Governors' Guide to Modernizing the Electric Power Grid

Executive Summary

Governors have a strong interest in ensuring that the electric power grid functions safely, reliably, and efficiently. Although it functions well overall and utilities have made many upgrades, the grid needs modern technologies and new infrastructure to meet the challenges and opportunities of the 21st century, including mitigating increased storm- and cyber-related threats, integrating the use of more renewable energy resources, and capitalizing on the greater availability of data on grid performance and electricity usage. Most recently, an attack by gunmen on a utility substation in California that caused damage but did not result in a power outage has drawn attention to another vulnerability of electricity infrastructure. By modernizing the grid, states and utilities have an opportunity to address those challenges, improve the operation and efficiency of the electric power system, and drive economic opportunities. Governors can help regulators, utilities, and customers better understand the benefits of grid modernization in terms of increased reliability, resiliency, and energy efficiency and how those benefits compare to the costs. Governors also can promote greater coordination among state, federal, and private partners—on transmission development, cybersecurity threats, and renewable integration—which can help modernization efforts occur more quickly and cost-effectively.

The electric power grid serves as the backbone of the energy system and is essential to other critical infrastructure. The grid consists of transmission and distribution networks that provide 11 billion kilowatt-hours of electricity to homes and businesses every day and allows the systems providing transportation, health care, and telecommunications to function. The U.S. transmission network consists of three major interconnection areas that span North America and constitute the world's largest and most complex system of generation, transmission, and distribution. Generally, the system is robust enough to meet every day needs. However, the grid's age and design—70 percent of transmission lines and transformers are at least 25 years old, 60 percent of circuit breakers are at least 30 years old, and much of the infrastructure was designed in the 1950s—make it vulnerable to disruption and limit its ability to take advantage of computer-controlled operations.

Several factors interact with the age and limited functionality of the grid to impede safe, reliable, and efficient operation:

- **Severe weather** is contributing to the increased frequency of widespread power outages. Major power outages (affecting more than 50,000 customers) are occurring more often, and weather continues to cause the overwhelming proportion of those outages and a majority of outages of all sizes.

- The emergence of new **cyber threats** exposes the grid to intentional and accidental cyber-related disruptions. Although cyber attacks against electric utilities have largely targeted the personal information of customers, the number of attacks on utilities is growing and grid infrastructure is increasingly a target.

- The physical layout of the transmission grid and the practices used to operate it constrain the **addition of renewable energy** resources, both utility-scale resources and distributed generation (which involves the small-scale production of electricity at or near homes and businesses). Meeting the increasing demand for renewable energy resources, driven in part by the 41 states and territories with renewable portfolio standards or goals, is not possible without greater investment in grid infrastructure and operations.

- **Traditional measurement and monitoring approaches** limit utilities' ability to make more efficient investments in grid infrastructure and generation resources and constrain consumers' ability to make better-informed decisions about their energy use.

Distinct from those factors is the increasing awareness of the vulnerability of the grid to other physical threats, most notably the protection of electricity infrastructure against targeted physical attacks. Earthquakes and electromagnetic disturbances (both natural and intentional) also pose threats to the grid. Although those threats are not the focus of this paper, addressing them should be considered alongside efforts to modernize the electric power grid.

Grid modernization goes beyond current efforts to implement a "smart grid," in which two-way communications technologies improve the efficiency of grid operations, and includes the following elements:

- **Increased communication capabilities and automation** on the local distribution grid that can help utilities more quickly respond to outages and redirect power away from affected lines, securely and easily share customer data, ease the transition to greater levels of distributed generation resources, and help utilities prevent and recover from cyber attacks, (Although, paradoxically, some cyber vulnerabilities stem from an increase in communication and automation devices that connect the grid to the Internet);

- **An expanded, technologically advanced, and optimized transmission system** that can better integrate utility-scale renewable resources and improve the reliability of the grid; and

- **Energy storage technologies** that can ease the integration of variable renewable resources and provide backup power during outages.

Integrating those technologies and practices into the electric power grid is likely to spur changes in the way electricity is generated, delivered, sold, and consumed. For utilities, states, and consumers, that change represents both opportunities and challenges. The opportunities—increased reliability and resilience, improved cybersecurity, easier integration of renewable energy resources, and greater use of data—can provide benefits that are estimated at as much as $2 trillion by 2030, if the interests of consumers, utilities, and state policymakers and regulators are aligned as much as possible. A chief challenge is that fully deploying the technologies associated with a more modern grid calls for a sizable additional investment. Utilities currently spend approximately $34 billion per year on new transmission lines and maintenance on both the transmission and distribution networks. To fully modernize the grid, utilities would need to spend an estimated additional $8 billion to $16 billion per year through 2030. Determining which entities will bear those costs, including how much of the cost utility customers pay, will be a critical factor in how extensively and rapidly the grid is modernized.

The need for grid modernization is coming at a trying time for the electric utility industry. The traditional business model faces challenges from a substantial decrease in the growth in demand for electricity nationally and a related drop in utility revenues. That decrease in demand growth is associated with various policy actions, changes in consumer preferences, and technology advancements that have led to the more efficient use of energy and an increased use of distributed generation that still requires grid services.

Annual growth in demand has decreased from a peak of 12 percent per year in the 1950s to negative levels of growth in several recent years. The U.S. Energy Information Administration projects average annual growth at less than 1 percent between 2011 and 2040. That puts upward pressure on the rates set to ensure that utilities can recover the costs of providing electricity service while the estimated costs of grid modernization will put additional upward pressure on rates. To mitigate those pressures, states and utilities may seek new ways to determine utility rates that will require collaborative efforts between governors, legislatures, public utility commissions, utilities, and consumers.

Governors can play an important role in efforts to modernize the grid including: developing and implementing solutions that promote resiliency, security, and efficiency across the entire grid; helping find the right balance between the costs and benefits and clearly communicating those to the public; and coordinating state, federal, and private sector activities. States, alongside federal agencies and electric utilities, have already taken steps toward grid modernization through efforts to develop a smart grid, but additional steps are needed to harmonize existing efforts and meet emerging challenges.

Some strategies for governors to pursue include:

- **Working with state utility commissions, other state agencies and utilities to align policies, regulation, and incentives that support grid modernization**. Governors have opportunities to work with utility commissions, other agencies and utilities to understand the range of benefits associated with grid upgrades; establish performance-based reliability requirements; incorporate grid modernization efforts into state energy assurance plans; and develop a coordinated approach to cybersecurity. Although state utility commissions are independent regulatory agencies, executive or legislative actions can prompt their investigations and decisions. An ongoing effort at the **Massachusetts** Department of Public Utilities seeks to understand the costs and benefits of grid modernization and identify regulatory actions that will help achieve Governor Deval Patrick's energy, environmental, and electricity reliability goals.

