The Future of the Grid
Evolving to Meet America's Needs

December 2014

Final Report

An Industry-Driven Vision of the 2030 Grid and Recommendations for a Path Forward

GRIDWISE ALLIANCE

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Foreword

The GridWise Alliance recently co-hosted with the U.S. Department of Energy's Office of Electricity Delivery and Energy Reliability (DOE-OE) a National Summit on the "Future of the Grid: Evolving to Meet America's Needs." The Summit was the culmination of a series of workshops during which over 400 industry stakeholders shared their vision and challenges for creating the "Grid of the Future." During the National Summit, Secretary of Energy Moniz charged us, the industry, along with federal, state, local and other private and public sector participants, with bringing our collective recommendations to policy makers as a critical next step in realizing the benefits of an improved grid.

We have heeded that charge and our collective vision of this "Grid of the Future" is included in this document, along with several key recommendations we believe are vital to achieving that vision, including how to navigate the transition over the next several years. These recommendations are critical to the entire ecosystem of electricity industry stakeholders and require bold leadership from the Department of Energy, the Administration, Congress, and the private sector.

The electric sector is facing changes that have not been witnessed in this industry for the past 100 years. If we do not act now to shape this transition, the changes will happen to us, rather than our industry leading the way to our future and that of the electric grid (system).

Now is the time for us not only to embrace, but to lead in shaping, the changes that will prepare us for the next several decades. As described in this report, the grid must become the enabling platform for our energy future. This grid must ensure resilience, mitigate vulnerabilities, incorporate innovation, and continue to provide affordable, safe, reliable, and ubiquitous power. To reach these objectives will require more than just good technical solutions. It will require new business models, new regulatory models, new responsibilities and obligations by the grid operators, more fully engaged consumers, and new providers that will facilitate increasingly innovative solutions. These are challenges that will require our best ideas, collaboration among all stakeholders, and dedicated, concrete actions.

The GridWise Alliance and our members are committed to do our part by continuing to work with DOE and the industry to address the recommendations in this report. We urge DOE to take a leadership role, in partnership with industry, to truly drive this transformation of our electric system forward.

Sincerely,

Robert Shapard
Chairman, GridWise Alliance
Chairman & CEO, Oncor

Scott Prochazka
Vice-Chairman, GridWise Alliance
President & CEO, CenterPoint Energy

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Report Overview

Over the past several years, the electricity industry has experienced fundamental changes on a scale not witnessed since the creation of the electric system more than 100 years ago. Our nation's grid—the electricity infrastructure between the generation sources and consumers—must evolve to respond to these changes in order to meet society's needs, changing expectations, and preferences. The evolution has already begun, and over the next 15 years and beyond, it will have significant implications for reliability, operations, security, resilience, consumer choice, and more. To successfully develop sustainable solutions to the challenging issues related to this evolution of the grid, it will be essential for all stakeholders to work together to understand each other's points of view and collaborate to develop the path forward.

With this in mind, the U.S. Department of Energy's Office of Electricity Delivery and Energy Reliability (OE) and the GridWise Alliance (GWA) partnered to facilitate a series of four regional workshops and a National Summit entitled "Future of the Grid: Evolving to Meet America's Needs" to create an industry-driven vision of the electric grid in 2030 and, more importantly, to begin forging a path to realizing that vision. To determine the vision of the future electric grid, the initiative looked at the grid in the context of the entire value chain of the electric system, which includes the grid infrastructure as well as generation, transmission, distribution, storage, and end use.

Through this initiative, OE/GWA convened stakeholders to hear first-hand their thoughts on the future grid and the operational capabilities that will be needed. This report captures the vision of the future electric grid and the associated potential changes in the utility business and regulatory models, as articulated by regional workshop and National Summit participants. Analysis of participant input by the OE/GWA team yielded four overarching recommendations supported by specific actions necessary for facilitating the transition to the future grid. The recommendations, which are provided in the final section of the document, "Planning the Transition: Recommendations for a Path Forward," will help to facilitate a smooth transition to achieving the vision while recognizing and supporting the diversity of specific approaches and implementation pathways needed by individual states, regions, and utilities.

