July 1, 2016

The Honorable Ernest Moniz
Secretary, United States Department of Energy
1000 Independence Avenue, SW
Washington, DC 20585

Dear Secretary Moniz:

On behalf of the GridWise Alliance, I am pleased to submit these comments on the Second Installment of the Quadrennial Energy Review (QER).[1] The GridWise Alliance commends the Administration for undertaking this effort to look at our nation's electricity system in a comprehensive manner.

GWA members represent experts across the industry who have cared for many years about these grid modernization issues, specifically pertaining to ratemaking structures, rate designs, jurisdictional authorities, security, reliability, resilience, affordability, and sustainability. Our comments focus on the following areas, which were highlighted in the DOE "Framing Document" for this Installment of the QER: innovation and technology; distributed energy resources; grid operations and planning; electricity markets and valuation; jurisdiction and regulations; resilience; and, cybersecurity and physical security.

We applaud the efforts that you and your staff have taken to focus on these issues. We trust that you will help ensure a smooth transition as a change in the Administration occurs, and that the Department will work to help prevent current grid modernization and security-related efforts from being halted or reversed during the succession planning efforts and thereafter.

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[1] The GridWise Alliance (GWA) consists of a unique cross-section of members, including electric utilities, information and communications technology equipment and service providers, national laboratories, academic institutions, Regional Transmission Organizations (RTOs) and Independent System Operators (ISOs), and more.

These comments are submitted on behalf of GridWise members, with the exception of our RTO/ISO and national laboratory members, and the Bonneville Power Administration.

GWA appreciates the opportunity to submit these comments and offers to continue to serve as an ongoing resource to the U.S. Department of Energy (DOE). For questions about this Submission, please contact: Ladeene Freimuth, Policy Director of the GridWise Alliance, at: lfreimuth@gridwise.org.

Sincerely,

Steven G. Hauser
CEO
GridWise Alliance

The GridWise Alliance's Comments for the Second Installment of the Quadrennial Energy Review (QER): An Integrated Study of the U.S. Electricity System
July 1, 2016

The GridWise Alliance (GWA) consists of a unique cross-section of members, including electric utilities, information and communications technology equipment and service providers, national laboratories, academic institutions, Regional Transmission Organizations (RTOs) and Independent System Operators (ISOs), and more. GWA is pleased to submit these comments.[2]

1) Innovation and Technology

Information and communications grid modernization-related technologies (ICT) and capabilities have been a key driver of transforming the electricity system, including generation, transmission, distribution and consumption. For example, grid modernization technologies and capabilities can provide "situational awareness" across the U.S. to help predict the actual or potential grid impacts of integrating distributed energy resources (DER), as well as avoid the reliability and other electric system problems that some states have faced. The rapid changes taking place across the industry create both challenges and opportunities that require DOE attention and support.

- DOE should support federal and state policies, and state-level business and regulatory model changes that facilitate the adoption and implementation of technologies and capabilities to accelerate the modernization of the grid.

- DOE should broaden its technical assistance to states, as they face new technical and policy issues with industry changes.

    - The Business Council for Sustainable Energy (BCSE) is aligned with these two recommendations and underscores the importance of ICT to grid modernization in its latest QER Comments.

    - GWA has advocated and continues to advocate for a federal "voluntary model framework" (i.e., in the Energy Policy and Modernization Act, S. 2012) that provides options and guidance for states to consider, as they undertake policy and regulatory changes (almost like a "cookbook" or "menu" of options), but does not indicate a preference for a particular approach or outcome.

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[2] These comments are submitted on behalf of GridWise members, with the exception of our RTO/ISO and national laboratory members, and the Bonneville Power Administration.

- DOE should facilitate a more rapid transition to the "Grid of the Future" by facilitating the adoption of "no regrets" technologies and policies (e.g., upgraded data models, Distribution Supervisory Control and Data Acquisition (DSCADA), Advanced Distribution Management System (ADMS), volt/VAR optimization, advanced sensing capabilities on distribution feeders, AMI/AMF, and more).

  Such "no regrets" technologies that enhance and/or expand the use of our current infrastructure (*e.g.*, energy storage, dynamic line rating, and advanced power flow control) will be "used and useful" into the future. They also will help reduce risks (especially investment risks) associated with future uncertainty. GWA provided a more detailed list of "no regrets" measures in its Comments submitted for Phase I of the QER (and has included this list again in ***Appendix 1*** of this document).

- DOE should provide significant financial support to develop and demonstrate large regional projects to provide an opportunity to test and evaluate a range of technologies, as well as innovative grid architectures and operational paradigms. The variability of the design and operation of grids across the country require a variety of demonstrations in different locations to ensure local and regional applicability of solutions.