- **Working with other states on a regional basis and with federal agencies to support cross-jurisdictional solutions**. The electric power grid in the United States is a large, interconnected network, crossing state and international boundaries, operated across multi-state regions, and regulated at both the state and federal level. That means that the challenges facing the grid go beyond state borders so it is important that states recognize where they can implement solutions with state, regional, and federal partners. That can include collaborating to integrate state and national efforts on grid cybersecurity, convening states to work on a regional basis to plan adequate transmission infrastructure to support renewable resources, and developing rules and pricing for how energy storage can integrate into the grid. Utility regulators in **Pennsylvania** have coordinated planning and information sharing with their counterparts in **Delaware, Maryland,** and **New Jersey,** along with utilities and federal agencies, to promote a regional approach to cybersecurity.

- **Addressing consumer concerns about data access and privacy.** Because the costs of utility efforts are passed on to customers, public understanding and acceptance of the technologies and their costs are critical to successful grid modernization. That is particularly true for technologies with which customers interact directly and that are meant to improve consumer access and choice, such as advanced meters and in-home devices that process detailed customer energy use data.

States can create standards for data access and privacy that provide clear direction on customer data ownership and access; they also can examine the costs and benefits of allowing customers to opt out of having advanced meters. States such as **California, Maine, Maryland,** and **Vermont** have worked to address consumer concerns, each taking different approaches to opt-out programs.

By pursuing those and other strategies, governors can help deploy new technologies and practices that make a modern electricity grid, in a way that supports energy, environmental, and economic goals while helping ensure the safe, reliable, and efficient delivery of electricity to consumers.

Introduction

Maintaining the flow of power over the grid is vital to the nation's economic future and standard of living. The electric power grid is the backbone of every area of the economy, including the energy sector. Disruptions in electric service cost an estimated $79 billion each year in damages and lost economic activity.[1] Meanwhile, the products and services of modern life—including air conditioning, refrigeration, computers, and digital devices—require a reliable supply of electric power. Even as the energy system transitions toward more distributed energy resources, the grid is necessary to supply backup power and balance the flow of electricity.

Electric power is delivered through a network of high-voltage transmission lines, lower-voltage distribution lines, and a host of substations and transformers before it reaches homes and businesses. During the past 100 years, the grid has grown from a haphazard system designed to meet local needs to a vast interconnected network of infrastructure, connecting consumers with 11 billion kilowatt-hours of electricity per day.[2] The grid is generally divided into two segments: The transmission system connects large power plants to substations and transformers across nearly 200,000 miles of high-voltage (69 kilovolts or higher) lines, and the distribution grid delivers power from substations directly to customers at lower voltages. Regionally, the U.S. transmission network consists of three major interconnection areas (the Eastern Interconnection, Western Interconnection, and Electric Reliability Council of Texas) that span North America and constitute the world's largest, most complex system of generation, transmission, and distribution.

Generally, the system is robust enough to meet every day needs. However, the infrastructure is becoming obsolete. Seventy percent of transmission lines and transformers are at least 25 years old, and 60 percent of circuit breakers are at least 30 years old.[3] Older lines and transformers are more susceptible to failure, and lines carry electricity less efficiently as they age. At the same time, much of infrastructure in the grid was designed in the 1950s, before the advent of the microprocessor, so utilities have had to adapt electromechanical systems to work with digital operations outside of their intended design. The transmission grid also was not designed for the level of bulk power shipments that are associated with the large-scale, wholesale electricity transactions that occur in many regions today, and while large penetrations of renewable resources are technically feasible, the continued development of location-constrained renewable resources has driven a need for longer transmission lines in areas with a limited number of interconnection points.[4]

Efforts to upgrade grid infrastructure are already underway. For several years, utilities have deployed

[1] Kristina Hamachi LaCommare and Joseph H. Eto, *Understanding the Cost of Power Interruptions to U.S. Electricity Consumers* (Berkeley, CA: Lawrence Berkeley National Laboratory, 2004). http://certs.lbl.gov/pdf/55718.pdf (accessed March 10, 2014).
[2] U.S. Energy Information Administration, "Short-Term Energy Outlook February 2014" (Washington, DC: U.S. Energy Information Administration, 2014), 21. http://www.eia.gov/forecasts/steo/pdf/steo_full.pdf (accessed March 10, 2014).
[3] Wiresgroup.com, "The Transmission Line" http://www.wiresgroup.com/images/TransmissionLine_IssueOneFinal.pdf (accessed March 10, 2014).
[4] Ibid.

What Makes a More "Modern" Grid?

The methods for modernizing the grid are varied and go beyond ongoing efforts to develop the smart grid. Upgrading the grid to overcome its shortcomings will involve physical and operational changes that will help states meet energy, environmental, and economic development goals. Some of those changes include:

- **Synchrophasors and phasor measurement units.** Devices that measure the power flow conditions across transmission and distribution lines in real time, permitting grid operators to maximize the efficiency of electric power as it travels over the grid;
- **Advanced metering infrastructure.** Commonly known as smart meters, these digital electric meters have two-way communication capabilities, radio frequency for remote reading, and the ability to connect to in-home devices over a wireless network;
- **Distribution automation**. A combination of real-time monitoring systems for the distribution grid and digitally controlled switches on lines and at substations allows utilities to better optimize power flows and can help the grid automatically reroute power if there is a fault or disruption;
- **Energy storage.** Grid-level energy storage can include kinetic storage such as pumped hydropower, compressed air, and flywheels as well as large-scale batteries. Future technological advances, along with supportive policy changes, could also make electric vehicles a source of storage capacity available on the grid; and
- **Transmission expansion and optimization.** The growth of the transmission grid can improve reliability, connect lower-cost power to customers, and integrate renewable resources. Larger balancing areas, multiple transmission pathways between resource and load, and shorter scheduling windows can all help the grid function more efficiently and reduce electricity costs for consumers.

Modernizing the grid will create opportunities for an expanded role for utilities and for new market entrants. Utilities will continue to implement technologies to modernize the grid and may expand their traditional role as suppliers of electricity to include a broader set of services made possible by new technology. Private sector technology firms will also have new markets and opportunities for their products. Manufacturers, software developers, and service providers will interface with utilities to produce and deploy advanced digital meters, network-connected devices, in-home energy monitors, and other devices to collect and transmit more data about the performance of the grid. Other third-party companies with and without a tie to the electricity sector may have software and services that aggregate or interpret customer energy data to allow for the more efficient use of electricity.

technologies to integrate communications and electricity delivery networks. More than 45 million advanced digital electricity meters have been installed, and an additional 24 million are expected to be added by 2015, for a total of 69 million meters covering more than 50 percent of U.S. households.[5] The 2009 American Recovery and Reinvestment Act provided $4.5 billion in federal resources to support states and utilities in updating grid infrastructure, including installation of smart meters and grid-level measurement and communication technology

[5] Innovation Electricity Efficiency, *Utility-Scale Smart Meter Deployments: A Foundation for Expanded Grid Benefits* (Washington, DC: IEE August 2013). http://www.edisonfoundation.net/iee/Documents/IEE_SmartMeterUpdate_0813.pdf (accessed March 10, 2014).

and piloting of innovative pricing and demand response programs.

At the same time, the U.S. transmission grid has grown to accommodate increasing levels of large-scale renewable energy generation and improve the reliability of the electricity system. Planned transmission additions have steadily increased since 2009, and the amount of planned transmission additions continues to increase.[6] Finally, approximately 2.5 percent of U.S. electric power capacity consists of energy storage, almost entirely in the form of pumped hydropower. Utilities and regional transmission organizations (RTOs) are exploring opportunities for adding capacity and technologies, including flywheels, advanced batteries, and compressed air storage.