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Introduction

Electricity is the foundation for America's economic success. Our digital economy, our national security, and our daily lives are highly dependent on reliable, safe, abundant, affordable, and secure electricity. Over the past several years, the electricity industry has experienced fundamental changes on a scale not witnessed since the creation of the electric system more than 100 years ago. New technological advances are providing new grid capabilities, prices for clean energy sources are becoming more affordable, our digital economy is even more dependent on electricity, and consumers are demanding fewer outages and faster response times when outages do occur.

Electricity is no longer just something the utility delivers to consumers. Consumers want more choice and control over their energy choices, and new unregulated entities are entering the market to meet consumer needs with new products and services. Prices for distributed energy resources (DERs) continue to decline, making these technologies cost competitive with utility service, and with each natural disaster consumers have an enhanced desire for resilience and reliability. Consumers have options and they are increasingly exercising them. As a result, grid dynamics are rapidly changing and increasing operational complexity.

The grid will play a critical role in meeting society's need for electricity, and changing conditions make it imperative that the grid—and grid operations—evolve. The evolution has already begun, and over the next 15 years and beyond it will have significant implications for reliability, transmission and distribution operations, security, resilience, and consumer choice. Many difficult issues must be addressed, including technology challenges, the evolution of the regulatory model, a rethinking of how electricity is priced and electric infrastructure investments are recovered, and who can provide value-added services. To successfully develop sustainable solutions to these tough issues, a collaborative process that includes all stakeholders will be essential.

With this in mind, the U.S. Department of Energy's (DOE's) Office of Electricity Delivery and Energy Reliability (OE) and the GridWise Alliance (GWA) partnered to facilitate a series of multi-stakeholder regional workshops and a National Summit entitled "Future of the Grid: Evolving to Meet America's Needs" to create an industry-driven vision of the grid in 2030 and, more importantly, to begin forging a path to realizing that vision.

To determine the vision of the future electric grid—the infrastructure between the generation sources and consumers—it was necessary to look at the grid in the context of the entire value chain of the electric system, which includes the grid infrastructure as well as generation, transmission, distribution, storage, and end use. Looking at the grid in the context of the entire value chain, one can gain an understanding of the evolving role of the grid as an enabling platform as well as the evolving role of grid operators. As the enabling platform, the grid (i.e., the physical infrastructure for electricity delivery) must be able to reliably integrate all generation sources and new third-party entities that will provide services to the larger electric system. Looking through this lens helps to illuminate necessary changes in the utility business models and the evolving regulatory framework. From there,

Electric System Versus Electric Grid

In this report, the term "electric system" refers to the entirety of generation, transmission, distribution, storage, and end use. The term "electric grid" refers to the electricity infrastructure that lies between the generation sources and the consumer (i.e., transmission and distribution, or electricity delivery).

the path for transitioning to the future grid, including the required shifts in consumer engagement, can be determined (see Figure 1).

Looking to 2030 and the future grid, the goal of the "Future of the Grid: Evolving to Meet America's Needs" initiative was to determine—through a holistic approach that considers the system's many interdependencies—a path forward that will ensure resilience, mitigate vulnerabilities, and incorporate innovation, while continuing to provide affordable, safe, reliable, and ubiquitous power.