- DOE should build on the excellent, cross-cutting work that has been launched with the Grid Modernization Initiative and the Grid Modernization Laboratory Consortium (GMLC) and should expand its support of industry-led (i.e., public-private partnership) projects through these and other efforts.

- GWA supports an accelerated depreciation period for "smart grid" technologies, echoing this recommendation of the National Electrical Manufacturers Association (NEMA) in its QER Second Installment Comments.

  GWA also echoes NEMA and BCSE's support for a variety of incentives to encourage accelerated change across the industry.

2) Distributed Energy Resources (DER): Demand Response, Distributed Generation and Distributed Energy Storage

Customers are increasingly finding value in installing energy generation and management technologies and systems on their property. Many of these technologies and systems can provide additional benefits to operating the grid. However, if they are not installed or managed correctly, they also can create problems for reliable grid operation. These changes are among the most challenging facing the modern grid and require particular attention from DOE.

DOE should support the following policies and approaches to facilitate the deployment of DERs:

- DOE should encourage states to explore and demonstrate the changing roles of various parties ("prosumers," aggregators, utilities, and so forth) by facilitating a greater understanding of, and by quantifying, the benefits and impacts of new technologies and various business models.

- DOE likely has a role in helping states identify the range of potential policy options to encourage technology innovation and the integration of DERs; and, DOE should quantify the impacts and benefits of each.

    - GWA urges continued federal leadership in developing, modeling, and analyzing various scenarios of differing penetration levels of DERs, for example, and their impacts on the grid (as incorporated in the Senate Energy Policy and Modernization Act, S. 2012); and, industry-led demonstration projects that build on prior efforts and evolve to reflect the changing grid and related policies and innovative technological solutions.

    - GWA emphasizes that, while DER integration represents one of the biggest challenges the electric system (and grid operators) faces, many other significant challenges, such as cybersecurity, storm management and recovery, work force development, and others, also face the industry.

- DOE should recognize – and should work with states, utilities, and others to help them recognize – that AMI/AMF are among the foundational investments needed as part of a holistic approach and transition to a future grid; as such, DOE should work with states and other stakeholders to help prioritize these technologies.

    - More specifically, DOE should encourage states and utilities to pursue full deployment of AMI across their service territories, while educating their customers on the benefits of the technology. States and utilities should provide customers the option to opt-out of the program.

    - DOE should emphasize the multiple benefits that these technologies and systems provide for customers as well as utilities to help maximize their value.

3) Grid Operations and Planning

The modernized electric grid (which we also have called the "Grid of the Future") is the enabling, central platform of the nation's electric infrastructure. GWA commends DOE for taking a holistic, cross-cutting approach through its Grid Modernization Initiative and GMLC, as noted above.

- As reflected in GWA's "Future of the Grid" effort, which was supported by DOE's Office of Electricity Delivery and Energy Reliability (OE), DOE should continue to undertake a ***comprehensive*** approach to examine changes to the utility business model, regulatory model, and consumer engagement, using the electric grid (or "Grid of the Future") as the framework through which to do so.

> The Business Council for Sustainable Energy (BCSE) also recognizes the need for a holistic approach, underscores that the grid is the "enabling platform," and acknowledges the need for a flexible approach in its latest QER Comments.

- Relatedly, DOE should support planning methods and technologies that will help reduce future uncertainty and associated risks. For example, planning methods that incorporate stochastics, to the extent feasible, and more accurately reflect future uncertainty can facilitate planning and investment decision-making processes.

> With all of the changes taking place, state and local legislators and regulators often lack sufficient information to make prudent decisions. Models are typically focused on historical precedence and do not always accurately reflect innovative new technologies and policies.

- DOE should develop a forward-looking and realistic model for determining the impacts on grid operations of a "high penetration" level of renewable resources for scenario development, and analytical purposes, given various states' aggressive renewable energy goals to support rapid technological advances and related cost reductions.

  DOE's scenario development for the QER should reflect current, already-ambitious renewable energy standards and goals that have been adopted by many states (e.g., CA, HI, NY, and more). GWA urges DOE not to use outdated or overly-conservative figures for "high," "very high," or any penetration levels in developing and modeling such scenarios.

