid implementation. For example, the Energy Information Administration, budget permitting, will undertake initial efforts to measure progress through its utility data collection mechanisms as early as 2012.

Just as the 20th century grid has supported the growth of America's dynamic economy, the 21st century grid will sustain that growth into the future. With tools for a clean energy economy, efficiency benefits for utilities, opportunities for consumers to engage and save money, and new areas for innovation, a smarter, modernized, and expanded grid can serve as a platform for American leadership in a clean energy future.

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Appendix A: The NSTC Subcommittee on the Smart Grid

The National Science and Technology Council created a Subcommittee on Smart Grid in July of 2010, recognizing the vital role of smart grid technology as a component of President Obama's commitment to prepare for a 21st century grid.[105] Drawing from ten Executive agencies, six offices within the White House, and three independent agencies serving in an advisory capacity, the Subcommittee was created to "provide policy recommendations and guidance for development of the Administration's Smart Grid policy," to "articulate a vision for the Smart Grid, including priorities, goals, and opportunities for Federal action," and to "develop a Smart Grid policy framework for the Administration, including a report for stakeholders."

Consistent with the President's commitment to open, transparent, participatory, and collaborative governance,[106] the members of the Subcommittee have reached out to over one hundred stakeholders to better understand how the Federal Government can collaborate with partners across the country and set policies to make America's electric grid smarter. These efforts have included:

- Requests for Information from the U.S. Department of Energy that influenced or were on behalf of the Subcommittee:
  - "Addressing Policy and Logistical Challenges to Smart Grid Implementation," September 17, 2010.[107] For a list of respondents, see page 92 of this Appendix.
  - "Implementing the National Broadband Plan by Studying the Communications Requirements of Electric Utilities to Inform Federal Smart Grid Policy," May 11, 2010.[108] For a list of respondents, see page 94 of this Appendix.
  - "Implementing the National Broadband Plan by Empowering Consumers and the Smart Grid: Data Access, Third Party Use, and Privacy," May 11, 2010.[109] For a list of respondents, see page 94 of this Appendix.
- A collaborative blog facilitated by the Office of Science and Technology Policy and the National Institute of Standards and Technology.[110]
- Direct outreach with stakeholders. For a list of stakeholders who participated in our direct outreach effort, see page 96 of this Appendix.

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105. For a description of the Subcommittee, and a list of participating agencies, see the Subcommittee's charter within this Appendix.

106. President Barack Obama, Memorandum of Jan. 21, 2009: Transparency and Open Government, 74 Fed. Reg. 15, at 4685 (Jan. 26, 2009), http://edocket.access.gpo.gov/2009/pdf/E9-1777.pdf.

107. The text of this Request is available at http://www.oe.energy.gov/DocumentsandMedia/9-22-10_Federal_Register-Smart_Grid_Implementation.pdf.

108. The text of this Request is available at http://www.gc.energy.gov/documents/Natl_Brdband_Elec_Util.pdf.

109. The text of this Request is available at http://www.gc.energy.gov/documents/Natl_Brdband_Data_Access.pdf.

110. Office of Science and Technology Policy, "Consumer Interface With the Smart Grid," Feb. 19, 2010, 75 Fed. Reg. 33 at 7526.

As this report made clear, the Federal Government will continue to engage and collaborate with a range of stakeholders as smart grid technologies and policies evolve. For information on the smart grid-related outlets for cooperation that the Obama Administration has developed, see Chapter 7 of this report.

Respondents to the September 2010 Request for Information

The original Request for Information is available at: http://www.federalregister.gov/articles/2010/09/17/2010-23251/addressing-policy-and-logistical-challenges-to-smart-grid-implementation.

To see the Request for Information responses, visit: http://www.oe.energy.gov/Smart%20Grid%20Request%20for%20Information%20and%20Public%20Comments.htm.