Those efforts represent the beginnings of a more modern electric power grid, but other steps also are necessary to seize the opportunities made possible by changes in the way electricity is generated, delivered, consumed, and sold. Modernizing the grid can improve the operation and efficiency of the electric power system and drive economic opportunities. To realize those benefits, state policymakers and regulators, consumers, and utilities must work to align their interests and ensure that technological and operational changes throughout the grid function as a whole.

Challenges and Opportunities

Modernizing the electric power grid can help states address challenges and opportunities and achieve a number of positive outcomes, including:

- Enhancing reliability, resiliency, and assurance;
- Addressing cybersecurity risks;
- Integrating variable and distributed generation; and
- Empowering customers with data.

Enhancing Reliability, Resiliency, and Assurance

Challenge

Recent storms, floods, and other natural disasters have demonstrated the shortcomings of the electric power grid including its susceptibility to weather-related disruptions. The number of power outages affecting at least 50,000 customers appears to be on the rise, and storms are the largest cause of those power outages. Between 2000 and 2004 there were 149 such incidents; 349 occurred between 2005 and 2009.[7] From January 2010 through the end of 2013, there were 346 such incidents.[8] Some studies project that severe storms will increase in frequency during the 21st century.[9] Since 2002, severe weather has been responsible for 58 percent of all power outages and 87 percent of those affecting more than 50,000 customers.[10] The cost associated with storms is also significant: The average cost of weather-related power outages to the U.S. economy since 2003 is estimated at between $18 billion and $33 billion per year.[11]

Several recent storms on the East Coast—such as Tropical Storm Irene in 2011, the June 2012 "derecho" storms in the mid-Atlantic, and Hurricane Sandy in October 2012—led to extended power outages, spurred calls for improvements in storm outage response, and pointed out the need to better protect the grid from storm damage. For example, in the aftermath of Hurricane Sandy, more than 8 million customers in

[6] North American Electric Reliability Corporation *2012 Long-Term Reliability Assessment* (Atlanta, GA: NERC November 2012). http://www.nerc.com/pa/RAPA/ra/Reliability%20Assessments%20DL/2012_LTRA_FINAL.pdf (accessed March 10, 2014).
[7] S. Massoud Amin "U.S. Electrical Grid Gets Less Reliable" IEEE Spectrum, posted December 30, 2010, http://spectrum.ieee.org/energy/policy/us-electrical-grid-gets-less-reliable (accessed March 10, 2014).
[8] Energy.gov, "Electric Disturbance Events (OE-417) Annual Summaries", Office of Electricity Delivery and Energy Reliability, http://www.oe.netl.doe.gov/OE417_annual_summary.aspx (accessed March 4, 2014).
[9] Noah S. Diffenbauch, Martin Scherer, and Robert J. Trapp, "Robust Increases in Severe Thunderstorm Environments in Response to Greenhouse Forcing," *Proceedings of the National Academy of Sciences* (September 2013) http://www.pnas.org/content/110/41/16361 (accessed March 10, 2014).
[10] Executive Office of the President, *Economic Benefits to Increasing Electric Grid Resilience to Weather Outages*, (Washington, DC August 2013). http://energy.gov/sites/prod/files/2013/08/f2/Grid%20Resiliency%20Report_FINAL.pdf (accessed March 10, 2014).
[11] Ibid.

Microgrids

One idea to enhance reliability and energy assurance that is generating growing interest from policymakers is the development of microgrids. Microgrids are interconnected buildings or facilities with adequate distributed generation resources to operate independently both during everyday conditions and in cases of emergency. Microgrids are seen as potentially beneficial for critical facilities such as hospital campuses, military bases, and government building complexes where prolonged power outages can have significant consequences and functioning as an electric "island" can help maintain operations. The presence of a large capacity of distributed energy could also help utilities shed load during peak or emergency times, improving system reliability beyond the microgrid, assuming the microgrid draws power from the grid during normal operations. Few microgrids exist in the United States, and issues need to be resolved before they could become more widespread, since microgrids are a departure from the traditional way in which electricity is generated and distributed. For example, combined heat and power systems or other distributed energy resources with enough capacity to power a microgrid may be cost prohibitive. Relatedly, state regulations may not appropriately compensate utilities for backup power in case of the failure of a microgrid.

17 states lost power, stretching from North Carolina to Maine and as far west as parts of Michigan. More than 1.3 million people were still without power a week after the storm.[12] The utility response time to Hurricane Sandy was comparable to that for other recent major hurricanes, but the scale of the outages drew attention to how the responses took place and the grid's inability to recover quickly.[13] In addition, the storm raised concerns about coastal development, the resiliency of other public infrastructure, and the availability of transportation fuels.

Opportunity

A modern grid "keeps the lights on" by being more reliable and more resilient. Reliability refers to the consistent delivery of power during normal operating conditions. Resiliency refers to the ability of the grid to continue operating and recover in a timely fashion when disruptions occur. Improvements to the grid, particularly at the distribution level, can improve both reliability and resiliency and help support state energy assurance efforts.

Modernizing the electric power grid can reduce the frequency and duration of outages. Some experts estimate that modernization could produce a 50 percent improvement in safety, reliability, and power quality.[14] A technologically advanced grid can be "self-healing," allowing utilities to identify potential disturbances early, shut down power lines in a way that has minimal effect on other portions of the grid, and quickly identify power outages and their causes.

Utilities are already working to use new technologies to help improve outage response. For example, one utility has reduced the average customer outage time by 33 minutes (or 47 percent) through

[12] Kayla Webley, "Hurricane Sandy by the Numbers: A Superstorm's Statistics, One Month Later", *Time*, November 26, 2012, http://nation.time.com/2012/11/26/hurricane-sandy-one-month-later/ (accessed March 10, 2014).

[13] Jonathan Fahey, "Duration of Sandy's Power Outages Typical", Associated Press, November 18, 2012, http://www.journalgazette.net/article/20121118/NEWS03/311189941/-1/NEWS09 (accessed March 10, 2014).

[14] Galvin Electricity Initiative, *Electric Reliability: Problems, Progress and Policy Solutions*, February 2011, http://www.galvinpower.org/sites/default/files/Electricity_Reliability_031611.pdf (accessed March 10, 2014).

Other Threats to the Grid

Severe weather and cyber attacks are not the only threats to the electric power grid. Governors should also be aware of some high-impact, low-frequency threats and how steps to modernize the grid might address them. They include:

- **Physical attacks.** A targeted physical attack on grid infrastructure such as substations or high-voltage transmission lines could potentially disrupt electricity flows over a wide area. Coordinated attacks that include both cyber and physical components pose additional risks that states and utilities should address.
- **Earthquakes.** The impacts of a seismic event could damage grid infrastructure and make restoration efforts difficult. Areas of seismic activity with large potential consequences for grid infrastructure include the New Madrid seismic zone in the Midwest/Southeast and the Cascadia subduction zone in the Pacific Northwest.
- **Space weather.** Strong solar flares could create magnetic disturbances in the atmosphere that disrupt electric currents traveling across the grid.
- **Electromagnetic pulses (EMP).** Intentional EMP releases by malicious actors could disrupt the flow of electricity in a similar fashion to space weather.