> As noted in a recent article, *"[o]n any given day, California gets more than 30 percent of its electricity from renewable energy. On many days that amount climbs to 40 percent, and on some days renewables reach 50 percent," said Steve Berberich, president and CEO of California Independent System Operator Corporation.*[3]
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> *"For Tom Dunn, president and CEO of Vermont Electric Power Company, the greatest challenge has been the lack of visibility and predictability around how renewables operate. But there are solutions here too. For the past two years, VELCO has been working with IBM to build the Vermont Weather Analytics Center that leverages IBM's energy demand forecasting systems and analytics capabilities, alongside high-resolution weather forecasting to enable better grid management."*
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> *"The product has been tailored to provide data down to 1 square kilometer of accuracy in Vermont. Inside each square kilometer, the system can forecast the weather up to 72*

[3] Pyper, Julia, "Electric Utilities Prepare for a Grid Dominated by Renewable Energy," GreenTech Media, June 16, 2016, available at: http://www.greentechmedia.com/articles/read/the-electric-industry-prepares-for-a-renewable-energy-dominant-grid.

hours in advance. So far, the system has enabled 90+ percent accuracy on load forecasting and 90+ percent accuracy for solar and wind forecasting. This capability allows VELCO to better manage its power plants and reduce running reserves. Solutions such as this make high levels of renewable energy penetration manageable."[4]

- DOE should continue to consider the requirements for transmission (and transmission scenarios) as well as distribution to facilitate the full potential for renewable resources and to maximize their actual development and deployment: looking out not just to 2030, but beyond to 2035 and 2050, using the latest models and granular data. DOE should develop scenarios accordingly, and should model and analyze these scenarios. While some supply resources are located near load and population centers, where these resources can be used, many renewable resources are located remotely. To meet renewable energy goals and requirements, as well as to meet demand with clean resources, DOE – and our Nation, states, utilities and all stakeholders – should help develop these renewable resources, which will require transmission as well as distribution-level infrastructure.

4) Electricity Markets/Valuation

Markets continue to emerge as a method for promoting innovation and encouraging private investment in the grid. While markets will not be uniformly adopted or implemented, understanding the value they provide is critical to guiding legislators and regulators toward prudent solutions.

- DOE should work with states, e.g., through technical assistance and/or other means, to encourage states to include AMF/AMI on the list of priority functionalities for initial utility investments. NEMA also emphasizes this point in its QER Second Installment Comments.

  These and other sensors and communications-based technologies are needed as part of a more holistic strategy to advance changes in business and regulatory models. GWA supports cost-effective options for providing these functionalities that enable dynamic pricing.

  - AMF networks can position the grid as a platform for the integration of DER.
  - AMF enables greater visibility into what is occurring at the edge of the grid – providing grid operators with situational awareness of DER. With more DERs, including microgrids, coming "on line," the need for visibility and control at the "edges" of the grid becomes increasingly important.
  - Advanced Metering Functionality (AMF) likely will require implementing a phased approach, from targeted to more complete deployment.
  - AMF capabilities will be needed for consumers who wish to participate in a DER market to provide and receive new services.

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[4] Pyper, Julia, "Electric Utilities Prepare for a Grid Dominated by Renewable Energy," GreenTech Media, June 16, 2016, available at: http://www.greentechmedia.com/articles/read/the-electric-industry-prepares-for-a-renewable-energy-dominant-grid.

    - All of the value streams should be considered in the planning for and deployment of these systems to maximize their value.

- DOE should investigate the impacts that DER variability patterns will have on the bulk power grid and the consequent changes in requirements for central generation.

- DOE should work with, and provide technical assistance to, states to help states advance evidence-based use of rate designs. More and better data and analyses are needed to understand the value and impacts that various rate designs have on customers.

    - Ultimately, the industry must move from a commodity-oriented approach (i.e., providing kilowatt-hours (kWh)) to a service-oriented model (somewhat similar to the telecommunications industry). In other words, utilities will be compensated, i.e., will charge consumers, *not* for volume-based transactions – in part or at all – but, rather, for providing services, deploying appropriate-scale advanced technologies, and for building and maintaining the "Grid of the Future" as the enabling platform, such that all regulated and unregulated stakeholders are made "whole" (i.e., continue to earn revenues in a sustainable manner, and that reliable, safe, and secure power is maintained).

    - Costs incurred to transform to an integrated, modern grid, and to maintain the grid, should be "allocated and recovered responsibly, efficiently, and equitably;" and, policy and regulatory frameworks should be developed to achieve these objectives.[5] Such models should take into account: market structure, regulatory barriers, and other such key considerations.

    - GWA supports a gradual transition to more dynamic rates, though urges a move toward more dynamic rates as soon as is practicable for that portion of customers for which it makes sense to do so, recognizing all of the changes that need to occur in the interim. GWA also recognizes that some portion of customers might never transition to more dynamic pricing structures.