- AARP
- ABB
- Alliance to Save Energy
- Ambient Corporation
- American Gas Association
- American Public Gas Association (APGA)
- American Public Power Association (APPA)
- American Society of Heating, Refrigerating and Air-Conditioning Engineers Inc. (ASHRAE)
- Association of Home Appliance Manufacturers (AHAM)
- AT&T
- Baltimore Gas and Electric Company (BGE)
- Browning, Stephen
- Center for Democracy and Technology/ Electronic Frontier Foundation
- CenterPoint Energy
- Cisco Systems
- City Utilities of Springfield, Missouri
- Consumer Electronics Association
- CURRENT Group
- Dairyland Power Cooperative
- Demand Response and Smart Grid Coalition (DRSG)
- District of Columbia Office of the People's Counsel (DC OPC)
- Divan, Deepak, Professor, Georgia Institute of Technology
- Edison Electric Institute (EEI)
- Electric Power Research Institute (EPRI)
- eMeter Strategic Consulting
- Energy Services of Pensacola
- EnerNOC
- Florida Power & Light Company (FPL)
- Galvin Electricity Initiative
- GridWise Alliance
- Grijalva, Santiago, Associate Professor, Georgia Institute of Technology
- Honeywell
- Ingersoll Rand
- Michigan Public Service Commission Staff
- National Action Plan Coalition
- National Association of Regulatory Utility Commissioners (NARUC)
- National Association of State Utility Consumer Advocates (NASUCA)
- National Electrical Manufacturers Association (NEMA)
- National Grid
- National Rural Electric Cooperative Association (NRECA)
- New America Foundation
- New York Independent System Operator, Inc.(NYISO)
- New York State Smart Grid Consortium (NYSSGC)
- The North American Electric Reliability Corporations (NERC)
- Ohio Consumers' Counsel
- Okaloosa Gas District
- OPOWER
- Oregon Public Utility Commission
- Pepco Holdings, Inc.
- Power North America
- Progress Energy
- RedSeal Systems
- Satcon Technology Corporation
- Southern Company Services
- Steffes Corporation
- TekTrakker Information Systems
- Telecommunications Industry Association (TIA)
- Tendril Networks, Inc.
- Toshiba International
- Toward Energy Efficient Municipalities, LLC
- Utilities Telecom Council (UTC)
- US Nuclear Regulatory Commission (NRC)
- Verizon/Verizon Wireless

Respondents to the May 2010 Requests for Information

To see responses to both Requests For Information, visit: http://www.gc.energy.gov/1662.htm.

The original Request for Information entitled "Implementing the National Broadband Plan by Empowering Consumers and the Smart Grid: Data Access, Third Party Use, and Privacy," is available at: http://www.gc.energy.gov/documents/Natl_Brdband_Data_Access.pdf.

The original Request for Information entitled "Implementing the National Broadband Plan by Studying the Communications Requirements of Electric Utilities to Inform Federal Smart Grid Policy," is available at: http://www.gc.energy.gov/documents/Natl_Brdband_Elec_Util.pdf.

Respondents to RFI entitled: Implementing the National Broadband Plan by Studying the Communications Requirements of Electric Utilities to Inform Federal Smart Grid Policy	Respondents to RFI entitled: Implementing the National Broadband Plan by Empowering Consumers and the Smart Grid: Data Access, Third Party Use, and Privacy
Alcatel-Lucent	AARP
Ambient Corporation	American Public Power Association (APPA)
American Petroleum Institute	Avista Corporation
American Public Power Association (APPA)	Baltimore Gas & Electric Company
AT&T	Building Owners and Managers Association
Avista Corporation	Cleco Power, LLC
Baltimore Gas & Electric Company (BGE)	Consumer Electronics Association (CEA)
BGE Current Communications Needs	Consumers Union, National Consumer Law Center, and Public Citizen
BGE Future Communications Needs	CPower, Inc.
Bonneville Power Administration	Demand Response and Smart Grid (DRSG) Coalition
Booz Allen Hamilton	DTE Energy Company
Cleco Corporation	Edison Electric Institute
Crow Wing Power	Elster Solutions
Dakota Electric Association	EnerNOC, Inc.
Diversified Energy Partners, Inc.	Exelon Corporation
DTE Energy Company	Florida Power & Light Company
East Central Energy	Google, Inc.
Edison Electric Institute (EEI);	Honeywell
EEI Smart Grid Data Flow Diagram; EEI Smart Meter Deployments; DOE Recovery Act Smart Grid Investment Grants	Idaho Power Company
Energy Services, Inc.	Joint Center for Political and Economic Studies
Exelon Corporation	National Association of Rural Utility Commissioners (NARUC)
Florida Power & Light Company	National Rural Electric Cooperative Association (NRECA)
GE Digital Energy; GE Smart Grid System Requirements	National Association of State Utility Consumer Advocates (NASUCA)
Great River Energy	Neustar, Inc.
Grid Net	Oncor Electric Delivery
Honeywell	Pepco Holdings, Inc.
Hughes Network Systems, LLC	Public Citizen's Energy Program; Supplemental Report