The technological solutions associated with modernizing the electric power grid can help states and utilities respond to those types of events the same way they respond to storms and cyber incidents, quickly and automatically rerouting power. At the same time, steps to "harden" grid infrastructure, including running transmission and distribution lines underground, tightening physical barriers around transformers and substations, and implementing microgrids, would protect infrastructure against both storms and physical attacks. Governors should examine how those techniques could work in tandem with efforts to modernize the grid to address all the potential threats to reliable operation of the grid and consider where there may be tradeoffs between reliability and resiliency (for example, if distribution lines are underground they are protected from storms but may make restoration efforts more challenging).

grid modernization efforts such as distribution automation and advanced meter deployment.[15] A grid that can be monitored in real time can help states maintain power during outages, allow utilities to restore power to critical facilities faster, and operate more efficiently during regular conditions. Utility-scale or distributed energy storage can help provide power during emergencies and help maintain reliability during peak events and normal operating ("blue sky") conditions, either as a source of quickly dispatchable electricity or by providing other services such as frequency regulation.

[15] GridWise Alliance, *Realizing the Value of an Optimized Electric Grid*, February 2012, http://www.gridwise.org/documents/RealizingtheValueofanOptimizedElectricGrid2.pdf (accessed March 10, 2014).

Addressing Cybersecurity Risks

Challenge

The threat of a cyber attack on energy infrastructure, and the grid specifically, is a growing concern. The cyber threats facing the grid could come from a variety of sources, making them harder to prepare for and prevent. Actors can include state-sponsored groups, terrorists or organized crime, hacktivists, and intentional or unintentional internal actors. Motivations can include gaining control of the power system, sabotage, and financial gain. Cyber threats against the U.S. energy system, including the electric power system, appear to be on the rise: The U.S. Department of Homeland Security's Industrial Control Systems Cyber Emergency Response Team (ICS-CERT) reported that it responded to 81 attacks against the energy sector in fiscal year 2012, the most of any sector; between October 2012 and May of 2013 (the first half of fiscal year 2013), it had already responded to 111 attacks on the energy sector. Energy sector attacks made up 41 percent of attacks warranting ICS-CERT response in 2012 and represented 53 percent of attacks in the first half of the 2013 fiscal year.[16] Those attacks were to both control systems and business systems: Although the ability of cyber attackers to cause a prolonged outage or destroy critical energy infrastructure poses the greatest risk, cybersecurity is also important for protecting customer data and personally identifiable information. The need to protect both operations of physical infrastructure and business systems is a particular challenge for the entire energy sector, not just the electric industry.

A paradox surrounds the grid's cyber vulnerabilities: The devices that connect the grid to the Internet and improve grid functionality increase the number of potential entry points for a cyber attack. Those include customer electricity meters as well as supervisory control and data acquisition switches throughout the system. The problem could be particularly acute in the early phases of grid modernization and smart grid efforts. States will need to work with utilities to ensure that technologies do not exacerbate cyber risks.

In addition to cybersecurity threats to the grid, there are increased concerns around the risk of direct physical attacks on the grid. An incident in April 2013 in which gunmen fired on a substation outside San Jose, **California**, raised awareness of how electric power infrastructure could be vulnerable to physical attacks. Although the attack damaged transformers, the state's grid operator was able to reroute power to avoid an outage. The attack also drew attention to the difficulty utilities would face replacing damaged transformers, since much of that equipment is custom-built, requires a long lead-time for manufacturing, and is difficult to transport.[17] In March 2014, the Federal Energy Regulatory Commission (FERC) directed the North American Electric Reliability Corporation (NERC) to develop standards aimed at protecting critical grid infrastructure from physical threats.[18] While the need to more quickly replace transformers will be addressed separately, other solutions aimed at hardening grid infrastructure against storms and responding to cyber threats can help address concerns around physical attacks and other high-impact, low-frequency events that might disrupt electricity delivery (see box on page 8).

Opportunity

Despite the paradox of vulnerability created by more digital capability, a modern grid provides an opportunity for improved cybersecurity, which is critically important as the electric power grid relies

[16] U.S. Industrial Control Systems Cyber Emergency Response Team "ICS-CERT Monitor April/May/June 2013", https://ics-cert.us-cert.gov/sites/default/files/Monitors/ICS-CERT_Monitor_Apr-Jun2013.pdf (accessed March 10, 2014).
[17] Rebecca Smith, "Transformers Expose Limits in Securing Power Grid", *The Wall Street Journal*, March 4, 2014.
[18] Federal Energy Regulatory Commission, "FERC Directs Development of Physical Security Standards", Press Release, March 7, 2014, http://www.ferc.gov/media/news-releases/2014/2014-1/03-07-14.asp#.UzM3mzbD-po (accessed March 26, 2014).

more on network-connected devices and information technology infrastructure. Modern grid technologies increase utilities' ability to control the functionality of the grid and improve understanding of and response to attacks, as existing information technology and energy infrastructure are merged into a single network. Just as with storm or demand-related outages, a modern grid can help prevent cyber-related outages from becoming more widespread, as the same distribution automation technologies that help route power away from downed lines could be used to "close off" sections of the grid that are corrupted through a cyber attack, assuming they are not compromised in the attack. Standardized communication and cybersecurity protocols built into devices and networks can also help utilities better manage cyber concerns.

Integrating Variable and Distributed Generation

Challenge

Renewable energy resources such as wind and solar can provide a variety of benefits to states, but their variability—the fact that they are not available consistently throughout the day—can add challenges for grid operators. Thirty-one states and territories currently have a renewable portfolio standard (RPS) in place requiring utilities to generate a certain percentage of electricity from renewable resources, and 10 states and territories have voluntary renewable energy goals.[19] Renewable resources (excluding hydropower) currently supply slightly more than 5 percent of electricity.[20] However, states and regions have demonstrated that their portion of the grid can support a larger portion of renewable resources—in 2012, nine states generated more than 10 percent of their electric power from wind, including two states (**Iowa** and **South Dakota**) that surpassed 20 percent.[21] Achieving nationwide penetration of renewables at or beyond the levels called for in many state RPSs (20 to 30 percent), although technically feasible, cannot occur without expansion or increased optimization of transmission infrastructure.[22]

As consumer demand grows and state and federal policies continue to call for an increase in the use of renewable resources, grid mangers will need to adapt to effectively integrate those resources without jeopardizing reliability. The technology and techniques used in the operation of the transmission grid are not optimized to support increased levels of utility-scale renewables. Current weather modeling and forecasting tools provide some information to grid operators to but do not provide full information around when wind and solar resources will be available, a problem exacerbated by long scheduling windows for transmission access (since the availability of wind or solar may not be perfectly consistent over an hour-long window as it is for thermal or hydropower plants). The size of utility balancing areas (the transmission connections in which electricity from multiple generation resources is balanced to meet load) and limited transmission pathways for remotely sited resources constrain their ability to be balanced with other resources. At the same time, distributed renewable resources, such as rooftop solar photovoltaic systems that are sited at or near the customer and are sized to meet their electric needs, pose a different challenge for utilities. The existing grid does not provide enough data to utilities and grid operators on when and how distributed resources are being operated and whether the power they generate is being used onsite or if excess power is being fed back into the grid.