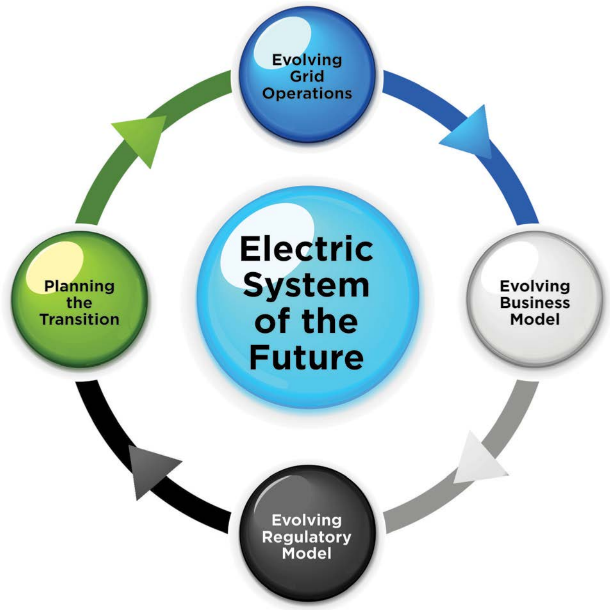

Figure 1. Elements of a holistic approach

The "Future of the Grid: Evolving to Meet America's Needs" Initiative

Over the course of six months, from late 2013 through the spring of 2014, OE and GWA held four regional workshops (Western, Central, Southeast, and Northeast) across the country to engage industry stakeholders in helping to formulate the future grid's requirements and identifying any possible regional variations.

Attended by more than 240 thought leaders from all stakeholder groups (e.g., utilities, regulators, state government officials, renewable energy providers, vendors, consumer advocates, academia, and third-party innovators), the workshops provided a platform for open and frank discussions about compelling issues within the industry and allowed participants to gain a fresh perspective on each other's views. (Appendix A provides a complete list of companies that participated in the regional workshops and/or the National Summit.)

Each regional workshop began with a group visioning exercise in which participants were asked to put aside the current legacy system and think about the type of system they would design today if starting anew. Participants were then split into breakout groups, each of which was given a different scenario to consider and discuss its implication for a future state of the grid in 2030. The breakout groups then discussed several key elements of the evolution of the grid: (1) capabilities needed for the future grid, (2) the changing role of grid operators, (3) the new technologies and financial models required to drive investment, (4) the policy and regulatory barriers to realizing the vision, and (5) the transition necessary to achieve the future grid. Participants were asked to consider the context of their group's assigned scenario while keeping in mind the vision for the future grid from the group visioning exercise.

Workshop Scenarios

The same scenarios were discussed at each workshop:

- Balancing Supply and Demand as Grid Complexity Grows
- Involving Customers and Their Loads in Grid Operations and Planning for Empowered Customers
- Higher Local Reliability through Multi-Customer Microgrids
- Transitioning Central Generation to Clean Energy Sources—Large Wind, Large Solar, and Large Gas

Although the scenarios are anchored in key factors affecting the grid, they do not represent an exhaustive examination of what is possible in 2030. Instead, they highlight possible scenarios and key areas that are plausible and facing industry today. The scenarios served to guide the discussion of 2030 grid operations from important and somewhat different perspectives.

To review, synthesize, and validate the findings and themes that emerged from the regional discussions, OE and GWA hosted a National Summit in Washington, DC, bringing together senior electricity industry leaders from across the United States for a series of panel discussions. Throughout the meeting, participants also provided input by responding to polling questions related to the panel topics. The polling results were displayed in real time. Selected results are presented in the body of this report, and the complete results can be found in Appendix B. While polling question results are not a definitive indication of stakeholder opinions, they are used in this report to emphasize the information gathered through the National Summit and regional workshops.[1]

Through the regional discussions, common themes emerged. One theme is that throughout the transition, as new opportunities for both consumers and third parties emerge, larger societal benefits will need to be balanced with the needs and desires of individual consumers. This will create increasing complexity in the market, and it will be essential to keep consumer benefits—collectively and individually—at the center of the discussion, while being mindful of reliability, safety, and cost considerations associated with transitions.

Although common overarching themes surfaced during the workshops, the methods for achieving this vision require further discussion. Specific transition plans for utility business models and regulatory models, to the extent they are developed, will depend on the service territory, utility, and/or state(s) involved. All industry stakeholders—including utilities, regulators, consumer advocates, third parties, and local governments—should work together to fulfill this vision for the future.