continued on next page

Respondents to RFI entitled: Implementing the National Broadband Plan by Studying the Communications Requirements of Electric Utilities to Inform Federal Smart Grid Policy	Respondents to RFI entitled: Implementing the National Broadband Plan by Empowering Consumers and the Smart Grid: Data Access, Third Party Use, and Privacy
Lake Region Electric Cooperative	The Real Estate Roundtable
Lower Colorado River Authority (LCRA); LCRA Current Communication Needs; LCRA Future Communication Needs	San Diego Gas & Electric
Qualcomm Incorporated	Silver Spring Networks
Meeker Cooperative Light and Power	Southern California Edison
Mille Lacs Energy Cooperative	Southern Company Services
Motorola, Inc.	Telecommunications Industry Association (TIA)
National Association of State Utility Consumer Advocates (NASUCA)	Tendril Networks, Inc.
National Cable & Telecommunications Association (NCTA)	United States Telecom Association
National Rural Electric Cooperative Association (NRECA)	Utilities Telecom Council
Northeast Utilities System	Verizon/Verizon Wireless
Oncor Electric Delivery; Oncor Current Communication Needs; Oncor Future Communication Needs	Whirlpool Corporation
On-Ramp Wireless, Inc.	Xcel Energy
Pepco Holdings, Inc.	
San Diego Gas & Electric (SDG&E)	
Silver Spring Networks	
Southern California Edison	
Southern Company Services	
Space Data Corporation	
Steele-Waseca Cooperative	
T-Mobile	
Tacoma Public Utilities	
Telecommunications Industry Association	
Tropos Networks	
Utilities Telecom Council	
Verizon/Verizon Wireless	
The Wireless Association (CTIA)	

Stakeholder Meetings with the NSTC Subcommittee on the Smart Grid[111]

State utility regulators including, but not limited to:
Arkansas Public Service Commission
California Public Utilities Commission
Connecticut Department of Public Utility Control
District of Columbia Public Service Commission
Illinois Commerce Commission
Maryland Public Service Commission
Michigan Public Service Commission
Missouri Public Service Commission
New York State Public Service Commission
Oregon Public Utility Commission
Public Service Commission of South Carolina
Public Utilities Commission of Ohio
Public Utility Commission of Texas
Vermont Public Service Board
And contacts through the National Association of Regulatory Utility Commissioners (NARUC)

State utility consumer advocates including, but not limited to:
Colorado Office of Consumer Counsel
District of Columbia Office of the People's Counsel
Maryland Office of People's Counsel
Pennsylvania Office of Consumer Advocate
And contacts through the National Association of State Utility Consumer Advocates (NASUCA)

Multiple nations through the Clean Energy Ministerial and International Smart Grid Action Network (ISGAN). ISGAN members include Australia, Austria, Belgium, Canada, China, the European Commission, France, Germany, India, Italy, Japan, Mexico, the Netherlands, Norway, Russia, Sweden, Switzerland, South Korea, and the United Kingdom. Additional meetings included Austria and Brazil.

AARP

ABB

Alliance to Save Energy

American Council for an Energy-Efficient Economy

American Electric Power

American Public Power Association

Arcadian Networks

AT&T

Battelle

Beacon Power Corporation

Belkin

Best Buy

Boston Consulting Group

Brattle Group

Brookings Institution

CableLabs

Cambridge Energy Research Associates

Center for American Progress

Centerpoint Energy

Cisco

The Climate Group

Comcast

Consumer Electronics Association

Consumers Union

Cooperative Research Network

CURRENT Group

Demand Response and Smart Grid Coalition

District of Columbia Consumer Utility Board

Dow

Drummond Group Inc.

DTE Energy

Duke Energy

EcoAlign

Edge Holdings LLC

Edison Electric Institute

Efficiency First

EPB of Chattanooga

Electric Power Research Institute

Elster Metering

eMeter

EnergyHub

EnergySolve Companies

EnerNOC

EnerTech Capital

Environmental Defense Fund

Ford Motor Company

Future of Privacy Forum

General Electric Energy

General MicroGrids

Global Intelligent Utility Network Coalition

Google

Great River Energy

GreenWave Reality

GridWise Alliance

111. The organizations and individuals listed here met with one or more members of the Subcommittee or staff during the course of the project. Not all Subcommittee members participated in each meeting.