    - Data support that an opt-out approach from dynamic rates yields better results. Customer education will be a critical component to the success and adoption of these new options. Greater transparency will be essential, as well. Over time, DOE should encourage states to consider opt-out rates.

5) Jurisdiction and Regulations

Based on GWA's "Future of the Grid" efforts, which were supported by DOE's OE, and its collective experience over the past decade, GWA believes that jurisdictional issues are critical to a twenty-first century grid, or the "Grid of the Future," including the range of related issues, such as "situational awareness," interoperability, cybersecurity, and more.

[5] Electric Power Research Institute (EPRI), *The Integrated Grid, Realizing the Full Value of Central and Distributed Energy Resources*, 2014, p. 5.

- DOE should be aware and bear in mind, as it undertakes this Phase of the QER and related analyses, that there are sensitivities around stating that ***"new"*** forms of coordination are needed between **FERC and State PUCs**. Forums already exist for regulators to coordinate and should be used to address new issues.

    - Largely speaking, FERC and states have established roles. Utilities might have to sort out some issues along the margins regarding which transactions are regulated by which authority, but the Federal Power Act (FPA) provides a good amount of clarity.

    - That said, more coordination likely will be needed between Regional Transmission Operators (RTOs)/Independent System Operators (ISOs) and distribution providers (e.g., a Distribution Service Provider (DSP) as in New York's "Reforming the Energy Vision" (REV) process) or system operators (such as a Distribution Service Operator (DSO), as has been proposed by some), in whatever form they take in the future.

- **Interconnection at the Federal versus the State Level:** DOE should coordinate with public and private stakeholders and recognize state-level policies, regulations, and/or efforts that already exist in this regard.

    The potential exists that increased DER may cause challenges related to determining whether interconnection falls under state or federal jurisdictional rules, but, again, we have no evidence that this is happening yet, so we would note the sensitivity here, as well, in the course of DOE conducting this Phase of the QER.

- **"Dual-Use" Assets:** In the area of rate setting and design, DOE should recognize "dual use" assets that provide both retail state-regulated services and participate in federally-regulated markets.

    The best current example is behind-the-meter storage that participates in retail markets by enabling retail customers to reduce peak load to avoid demand charges and can be aggregated to participate in wholesale energy and ancillary service markets. A related issue is separating the charging energy (for batteries) between wholesale and retail rates.

6) Resilience

GWA has identified from its Superstorm Sandy Workshop, as well as its collective years of experience, some of the benefits of smart grid technologies and capabilities (several of which are highlighted below), particularly with respect to enhancing resilience during extreme weather events – and beyond.[6] For example, sensors and other communications-based technologies provide critical data that allow for more efficient operations and quicker response times to weather and other events that

[6] GridWise Alliance, *Improving Electric Grid Reliability and Resilience: Lessons Learned from Superstorm Sandy and Other Extreme Events," June 2013, available at: www.gridwise.org.*

threaten reliability. Additional examples of some resilience-related benefits of grid modernization technologies and capabilities are provided in ***Appendix 2***.

- DOE should work with appropriate federal, state, local, and other stakeholders to encourage "hardening" of infrastructure to enhance resilience. Technological solutions alone will not solve these issues.

  The importance of the need for "hardening" of certain types of grid-related infrastructure as well as of key technological solutions also are highlighted in the Edison Electric Institute's (EEI) latest QER Comments.

  Some examples follow:

  - Integrating Advanced Metering Infrastructure (AMI) with other restoration processes **shaved 2–3 days** off the time it otherwise would have taken to completely restore power during an extreme weather event – i.e., a 10–15 percent improvement in the speed of power restoration.[7]

  - In the past when a power outage occurred, "a utility worker would be dispatched to locate the fault and manually reset switches on the transmission lines to reroute power. Now this can be done automatically through fault detection, isolation and restoration, or FDIR — sometimes referred to as `self-healing' technology." "This smart technology can instantly detect a fault and automatically reroute electricity to keep customers from losing power in the first place. The tool uses automated switching between two distribution system feeders and control algorithms to isolate the problem and restore the system."[8]

  - FPL has a Power Delivery Diagnostic Center, which uses grid modernization technologies and data analytics to quickly diagnose problems, so that field workers can fix them more rapidly and thereby facilitate more efficient system restoration, when outages do occur. Previously, field workers had to perform the diagnostics first. This Center also helps detect and prevent outages more readily.[9]

  - FPL and other utilities are pre-positioning crews prior to an extreme event, to expedite power restoration, once that extreme event has passed through the area. Moreover, FPL has entered into a first-of-its-kind agreement with the National Guard to jointly coordinate in