[1] Polling results should not be used to extrapolate further conclusions—the polls were not conducted in a scientific manner and the sampling size may not be representative of the electric industry as a whole.

About This Report

This report has been developed based on input from regional workshop and National Summit participants and reflects their collective visions for the future state of the electric grid, electric system, and business and regulatory models. The recommendations for a path forward were developed based on participant input and analysis by the OE/GWA team. While the report reflects the vision that was communicated by participants, the report is not an endorsement by everyone who participated. Input from all participants has been instrumental in outlining the vision; however, continued engagement and discussion will be essential as the industry continues this important transformation.

In addition, this report will serve to inform DOE and industry research and development efforts and educate all stakeholders—including state and federal policy makers and regulators—on the issues that stakeholders think must be addressed to ensure that the future grid continues to be affordable, reliable, and resilient in order to support our economic prosperity and energy security. The report also intends to provide valuable perspective on the industry's future vision for the grid to DOE's Quadrennial Energy Review.

Vision of the Future Electric System

The grid will be a key component of the future electric system; it will be the network that serves as the backbone of our electric power system. The electric system is at the heart of our national economy. The grid (the wired network) will be the platform for enabling consumer choice, providing for the public good, and enabling future innovation. It will reliably integrate all energy sources and respond to wide fluctuations in supply from central and distributed generation. The grid will serve as a very dynamic two-way power flow system of the future, ensuring that the system remains stable and resilient.

The electric system of the future will include both central and distributed generation sources with a mix of dispatchable (i.e., controllable) and non-dispatchable resources. While central generation will continue to play a major role, there will also be other generation supply options. The ability of the grid to reliably integrate these new generation options will require it to be more flexible and adaptable. DERs, including photovoltaics, wind, fuel cells, local generation, storage, and demand response, will play a more significant role.

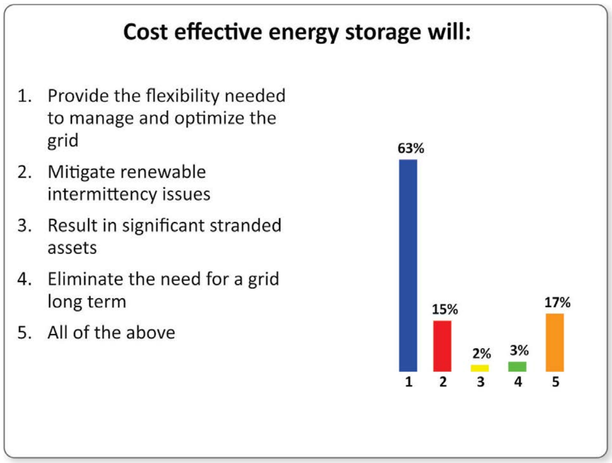

Figure 2. National Summit polling results – energy storage

Energy storage will be a key component in future system design, but it will not replace the need for dispatchable generation. The grid operator, as well as microgrid owners/operators, will leverage energy storage along with responsive loads and dispatchable generation sources to optimize operation of the system. Energy storage will allow opportunities for mitigating the variability in non-dispatchable generation sources such as solar photovoltaic and wind generation, as well as provide some additional ancillary services such as spinning reserve[2] requirements. (See Figure 2, which shows the polling results from National Summit participants, echoing discussions in the regional workshops.)

Consumers will use the grid in different ways. More consumers will become "prosumers"—both consumers and producers of energy. The grid will no longer just be a "delivery pipe" for power. Power will flow both ways, and other ancillary services may also be provided by these new prosumers. Infrastructure and systems to manage this "transactive energy"[3] environment will need to be developed and implemented. Rates and pricing will need to be reformed to ensure fairness to prosumers, traditional energy consumers, and traditional utility suppliers. (See the text box "The Dynamic Nature of Pricing for Electricity: A Real-Life Example.")