HomeGrid Forum
Honeywell
Hoosier Energy Rural Electric Cooperative
House Committee on Science and Technology
Hewlett Packard
IBM
Information Technology Industry Council
Intel
International Brotherhood of Electrical Workers
Itron
Johnson Controls International
Landis and Gyr
Lawrence Berkeley National Laboratory
Lockheed Martin Energy Solutions
Microsoft
Missouri Department of Natural Resources
MIT—Future of the Grid Study Group
Mitre
National Academy of Sciences
National Cable & Telecommunications Association
National Consumer Law Center
National Grid
National Renewable Energy Laboratory
NDN
National Electrical Manufacturers Association
North American Electric Reliability Corporation (NERC)
NorthWestern Energy
National Rural Electric Cooperative Association
Oncor
OPOWER
Pacific Northwest National Laboratory
Panasonic
Panasonic Electric Works Laboratory of America
Pecan Street Project
Pepco
PJM Interconnection
Power Systems Consulting
Progress Energy
Public Citizen
Reliant Energy
Resources for the Future
RockPort Capital
Sacramento Municipal Utility District
Salt River Project
Science and Technology Policy Institute
Silicon Valley Leadership Group
Silver Spring Networks
Smart Grid Consumer Collaborative
Smart Grid Interoperability Panel
Smart Meter Pilot Program Inc.
SmartSynch
Southern Company
SunSpec Alliance
Sawnee EMC
Telecommunications Industry Association
Tendril Networks
Texas A&M University
To The Point
Trilliant
University of California, Berkeley
University of Colorado
University of Illinois
US Nuclear Regulatory Commission
Utilities Telecom Council
Van Ness Feldman
Vermont Electric Power Company
Venrock
Verizon
Whirlpool
Xcel Energy
ZigBee Alliance

National Science and Technology Council Establishes Subcommittee on Smart Grid

CHARTER
of the
SUBCOMMITTEE ON SMART GRID
COMMITTEE ON TECHNOLOGY
NATIONAL SCIENCE AND TECHNOLOGY COUNCIL

A. Official Designation

The Subcommittee on Smart Grid is hereby established by action of the National Science and Technology Council (NSTC) Committee on Technology.

B. Purpose and Scope

The Smart Grid is a vital component of President Obama's comprehensive energy plan, which aims to reduce harmful greenhouse gas emissions and U.S. dependence on oil, create jobs, and help U.S. industry compete successfully in global markets for clean energy technology. The American Recovery and Reinvestment Act of 2009 included $11 billion for smart grid technologies, transmission system expansion and upgrades, and other investments to modernize and enhance the electric transmission infrastructure to improve energy efficiency and reliability. The purpose of the Subcommittee on Smart Grid is to establish an interagency process that will focus on furthering the goals of President Obama's comprehensive energy plan and the Recovery Act, and specifically, to provide policy recommendations and guidance for development of the Administration's Smart Grid policy.

C. Functions

- The Subcommittee will articulate a vision for the Smart Grid, including priorities, goals, and opportunities for Federal action.
- The Subcommittee will develop a Smart Grid policy framework for the Administration, including a report for stakeholders that includes analysis of (and, where appropriate, guidance on) key economic, business case, consumer acceptance, and technology issues.
- The Subcommittee will facilitate a coordinated effort across the Federal agencies to advance the Administration's goals for the Smart Grid.

D. Membership

The following Federal departments and agencies are represented on the NSTC Subcommittee on Smart Grid:

- Department of Agriculture
- Department of Commerce
- Department of Defense
- Department of Energy

- Department of Homeland Security
- Department of Housing and Urban Development
- Department of Justice
- Environmental Protection Agency
- General Services Administration
- National Science Foundation
- Executive Office of the President
- Council on Environmental Quality
- National Economic Council
- Office of Science and Technology Policy
- Office of Management and Budget
- Council of Economic Advisors
- National Security Staff
- And other departments and agencies designated by the Chair.

The Federal Energy Regulatory Commission, Federal Communications Commission, Federal Trade Commission, and other independent agencies as appropriate, shall be represented on this Subcommittee in an advisory capacity.

E. Termination Date

The Subcommittee on Smart Grid of the NSTC Committee on Technology is envisioned as a standing subcommittee, with an evolving set of responsibilities and an ongoing mandate to catalyze, support, and elevate the quality of the Federal government's involvement in the Smart Grid.

F. Determination

We hereby determine that the formation of the Subcommittee on Smart Grid is in the public interest in connection with the performance of duties imposed on the Executive Branch by law, and that such duties can best be performed through the advice and counsel of such a group.