[19] Database of State Incentives for Renewables & Efficiency, "Renewable Portfolio Standards Policies", http://www.dsireusa.org/documents/summarymaps/RPS_map.pdf (accessed March 10, 2014).

[20] U.S. Energy Information Administration, "How Much of Our Electricity is Generated from Renewable Energy?" May 7, 2013. http://www.eia.gov/energy_in_brief/article/renewable_electricity.cfm (accessed March 10, 2014).

[21] Carl Levesque, "Wind Now 10% of Electricity in Nine States, Over 20% in Iowa, South Dakota", *Renewable Energy World*, March 28, 2013. http://www.renewableenergyworld.com/rea/news/article/2013/03/wind-now-10-of-electricity-in-nine-states-over-20-in-iowa-south-dakota (accessed March 10, 2014).

[22] L. Bird and D. Lew, *Integrating Wind and Solar Energy in the U.S. Bulk Power System: Lessons from Regional Integration Studies* (Golden, CO: Joint Institute for Strategic Energy Analysis, September 2012). http://www.nrel.gov/docs/fy12osti/55830.pdf (accessed March 10, 2014).

Net Metering

Forty-five states and territories, along with utilities in three additional states, have established net metering provisions that have been an important policy tool for supporting the use of distributed renewable energy, in particular solar photovoltaic systems. Net metering allows customers with distributed generation installations to sell power generated in excess of demand back to the utility grid, usually at the full retail price of electricity. Distributed generation can provide benefits to the grid, including enhancing reliability within specific localized areas, which are not necessarily monetized in state utility regulation. However, as the use of distributed generation has grown, substantially in some states, utilities, public utility commissions, consumer advocates, and others have raised concerns that net metering customers who still rely on the transmission and distribution network are not contributing equitably to the upkeep of the network, since they can potentially offset their full utility costs with net metering payments, potentially negatively affecting utility revenues and grid reliability. For that reason, states such as **South Dakota** have opted not to establish net metering policies while others are exploring modifications and alternatives to their net metering provisions. States such as **Arizona** and **California** recently adjusted their net metering provisions to address those concerns and begin to better consider the costs and benefits. **Minnesota** is examining the use of a distinct rate that solar power customers would pay as an alternative to net metering. The **Colorado** Public Utilities Commission is currently weighing an updated renewable energy plan from the state's largest utility that includes significant changes to its net metering provisions. Given the emerging nature of this issue, the NGA Center is working closely with governors' offices to inform them about recent research and policy developments on net metering and potential adjustments and will capture best practices as they develop.

Opportunity

Deployment of communications technology on both the transmission and distribution portions of the grid will allow for the integration of more variable or distributed energy resources. At the transmission level, utilities and grid operators can use that technology to more quickly respond to shifts in supply associated with increased penetration of utility-scale variable resources such as wind and solar. Larger balancing areas with multiple transmission pathways and more frequent scheduling of transmission will smooth out the variability of resources such as wind and reduce the need for additional generation to "firm" variable resources. Both foreign and domestic utilities are taking steps to demonstrate how that is possible with existing technologies. For example, combining four forecasting areas in Germany reduced forecasting error for wind power by 25 percent.[23] Merging balancing areas in **Minnesota** reduced the ramping requirements for firming generation by 14 percent.[24]

Large-scale storage can help facilitate the integration of variable wind and solar resources. Storage can be

[23] American Physical Society, *Integrating Renewable Electricity on the Grid*, (Washington DC: APS, June 2010), http://www.aps.org/policy/reports/popa-reports/upload/integratingelec.pdf (accessed March 10, 2014).
[24] Ibid.

used alongside wind and solar to offset variability and maintain the balance of power on the grid, or to capture electricity generated during times of low demand and make it available during periods of high demand, thereby reducing the price. Battery storage alongside a wind farm in **West Virginia** provides reserve capacity for the PJM Interconnection, the independent entity that manages transmission operations and the wholesale electricity market in all or part of 13 mid-Atlantic and Midwestern states and helps manage changes in wind conditions to ensure consistent flow of electricity.[25]

At the distribution level, advanced meters can, along with complementary regulations such as net metering, allow customers to more efficiently sell self-generated power back onto the grid, whether through small-scale wind and hydro in rural areas, solar photovoltaic systems, and fuel cell or combined heat and power installations. Modernizing the distribution grid also can allow utilities to respond more quickly to sudden fluctuations in net demand that can come with greater distributed generation, with additional generation resources, storage, or demand response.

Empowering Customers with Data

Challenge

The current grid was designed and built to deliver electricity from a power plant to a residence or business, measured with an electromechanical meter and read in person, providing the utility with adequate information to bill its customers. However, both state policy makers and utilities are seeking to encourage consumers to make better-informed decisions about how they use energy in order to lower costs, reduce the environmental effects of electricity generation, and reduce stress on the grid. Smart appliances (which use communications technology to operate automatically or in response to user preferences or external controls), electric vehicles, utilities' demand response programs, and energy efficiency programs that are behavior-based require the collection of detailed data on energy use and the ability to communicate that data between utilities and end users in a way that the traditional grid does not easily facilitate.

Opportunity

Improving consumer access to information about their energy use can facilitate new energy conservation and efficiency programs that capitalize on real-time measurements of grid conditions or changes in consumer behavior patterns. In-home devices and time-of-use dynamic variable peak pricing structures, made possible by grid communications technology, help customers take advantage of opportunities around electric vehicles and energy management or conservation. That can help customers lower their energy bills, and reduce peak demand for electricity overall and at peak periods, and improve overall efficiency. Reducing demand overall or at peak may also have environmental benefits through reduced emissions and improved system reliability. The initial results of a pilot program for time-of-use pricing at **Oklahoma** Gas & Electric suggested Electric's SmartHours program, which utilizes dynamic peak pricing, demonstrates that, were the program expanded, reductions in per-customer overall and peak demand for participating customers may be large enough to defer building new generation until after 2020. Utilities can also use more granular data generated by advanced meters to measure and verify savings associated with energy efficiency programs more accurately and, therefore, to improve program design and deployment.[26]

What's Keeping Us from Getting There?

Integrating those technologies and practices into the electric power grid represents both challenges and opportunities for states, utilities, and consumers. As described above, the opportunities—increased reliability and resilience, improved cybersecurity, easier integration of renewable energy resource, and

[25] AES Energy Storage, "Deployments" http://www.aesenergystorage.com/deployments.php (accessed March 10, 2014).
[26] Oklahoma Gas & Electric Co., *Integrated Resource Plan*, October 2012. http://occeweb.com/pu/OGE%202012%20IRP.pdf (accessed March 10, 2014).

greater use of data—can provide sizable benefits. However, states will need to address the cost of the investment and various implementation challenges in order to capture all those benefits.