Multi-customer and single-customer microgrid operations will complement the future grid. Microgrids, where feasible or desired, will complement the grid instead of competing with it, providing services to utilities and vice versa. Aggregating distributed generation into microgrids might offer benefits for managing significant concentrations of distributed generation and consumer-owned renewables. With accurate market price signals, utilities would be able to call on these

[2] Spinning reserve: The extra generating capacity that is online and can instantaneously respond to changes in load.

[3] Transactive energy: The ability for consumers and end devices to buy and sell energy and related services in a dynamic and interactive manner. A full definition of transactive energy can be found at www.gridwiseac.org/about/transactive_energy.aspx.

microgrids to optimize generation and reduce load on peak demand days or for other operational efficiencies, including reducing the impacts of outages. This could be a win-win with consumers, third-party providers, and utilities working together.

The Dynamic Nature of Pricing for Electricity: A Real-Life Example[4]

Determining the right price for electricity service will be critical to a successful transformation of the energy system of the future. Pricing is an essential element—it brings together all of the other factors. Without the correct pricing structure, the wrong behavior is incentivized and the resulting impact to grid operations can be detrimental.

Current rate structures in California were developed based on historic usage patterns. However, usage patterns are shifting due to changing customer profiles and end-use requirements, but pricing structures have not been adjusted to match these usage changes. The changing usage patterns have resulted in a shift in peak load, and incentives that used to work in the past have become misaligned and unintentionally incentivize behavior contrary to their original intended objective.

For example, today in California, consumers on the legacy Time-of-Use (TOU) tariff are incentivized to avoid energy usage between the hours of 11 am and 6 pm. Consequently, consumers wait until 6 pm to turn on their air conditioning because electricity is cheaper at that time and despite the fact that the system peak has shifted and now extends from 2 pm until as late at 9 pm. At the same time, consumers who generate distributed rooftop solar power and are under a Net Energy Metering (NEM) TOU tariff (under which consumers are paid for the energy they produce and put on the grid) reach their peak energy production at approximately 1 pm. These consumers are currently compensated at the highest rate under the NEM TOU tariff for energy that they produce at 1 pm, even though the grid often has an oversupply of energy at this time since the peak has shifted.

This example points to the very dynamic environment and illustrates why utility practices as well as flexible rate structures are needed that can adjust incentives and opportunities for bill savings when customers change their electricity demand and can accommodate the dynamic changes in a timely fashion.

Although pricing and incentives can (and should) help markets get off the ground, pricing must keep up with the dynamic changes in the system; otherwise, it can lead consumers and investors to make bad decisions that will put the implementation of valuable new technologies and capabilities at risk and can have a negative impact on the overall efficiency of the system.

There likely will be a mix of regulated and competitive services. With third-party providers entering the market to offer consumers new services that are not part of regulated pricing or rates, a mixture of regulated and competitive services will emerge. These offerings will need to be unbundled so that the value of the grid can be priced accordingly; grid investments can be appropriately recovered; and third-party providers and consumers can make informed, open-market decisions with that pricing knowledge.

[4] This text box is only an example of how pricing can impact operations, and how this relationship needs to be considered and reevaluated. There are many different ways to achieve desired outcomes, and rate structures can take many forms to accommodate potential inequalities among a customer base.

There will be a retail market for services. In order for consumers/prosumers to be active participants, a retail market exchange that supports the true value of renewable energy, traditional energy, capacity, distribution, transmission, aggregation, and other services provided by market participants will develop in some jurisdictions, depending on the market structure and state policies. In addition, locational marginal pricing at the distribution grid level could be one approach to enable the grid operator to optimize grid/system operations and performance.

The system will be even more complex. With all of the new entities and energy resources, managing and optimizing the system will become increasingly challenging, even with all of the new tools and technologies available to grid operators. It is highly likely that the tools and technologies will be deployed ahead of the regulations that will govern their use, which will add to this complexity.