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[7] GridWise Alliance, *Improving Electric Grid Reliability and Resilience: Lessons Learned from Superstorm Sandy and Other Extreme Events," June 2013, available at: www.gridwise.org*.
[8] Bonneville Power Administration, *Pacific Northwest Smart Grid Demonstration Project: A Compilation of Success Stories*, Idaho Falls Power Project, page 21, available at: http://www.bpa.gov/Projects/Initiatives/SmartGrid/DocumentsSmartGrid/A%20Compilation%20of%20Success%20Stories.pdf.
[9] Power Delivery Diagnostic Center Fact Sheet, FPL.com.

the case of a disaster, particularly a severe storm or hurricane, to enhance each entity's as well as overall response capabilities.[10]

7) Physical and Cyber Security

Sensors can detect and prevent outages from occurring; or, enable power to be restored before a commercial or residential often is aware that an outage ever occurred. Such sensors, and the data and data analytics that are gathered from such technologies, also can be used (along with other "situational awareness" and automation to help restore power much more quickly and precisely, when noticeable outages do occur. These technologies have been demonstrated and are more prevalent at the transmission level; GridWise's research shows that more work needs to be done to bring such technology to the distribution level and to scale it. ***Appendix 3*** provides some additional information on cybersecurity and physical security.

GWA also supports the following security-related recommendations made by the Edison Electric Institute (EEI) in its latest QER Comments.

- DOE should continue to encourage and support public-private partnerships to enhance cybersecurity and physical security, due to natural and human-caused threats, including the work of the Electric Subsector Coordinating Council (ESCC), which is comprised of electric utility and trade association CEOs and government representatives.

- DOE should help ensure a smooth transition as a change in the Administration occurs and should help prevent current grid modernization and security-related efforts from being halted or reversed during the succession planning efforts and thereafter.

[10] News release, "FPL and Florida National Guard form historic, first-of-a-kind partnership to enhance disaster response capabilities," May 2, 2014, available at: http://newsroom.fpl.com/2014-05-02-FPL-and-Florida-National-Guard-form-historic-first-of-a-kind-partnership-to-enhance-disaster-response-capabilities.

Appendix 1: "No Regrets" Measures

The table below highlights some of GWA's recommended near-to-medium-term measures and their rationales. Such measures could include but are not limited to the following.

Measure or Technology	Driver	Comments
Getting the grid ready………		
Upgrade Geographic Information System (GIS) Data Models	Must have the right data to drive the models. The data needed for the advanced modeling of the distribution system exceed the data that have been needed to drive Outage Management Systems (OMS) and load flow analyses that have been utilized to date.	Utilities that have undertaken new Advanced Distribution Management Systems (ADMS) have found that they need additional data to drive their models.
Distribution Supervisory Control And Data Assess (DSCADA)	Must have visibility and control to key components on the distribution grid.	Many utilities do not have DSCADA systems deployed, or have only limited capabilities with the systems deployed today. These systems must be upgraded to give the utilities the visibility and control not only to the feeder breakers, but to key distributed automation on their feeders.
Advanced Distribution Management Systems (ADMS)	Must be able to model the distribution feeders in near real time and on a continual basis, with feedback control points to validate the model.	To enable two-way power flows on the distribution grid, the grid operator will need this advanced modeling capability. Additional modules or systems will be needed to perform functions such as Volt/VAR Optimization (VVO) and Distributed Energy Resource Management (DERM). As increasing levels of DERs are added to the system, these additional capabilities will be required to effectively manage system stability and reliability.
Distributed Energy Resource Management (DERM)	DERM systems will be needed when penetration levels of DERs reach a level at which they are affecting system reliability and stability.	State policies and objectives that incent consumers and third parties to install DERs will have significant impacts on the speed of adoption within a given state. Consideration should be given to how this DERM functionality will be incorporated during the design phase of ADMS. This functionality could be provided as an add-on module to the ADMS, or could be a stand-alone system that is integrated for operational purposes. Timing to install DERM will depend on the penetration levels of DERs.