While the estimated benefits of grid modernization that could be realized by 2030 are as high as $2 trillion, modernizing the electric power grid would require a sizable investment in new infrastructure at a time when growth in electricity demand, and therefore growth in utility revenues, has slowed. The cost estimates for modernizing the grid range from $340 billion to $850 billion by 2030. Utilities currently spend approximately $34 billion per year on transmission and distribution infrastructure and maintenance. Additional expenditures needed for grid modernization are estimated to be between $8 billion and $16 billion per year through 2030.[27]

Regardless of the exact costs, determining how those costs will be shared by the private and public sectors and recovered from customers remains a challenge. Retail utilities seeking to invest in grid infrastructure upgrades (and state regulators who must approve those investments) must balance the need for improvements against increased costs to customers. That is especially difficult as low load growth is already putting upward pressure on rates. The rate of growth has consistently decreased since the 1950s (when it was as much as 12 percent per year), and demand even fell in several recent years following the 2008 economic recession. Although the trend in demand growth is expected to plateau between 2011 and 2040, the annual average is projected to be less than 1 percent.[28] Additionally, the public is looking to utilities to accelerate infrastructure upgrades to improve resiliency. Utilities will need to balance those needs while effectively communicating both short- and long-term benefits to customers and utility commissions.

The issue of cost recovery can involve several states when allocating the cost of interstate, high-voltage transmission lines. The methodologies used to allocate transmission costs vary and remain contentious in some regions. The challenges are particularly true for lines that support renewable energy or have broad reliability benefits, as there remains disagreement about how to define the benefits or beneficiaries (and therefore who should bear the cost). The Federal Energy Regulatory Commission's (FERC) recent Order 1000 requires each transmission planning region to develop intraregional and interregional cost allocation rules and is leading some regions to consider new approaches to cost allocation.

What Can Governors Do?

Governors have a lead role in shaping the energy policies that affect the speed and processes by which grid modernization can occur. Through executive authority or in concert with their legislatures, governors set targets for renewable energy and energy efficiency, oversee comprehensive state energy and energy assurance planning, and can direct their utility commissions or other advisory groups to explore new technologies or regulatory approaches. In all but 13 states, governors directly appoint utility commissioners, although staggered terms and rules governing party membership often result in appointees of different gubernatorial administrations serving on a commission together.

State utility commissions regulate most of the utilities that provide retail electricity service to customers. As part of their authority to determine if a utility's rates are just and prudent, commissions approve utility investments and implement rules concerning electricity sales and markets. That, in turn, determines

[27] Electric Power Research Institute, *Estimating the Costs and Benefits of the Smart Grid*, March 2011.http://www.epri.com/abstracts/Pages/ProductAbstract.aspx?ProductId=000000000001022519; and Charles A. Goldman et al., "Utility Business Models in a Low Load Growth/High DG Future: Gazing into the Crystal Ball?" Lawrence Berkeley National Laboratory, April 2013. http://emp.lbl.gov/publications/utility-business-models-low-load-growthhigh-dg-future-gazing-crystal-ball (accessed March 10, 2014).

[28] U.S. Energy Information Administration, ""U.S. Economy and Electric Demand Growth are Linked, but Relationship is Changing" March 22, 2013 http://www.eia.gov/todayinenergy/detail.cfm?id=10491 (accessed March 10, 2014).

the technologies and timeframes for utility grid modernization efforts. States also have the authority to site and permit grid infrastructure, including transmission lines and generation facilities. In most states, the utility commission fills that role, but some states have independent energy siting authorities.

Governors can help regulators, utilities, and customers better understand the benefits of grid modernization in terms of increased reliability, resiliency, and energy efficiency and how those benefits compare to the costs. Governors can promote greater coordination among state, federal, and private partners—on transmission development, cybersecurity threats, and renewable integration—which can help modernization efforts occur more quickly and cost-effectively.

Below are a few examples of actions that governors have taken or can take to help address some of the challenges states face in modernizing their portion of the grid, including:

- Working with state utility commissions and other state agencies to align policies, regulations, and incentives that support grid modernization;
- Working with other states and federal agencies to support cross-jurisdictional solutions; and
- Addressing consumer concerns on data access and privacy.

Working with State Utility Commissions, Other State Agencies and Utilities to Align Policies, Regulations, and Incentives that Support Grid Modernization

States have several levers at their disposal to advance grid modernization, few—if any—of which can be pulled by any state agency acting by itself. Governors can help initiate and oversee grid modernization policies or regulations that align with their state energy policies and goals.

- **Work with public utility commissions and utilities to understand the benefits associated with grid upgrades (including reliability, resiliency, integration of renewables, and cybersecurity) and then develop regulations that capture those benefits**. Governor Deval Patrick's efforts in **Massachusetts** to promote energy efficiency and renewable energy, including the state's Green Communities Act, led the Department of Public Utilities (DPU) to begin a formal regulatory effort to explore grid modernization. In October 2012, the DPU opened an investigatory docket that looks at capturing the benefits: improved reliability, decreased electricity costs, increased penetration of energy efficiency and renewable energy, and greater customer empowerment to achieve those goals. That includes developing a new framework for assessing the costs and benefits of technologies and policies related to grid modernization, including impacts such as improved reliability and increased customer choice that are more difficult to quantify.[29] A stakeholder working group was created to provide guidance to the DPU on the appropriate next steps and pace for implementing grid modernization technologies.

  One of the elements of the Massachusetts effort, at which other states and utilities are taking a closer look, is updating time-of-use (TOU), or dynamic, pricing structures as a means to use new grid technologies and capture benefits that cannot be done with flat electric rates. Most TOU pricing programs offer customers variable rates that change only a few times during the day. As grid technologies advance, utilities may be able to send more frequent price information

[29] Commonwealth of Massachusetts Department of Public Utilities, "Investigation by the Department of Public Utilities on its own Motion into Modernizing the Electric Grid" DPU 12-76, October 2, 2013, http://magrid.raabassociates.org/Articles/D.P.U.NOI%2012.76.pdf (accessed March 10, 2014).

to customers. Such programs are possible only with advanced meters and other technologies that allow the meters to receive and store hourly price information. Governors can encourage regulations to capture the benefits of TOU pricing and support legislation to advance those efforts. For example, **Illinois** law requires utilities to offer hourly TOU pricing programs to their residential customers. By discouraging electricity use during peak hours, one such program run by the state's largest utility since 2007 has saved participants more than 15 percent on electricity costs compared with what they would have paid under the standard flat rate.[30] Those reductions also help the utility ease stress on the transmission grid, which improves reliability.