Volt/VAR Optimization (VVO)	To improve grid efficiency and ensure power quality, as new complex resources are integrated into the grid.	VVO could be a module of the ADMS or a stand-alone system but, at a minimum, will need to be integrated for operational purposes to ADMS.
Distribution Feeder Balancing Program	To better manage and leverage voltage management capabilities to maintain power quality on the grid.	To reduce losses and better manage the voltage and VARs on the distribution grid, the distribution feeders will need to be balanced as far out on the feeders as is economically and practically feasible. This may require increasing conductor size or pulling in additional conductor phases in some areas. As part of the design and analysis phases of the ADMS and VVO, utilities should consider how much feeder balancing would be needed.
Advanced Sensing Capabilities on Distribution Feeders	To increase situational awareness of grid conditions.	To support the ADMS models and enable the optimization of grid operations, additional sensing components will be needed. Advanced meters could comprise one component of this sensor network, particularly when looking at VVO functionality.
Asset Management Systems (AMS)	To track and enable more condition-based maintenance on the distribution grid.	Given the increase in sophisticated assets on the distribution grid, tracking and understanding the condition of these assets will become increasingly important to control maintenance costs and ensure the reliability of the system and its assets.
Getting the exchange and settlement infrastructure in place:		
Meter Data Management Systems (MDMS)	To establish the foundation for managing consumer usage data. Enables the utility to gain a better understanding of the ways in which consumers are using electricity.	An MDMS will allow the utility to gather and analyze their consumers' usage data, giving them a deeper understanding of how consumers are currently using electricity. An MDMS is a critical component of any advanced metering system. By establishing an MDMS in advance of an advanced meter deployment, the utility will be positioned to more quickly leverage data/information from advanced meters, and to offer immediate value to the consumer, once the deployment has occurred. In addition, by leveraging MDMS with current metering information, the utility can perform additional analytics on this usage information. This analysis will be useful in developing new programs for consumers as well as providing insights they can use in planning an advance meter deployment. These data or information also will provide the utility with an understanding of the impacts of DERs as they are installed on the system.

Advanced Metering Infrastructure (AMI) *(Adopting a Phased Approach from Targeted Through Complete Deployment)*	Positions utilities and consumers to have the ability to purchase or supply services to the grid, in association with the implementation of DERs. This is a critical component need to establish the platform for transaction management, including the buying and selling of services as well as measurement and verification of transactions for settlement purposes.	AMI capabilities will be needed for consumers who wish to participate in a DER market to sell and receive new services. This same infrastructure can provide numerous operational benefits as well as serve as sensors on the network to enhance situational awareness and allow the grid operator to optimize network operations. All of the value streams should be considered in the planning for and deployment of these systems to maximize their value, including by state regulators.
Infrastructure that supports both:		
Communications Infrastructure	Foundational in nature. Planning should incorporate all new requirements for managing the grid as well as enabling the AMI that will be required to support the robust buying and selling of services via the grid as the "enabling platform."	Communications infrastructure varies in size, etc., and lacks uniformity of structure. Taking into account a given utility's topology and the availability of public telecommunications infrastructure, an optimal design then can be developed. Communications infrastructure that overlays the electric grid infrastructure is the foundational capability that enables situational awareness and remote management. It should not be planned for in a "siloed" manner but, rather, should be done holistically. Planning for this infrastructure needs to incorporate all communications requirements, both immediate or emergency, and planned, and should remain flexible and agile to accommodate emerging requirements as much as possible.
Data Analytics	Turning data into "actionable" information will require a focus on developing and deploying data analytics capabilities.	By their very nature, the modernization of the distribution grid and the deployment of AMI will result in utilities having more data, i.e., "big data." Data analytics are required to turn these data into "actionable" information and to ensure these data are leveraged for their maximum value to consumers and utility operations.

Appendix 2: Sample Benefits of Grid Modernization Technologies and Capabilities in Enhancing Resilience

"Through October of 2014, ComEd said grid modernization has helped avoid more than 1 million outages and reduced the frequency of outages by 19 percent."[11]

PG&E's Smart Grid Estimated Project Benefits – July 2013 to June 2014:

- Direct Customer Savings: $21.2 Million
- Avoided Costs: $11.0 Million
- Customer Energy Usage: $4.5 Million
- Customer Reliability Costs: $42.1 Million
- Total Cost Savings: $79.1 Million
- Reliability: Avoided 33.3 million customer outage minutes[12]
- "In 2013, not only did the average duration of a service interruption for a PG&E customer fall to an all-time low, but customers also experienced the fewest service interruptions in company history. Customers have seen a 40 percent improvement in the average duration of a service disruption and a 27 percent improvement in the number of customer interruptions since 2006. PG&E's Smart Grid investments played a key role in its ability to deliver these results."[13]

AEP's Smart Grid Demonstration Project implemented a range of grid modernization technologies and capabilities that helped enhance grid reliability and efficiency, lowered energy use by consumers, and reduced peak demand. The effort also helped AEP Ohio "improve efficiencies, identify and respond to outages more quickly, and better monitor and control the operation of the distribution grid."[14]

> The most significant advantages of its Distributed Automation Circuit Reconfiguration (DACR) effort were "its impacts to reliability and its use during major events." Yet, even ***excluding*** major events, "the Project was able to reduce Customer Minutes of Interruption (CMI) by 1,602,647 minutes, improving reliability for 19,309 consumers in 2012 and by 2,606,781 minutes, improving reliability for 31,407 consumers in 2013."[15]

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[11] Wernau, Julie, "ComEd's smart grid plan may get more time," Chicago Tribune, December 2, 2014, available at: http://www.chicagotribune.com/business/ct-smart-grid-extension-1203-biz-20141202-story.html.

[12] PG&E, *PG&E Smart Grid Annual Report – 2014*, October 1, 2014, page 8. Projects that contribute to PG&E's Smart Grid project benefits include: PG&E's SmartMeter™ project; PG&E's SmartMeter™ outage information improvement; PG&E's SmartRate™ program; PG&E's Home Energy Reports project Energy Alerts, and My Energy Site; PG&E's automated demand response program; PG&E's Fault Location and Service Restoration (FLISR) project; and, PG&E's Modular Protection and Automation Control (MPAC) project.

[13] PG&E, *PG&E Smart Grid Annual Report – 2014*, October 1, 2014, page 2.

[14] AEP Ohio, Executive Summary, "Final Technology Performance Report, gridSMART Demonstration Project, A Community-Based Approach to Leading the Nation in Smart Energy Use," DOE Smart Grid Demonstration Project, June 2014, page 2.

[15] AEP Ohio, Executive Summary, "Final Technology Performance Report, gridSMART Demonstration Project, A Community-Based Approach to Leading the Nation in Smart Energy Use," DOE Smart Grid Demonstration Project, June 2014, page 35.

Grid modernization technologies and capabilities also can save truck rolls, thereby time (overtime for crews), payments for these crews, and reduce transportation emissions and fuel costs, and more.

> During Superstorm Sandy, for instance, one utility alone reported such efforts saved more than 6,000 truck rolls during Superstorm Sandy and resulted in at **least $1 million in restoration cost savings,** and other substantial societal cost savings.[16]

[16] GridWise Alliance, *Improving Electric Grid Reliability and Resilience: Lessons Learned from Superstorm Sandy and Other Extreme Events," June 2013, available at: www.gridwise.org.*

Appendix 3: Cybersecurity and Physical Security

The challenges with security in the power sector differ from challenges facing the financial or other critical infrastructure sectors. Concerns with respect to privacy for customer data exist. But, in general, the data have little or no security value and, in fact, permitted tolerances of many data values are part of published reliability standards. Encryption is used to authenticate the communicating devices, prevent man-in-the-middle data substitution, and prevent replay attacks as well as other attacks that could compromise data integrity.

Many of the technologies developed for "Bring Your Own Device" in the commercial IT realm also are applicable to device-to-device communication. These rely on device identity management and threat analysis based on the context of the communication - where the device is, when the communication occurs, what actions are being requested at the network layer (things like ARP or DNS requests, etc.), frequency of communication (potential denial of service), the source and destination of the communication, including whether these entities or devices normally communicate with one another. Comprehensive solutions exist that can be deployed, including in a managed solution(s).

As an example, meter data from smart meters always goes to a meter data management system and has readily-identifiable patterns as well as frequency(ies). If a meter is compromised and starts sending data to the SCADA system, this would immediately be "flagged," despite the data itself being encrypted and the end point (i.e., the meter) being authenticated. "Flagged" could mean anything from generating an alert to proactively being blocked, according to rules that are established by a utility.

Another vital element to security is having a network with capabilities to monitor traffic ***without*** affecting data transmission bandwidth or latency. In addition, having machines learning normal patterns to be able to identify traffic that is not normal ***at the first packet***, without relying on "backward-looking" malware signatures that can only identify attacks that have been seen before, is vital.

Importantly, DOE should be aware that: the most powerful security tools available ***cannot*** be used on serial communication links.

Global network threat monitoring and intelligence-sharing capabilities exist, as do highly-secure supply chain and product life-cycle processes.

Sensors can detect and prevent outages from occurring; or, enable power to be restored before a commercial or residential often is aware that an outage ever occurred. Such sensors – and the data and data analytics that are gathered from such technologies – also can be used, along with other "situational awareness" and automation, to help restore power much more quickly and precisely, when noticeable outages do occur. Such technology has been demonstrated and is more prevalent at the transmission level; GWA's research shows that more work needs to be done to bring such technology to the distribution level and to scale it.