- **Establish performance-based reliability requirements to spur accelerated upgrades to the grid**. Following significant storm-related outages, governors in **Connecticut** and **Maryland** created task forces that recommended performance standards for utilities. Both states have since adopted preliminary reliability performance requirements. At the recommendation of a panel created following Tropical Storm Irene and an October nor'easter within three months of each other in 2011, the Connecticut Public Utilities Regulatory Agency (PURA) adopted performance standards in November 2012. Those standards require both electric and natural gas utilities to develop emergency response plans that feature protocols for communicating with state and local agencies and a strategy for assigning priority to restoration efforts. Each utility plan will need to include specific responses for when 10, 30, 50, and 70 percent of its customers are without service. Utilities must update their plans every two years, and utilities that are found not to have effectively implemented their plans following an emergency event will be subject to financial penalties.[31]

  The Maryland Grid Resiliency Task Force recommended that the Public Service Commission (PSC) incorporate both incentives for meeting minimum reliability standards and penalties for falling short. The goal is to better align utility, state, and customer motivations and help utilities set priorities among competing capital expenditures. The report suggested that the state's reliability metrics could be used as a starting point and expanded to include factors such as safety and customer satisfaction. The report also recommended that utilities consider new cost-benefit criteria that take into account the economic loss to the state and customers when measuring the cost-effectiveness of resiliency measures.[32]

- **Incorporate grid modernization efforts into state energy assurance plans**. As states develop or update their energy assurance plans, governors can direct the inclusion of grid modernization efforts, since state energy offices within the executive branch develop those plans in most states. As an addendum to its energy assurance plan, the **Oregon** Department of Energy commissioned a study in 2011 on how integrating distributed generation and smart grid technologies could improve the resiliency of the state's electric power grid.[33]

[30] ComEd.com, "Program Overview" ComEd Residential Real-Time Pricing Program, https://rrtp.comed.com/about/ (accessed March 10, 2014).
[31] State of Connecticut Public Utilities Regulatory Authority, Docket 12-06-09 "PURA Establishment of Performance Standards for Electric and Gas Companies." November 1, 2012.
[32] Office of Governor Martin O'Malley, *Weathering the Storm: Report of the Grid Resiliency Task Force*, September 24, 2012, http://www.governor.maryland.gov/documents/GridResiliencyTaskForceReport.pdf (accessed March 10, 2014).
[33] R.W. Beck, Inc, for the Oregon Department of Energy, *Distributed Energy Resiliency* Study, June 29, 2011, http://www.oregon.gov/energy/RENEW/docs/R1444%20Oregon%20Distributed%20Energy%20Resiliency%20Study.pdf (accessed March 10, 2014).

The report identified the ways in which distribution automation (through which technologies allow utilities to monitor grid conditions and automatically reroute power in case of a fault) and other upgrades could improve reliability and resiliency and recommended that the plan promote using distributed resources to improve resiliency. Notably, the report pointed out that, at that time, utilities in the state had plans to deploy smart grid technologies, but those plans were focused mostly on deploying advanced meters and had not addressed using grid technologies to mitigate outages and emergencies and urged inclusion of this focus.

- **Develop a coordinated approach to cybersecurity that balances minimum federal standards with appropriate assessments of risk and improves understanding of whether cyber-related investments are prudent for customers**. Protecting critical infrastructure, including the electricity grid, from cyber threats is a rising concern for governors. In September 2013, the National Governors Association released *Act and Adjust: A Call to Action for Governors for Cybersecurity.*[34] That document includes a set of short-term recommendations for governors to take to improve their state's cybersecurity posture. The *Call to Action* focuses on protecting state government-owned assets and networks, but several recommendations—including establishing a strong governance structure and creating a culture of risk awareness—are relevant for ensuring other networks, such as the electric power grid, are protected against increasing cyber risks.

  Several states, through their utility commissions, have created ongoing dialogues with their utilities and other parties to increase intrastate coordination around cybersecurity and ensure that utilities prepare and respond appropriately. The **Indiana** Utility Regulatory Commission held a two-day workshop in April 2013 for utilities and RTOs on utility cyber readiness. The session included several other state agencies and was designed to promote intrastate, state-utility, and cross-utility coordination.[35] Staff from the National Association of Regulatory Utility Commissioners have been traveling to state utility commissions to discuss cybersecurity issues and help commissioners understand the types of questions to ask utilities about their cyber preparedness.[36] Included in those questions are how they are complying with mandatory standards, steps they are taking beyond compliance with those standards, and how they incorporate risk management into their cybersecurity plans. Governors' offices can support the process by being involved in those discussions and furthering a dialogue among utilities and utility commissions.

Working with Other States on a Regional Basis and with Federal Agencies to Support Cross-Jurisdictional Solutions

The combined state-federal regulation of the electric power sector, coupled with the fact that electrons do not respect state boundaries, means that interstate and intergovernmental coordination will be necessary for modernizing the electricity grid just as it is in other areas of energy policy. Governors can look to pre-existing regional forums or create their own opportunities, such as governors' energy summits, to foster greater communication and collaboration.

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[34] Thomas MacLellan, "Act and Adjust: A Call to Action for Governors on Cybersecurity" (Washington, DC: National Governors Association Center for Best Practices, September 2013). http://www.nga.org/files/live/sites/NGA/files/pdf/2013/1309_Act_and_Adjust_Paper.pdf (accessed March 10, 2014).
[35] Indiana Utility Regulatory Commission, "Indiana Utilities Serious About Cybersecurity", Press Release, April 11, 2013, http://www.in.gov/iurc/files/Indiana_Utilities_Serious_about_Cybersecurity(1).pdf (accessed March 10, 2014).
[36] Miles Keogh and Christina Cody, "Cybersecurity for State Regulators 2.0" (Washington, DC: National Association of Regulatory Utility Commissioners, February 2013). http://www.naruc.org/Grants/Documents/NARUC%20Cybersecurity%20Primer%202.0.pdf (Accessed March 20, 2014).

- **Create or participate in collaborative efforts to develop plans for integrating state and national efforts on grid cybersecurity.** The protection of the electricity grid against cyber threats is not the exclusive domain of the state. Sharing information across levels of government, across state lines, and between the public and private sectors is a critical first step in being prepared for a cyber attack. NGA's ongoing efforts around cybersecurity include developing a list of actions that governors can take to enhance the cybersecurity of energy systems and infrastructure, including the electricity grid. An issue brief on that topic is due to be released in mid-2014.

  Several formal and informal opportunities have helped states share information and assess risks and vulnerabilities. **Pennsylvania** has hosted regional cybersecurity meetings that have included federal agencies and utility commissioners from **Delaware, Maryland,** and **New Jersey**. The purpose is to break down silos among states and between state and federal agencies and have helped all of the states involved build capacity around cyber awareness and the steps they can take with their utilities. Governors can work together to convene or encourage their commissions to convene parties in their region similarly.

- **Convene states to work on a regional basis, with RTOs/ISOs/planning groups, to plan adequate transmission infrastructure**. While state representation on regional transmission operating and planning groups varies by region, in some cases involving state utility regulators and in others governors' offices, all governors can play a greater role in interacting with those groups.

  In 2010, the states in the territory of the Midcontinent Independent System Operator (MISO, known then as the Midwest ISO)—**Illinois, Indiana, Iowa, Kentucky, Michigan, Minnesota, Missouri, Montana, North Dakota, Ohio, South Dakota,** and **Wisconsin**—helped develop a new cost allocation methodology for transmission projects. The methodology creates a new class of transmission projects—multi-value projects (MVPs)—that provide benefits to the entire region (such as renewable energy integration and increased system reliability and whose costs are spread to customers in the MISO jurisdiction and some export customers. FERC approved the MVP cost allocation in December 2010. MISO is also looking at a portfolio of projects, not just individual lines, to best capture the resulting broad regional reliability and renewable integration benefits. MISO's analysis has found that the benefit–cost ratios for each of the states were positive and relatively equal, ranging from a low of 1.8 to 1 to a high of 3 to 1. Not all MISO states approve of the outcome, citing concerns about attribution of benefits, and therefore the allocation of costs, to areas within MISO far removed from specific projects. However, representatives from each of the involved states were able to participate in the process, through their regional state committee and through direct interaction with MISO.[37]

- **Develop or work with utilities or RTOs to set rules and pricing for how energy storage can integrate into the grid and provide backup power and other market services**. In 2010, **California** passed legislation requiring utilities to develop plans for integrating storage technologies and began a regulatory proceeding

[37] Andrew Kambour, *State Strategies for Accelerating Transmission Development for Renewable Energy,* (Washington, DC: National Governors Association Center for Best Practices, January, 2012) http://nga.org/files/live/sites/NGA/files/pdf/1201ENERGYTRANSMISSIONWP.PDF (accessed March 10, 2014).

to determine appropriate storage procurement targets for the state's investor-owned utilities. In 2013, the California Public Utilities Commission proposed energy storage targets of 1,325 megawatts by 2020 following two years of exploration of market barriers and potential uses of energy storage technologies within the grid. The proposal differentiates between storage systems connected to the transmission system, distribution system, and customer-sited storage and does allow for off-ramps of up to 40 percent if storage cannot be procured cost-effectively. The rule did not require that storage take priority in the utility loading order, as had been requested by storage developers. Regardless, the goal of the rule is to set appropriate market signals for energy storage in the state. In the **PJM Interconnection** (which covers all or part of **Delaware, Illinois, Indiana, Kentucky, Maryland, Michigan, New Jersey, North Carolina, Ohio, Pennsylvania, Tennessee, Virginia,** and **West Virginia),** new rules have made it easier for storage to provide what is known as frequency regulation service, where resources are used to fill in short-term gaps in power production to maintain the desired frequency of power on the grid. Those rules followed a change in FERC's compensation rules for frequency regulation service, so similar opportunities may exist in other regions.

Addressing consumer concerns about data access and privacy

Governors can help ensure public support for grid modernization through efforts that help protect data privacy, ensure consumer choice in customer-facing technologies, and fully explain the short-term costs and benefits of investments.

- **Create standards for data access and privacy that provide clear direction on customer data ownership and access.** States can establish clear rules for customer data access and privacy. In 2010, the governor of **California** supported legislation that required the California Public Utilities Commission (CPUC) to adopt a set of comprehensive rules governing how customers access the data generated by their smart meters while protecting data privacy. The three investor-owned utilities in the state are required to provide customers with daily information on their historic energy use and expected final monthly bill and develop plans to roll out home area network-enabled devices so that customers can access real-time data. Under the rules, customers have the sole right to authorize third parties to receive data, and utilities have no new liability for misuse of data by third parties. The CPUC will have jurisdiction over protecting data privacy when third parties get data from the utility but not over data accessed by third-party technologies directly from the customer's meter.[38]

- **Thoroughly examine the costs and benefits of allowing customers to opt out of having advanced meters.** In every state, some residents may be uncomfortable with advanced digital meters for perceived health, safety, or privacy reasons. States face a tradeoff in allowing customers to opt out of having an advanced meter: Addressing customer concerns in advance might decrease backlash and accelerate deployment, but allowing for opt-out poses costs to the utility from maintaining analog meters, such as the need for in-person meter readings. Different states are offering different approaches to opt-out programs, including a single-tier fee for

[38] California Public Utilities Commission, "Order Instituting Rulemaking to Consider Smart Grid Technologies Pursuant to Federal Legislation and on the Commission's own Motion to Actively Guide Policy in California's Development of a Smart Grid System", Decision 11-07-056, July 28, 2011 http://docs.cpuc.ca.gov/published/FINAL_DECISION/140369.htm (accessed March 10, 2014).

opting out, a multi-tiered approach for different technology options, and permitting opt-out at no cost. As demonstrated in the examples below, state utility commissions determine the regulatory details, but governors can help frame the discussion about opt-out approaches and trade-offs. **California's** large utilities offer a single opt-out option: a $75 initial fee followed by a $10 monthly charge, although the fee is lower for eligible low-income customers. Early results from Pacific Gas & Electric's opt-out program estimated that 4,400 customers chose not to have a smart meter installed out of more than 8 million customers, or .05 percent.

In **Maine,** the Public Utilities Commission approved a two-tiered fee approach in 2011. Fees are $20 up front and $10.50 per month for customers with smart meters to have transmitters turned off; customers opting to keep analog meters are being charged $40 up front and $12 per month. The fees for low-income customers are 50 percent of those for other residential customers. According to Maine's largest utility, approximately 1.3 percent of customers (8,400 total) have opted out.[39]

Maryland explored a three-tiered approach that takes advantage of technology options: Customers may remain with an analog meter, receive a digital meter that does not broadcast any radio frequency (RF), or receive a digital meter with limited RF functionality. The cost to customers would be different for each option.[40] In February 2014, the state's Public Service Commission established opt-out fees for each of its regulated utilities but has not acted on any of the alternative approaches.[41]

In **Vermont,** Governor Peter Shumlin signed legislation in 2012 that allowed customers to opt out at no charge, including customers with smart meters already installed who seek to return to analog meters. Central Vermont Public Service had proposed a $10 monthly fee for opting out.[42]

Conclusion

As in other sectors of the economy, digital and mobile technologies are becoming necessities in the electric power sector, and new energy technologies are reshaping the generation and delivery of electricity. Governors can help deploy those technologies, along with the other practices that make up a modern electricity grid, in a way that supports energy, environmental, and economic goals and helps ensure the safe, reliable, and efficient delivery of electricity to consumers.

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[39] SmartGridNews, "Maine Lawmakers Introduce Bill to Kill Smart meter Opt-out Fees", March 14, 2013, http://www.smartgridnews.com/artman/publish/Technologies_Metering/Maine-lawmakers-introduce-bill-to-kill-smart-meter-opt-out-fees-5594.html/#.UzW-3_ldVxJ (accessed March 10, 2014).
[40] Maryland Public Service Commission, Order No. 85294, January 7, 2013, http://webapp.psc.state.md.us/Intranet/Casenum/submit_new.cfm?DirPath=C:\Casenum\9200-9299\9208\Item_187\&CaseN=9208\Item_187 (accessed March 10, 2014).
[41] Maryland Public Service Commission, "Maryland PSC Establishes Smart Meter Opt-Out Fees", Press Release, February 26, 2014, http://webapp.psc.state.md.us/Intranet/sitesearch/Whats_new/Maryland%20PSC%20Establishes%20Smart%20Meter%20Opt-Out%20Fees.pdf (accessed March 10, 2014).
[42] Katherine Tweed, "No Smart Meter, No Cost in Vermont", *GreenTech Media*, May 15, 2012, http://www.greentechmedia.com/articles/read/no-smart-meter-no-cost-in-vermont (accessed March 10, 2014).

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