Under Federal Energy Regulatory Commission (FERC) oversight, electric utilities must comply with North American Electric Reliability Corporation (NERC) Critical Infrastructure Protection (CIP) Standards for cybersecurity and that now also exist for physical security. NERC CIP Standard 014 calls for security plans, based on a risk or threat assessment, though only for "high impact" cyber assets, such as control centers. No connection presently exists between NERC CIP Standard 014 and NERC CIP Standard 006. Physical security professionals take much more of a systems and architectural approach using a Threat Assessment as the core for a comprehensive physical security plan that balances cost of remediation against threat probability and consequence of occurrence.

Most electric power infrastructure is out in the open and is quite extensive and/or expansive. Physical security must have at its core: system resilience, i.e., the ability to route power along alternate paths and isolate faulted segments. There must be an ability to correlate data from multiple upstream and downstream sensors to identify and distinguish a compromised or malfunctioning device from one that is correctly reporting information requiring remedial action. The electric utility industry has some of this type of resilience in place, though the Threat Assessment that underlies it is equipment malfunction. One example is that, despite a recent incident in California involving damage to physical infrastructure, not a single customer lost power.

GWA supports the points made in EEI's latest QER Comments that: in addition to the CIP requirements, the industry also uses voluntary standards, as well as other tools, scenario exercises, best practices, and more to constantly work to improve the security of the electric system.

Potential (physical) security concerns around Geomagnetic Disturbances (GMD) (or CMD (coronal mass discharge)) must be distinguished from potential concerns pertaining to electromagnetic pulses (EMP).

Geomagnetic Disturbances (GMD):

"Solar Flare GMDs: GMDs caused by solar flares are naturally occurring events the electric industry has addressed for decades. They result in two types of risks: (1) damage to bulk power system assets (e.g., transformers); and (2) loss of reactive power support, which could lead to voltage instability and power system collapse."[17]

Sufficient sun monitoring and observation exist that GMDs offer some advance warning. The remediation against another Carrington Event is rapid system shutdown and segmentation to prevent induced surges from transiting the grid and impacting substations and control centers. Isolated from long transmission or distribution lines, local currents induced in a substation or control center are well within protections already in place for lightning strikes. The challenge for GMDs is to have a coordinated and practiced response plan in place in advance. Even with optimal planning, it could take on the order of 24 hours or more to re-start the grid nationally, as this takes place in sections, as they are re-started sequentially with some restarting as soon as the event has passed, likely a couple of hours (i.e., "black start").

[17] Information provided by EEI on July 1, 2016.

Based on these risks, NERC also has developed two "mandatory and enforceable GMD industry standards that are on track for implementation and further refinement."[18] The first became enforceable on April 1, 2015. The second (phase of the) "GMD standard was approved by NERC's Board of Trustees and submitted to FERC for approval on January 21, 2015."[19]

Electromagnetic Pulses (EMP - very high cost, low probability):

In scenarios which often are attributed to terrorists or rogue states, an EMP might have a severe impact, but it would likely occur locally, as opposed to a hemispheric impact of a GMD. The other key difference between a GMD and an EMP is that it is very unlikely there would be much, if any, advance notice of EMP.

EMPs are still subject to the inverse square law that governs all electromagnetic fields where the intensity diminishes as the square of the distance from the source.

The remediation here would be surge arrestors capable of dealing with vastly higher levels of energy than lightning strikes placed in strategic locations along the grid. Given the costs involved, the relatively low likelihood of occurrence, the fact that the effect of well-placed surge arrestors would be to isolate the damage to a local area (which is the likely result anyway), it would appear to be a much better plan to strategically locate spare parts and rehearse repair/response much like storm responses are planned and rehearsed.

To elaborate, following are two different types of EMPs:

- "High-Altitude Nuclear Blast EMP: A high-level EMP caused by the detonation of a nuclear weapon in the atmosphere is a high-consequence, low-likelihood threat that would have a potentially catastrophic impact on society. Further, since the planning and launching of a nuclear attack on U.S. critical infrastructure would be an act of war or terrorism, the federal government must be primarily responsible for preventing high-level EMPs as a matter of national security. The impacts of a high-level EMP on the electric grid are still not fully understood, but are being studied by the Electric Power Research Institute, the federal national labs, and others, with some mitigation strategies, such as shielding equipment and procuring spare equipment, already being utilized," as underscored in the previous paragraph.[20]

- "Directed Energy EMP Weapons: This category of devices may pose a more narrowly focused EMP threat to a single facility or piece of equipment similar to a traditional physical attack. Thus, mitigation strategies include more typical physical protection measures such as line-of-site security, access controls, and system redundancy."[21]

[18] Information provided by EEI on July 1, 2016.
[19] Information provided by EEI on July 1, 2016.
[20] Information provided by EEI on July 1, 2016.
[21] Information provided by EEI on July 1, 2016.