Envisioning Retail Market Exchanges

Retail market exchanges would provide the physical and institutional structure through which retail consumers and third-party providers could buy and sell electricity and ancillary services in an open market. Through exchanges, consumers would be able to choose between competing electricity suppliers. There is no one-size-fits-all concept for retail market exchanges. Retail market exchanges in different jurisdictions may operate under similar guidelines and principles, but their applications could be significantly different.

Vision of the Future Electric Grid

Society will continue to need and—perhaps more importantly—want a reliable and robust electric grid to serve as the backbone of our electric power system. The role of the grid is changing significantly and the future grid of 2030 likely will look and be managed differently than today. In many parts of the country, the grid will no longer be just a one-way "delivery pipe" for electrons; however, it will continue to play a vital role in America's future economy.

While the grid will be increasingly complex, it will be more flexible, adaptable, and responsive. It will be internally sophisticated but outwardly simple for consumer interaction.

The grid (i.e., the physical infrastructure for electricity delivery) will be the enabling platform—much like the body's central nervous system—for a very dynamic and complex system with many interdependencies. In systems where consumers deploy significant DERs, the distribution grid will be the enabling platform.

Balancing supply and demand will remain a key function of the future grid and the future grid operator. The current electric system has been designed primarily to provide power in one direction, from the utility to the consumer, and today's system requires that utilities match generation (supply) to load (demand) in real time. In the future, power will dynamically flow in two (or perhaps more) directions, requiring a change in how balancing is done.

Grid operators will need to be able to predict conditions in close to real time with sophisticated modeling and state estimation capabilities.[5] Operators will have real-time situational awareness and will use new tools to manage this new dynamic system to meet their continuing obligation to balance supply and demand on the system. This capability will allow for more efficient dispatch and system balancing as DERs are incorporated into the equation. Greater situational awareness, made possible by technologies such as remote sensing and control capabilities, will also allow utilities to better plan upgrades and maintenance to their systems.

Interdependencies and interactions between transmission and distribution system operations will grow. The distribution grid will look and act more like today's transmission grid as it balances supply and demand from retail consumers/producers. Information will be exchanged between the transmission and distribution systems in near real time, which will necessitate more integrated coordination between the two systems. The exchange of information vertically will be automated and optimized by the development of standard data structures.

Visibility from transmission to interactive end devices will be provided by various sensing capabilities and devices. This visibility will enable control at the edge and allow transmission operations to "see" distributed resources and understand their impact on the transmission grid. This is particularly important because there will be a network of endpoints connected to the future grid, controlled by consumers who will not act in the same way.

A high-bandwidth, low-latency, cost-effective communication system will be needed to overlay the entire grid. This communication infrastructure will be essential to achieving the objectives and functionalities of the grid.

There will be real-time, automated communications to end-use devices and equipment. There will be ubiquitous sensing of grid components and end-use devices with interoperable machine-

[5] State estimation: A method for estimating the state of the transmission grid using current measurements and network models.

to-machine communication. Devices will have two-way communication with the grid and will be largely automated. Automation of responsive end-use devices will be based on consumer preferences.

Distributed grid intelligence will expand. This will require vertical-horizontal coordination and integration. Operations within an organization's/utility's domain (vertical) should collaborate with other entities (horizontal) that also interact with the grid (e.g., microgrids and third-party renewable providers).

The grid's increasing complexity will require numerous technological and business process changes:

- Self-learning systems.
- Larger transmission-level balancing areas or increased coordination between transmission-level balancing areas, as well as more granular balancing capabilities at the distribution level.
- Balancing capabilities utilizing both supply-side and load-side options.
- Security and privacy implemented in all aspects of the system, down to end-use devices.
- Plug-and-play capabilities.

Microgrids will play a role in the future grid and will either operate in parallel or in island mode as needed. Microgrids will be used for managing multiple DERs in some areas. Microgrids will include single- and multi-customer solutions; utility-, community-, and privately owned microgrids; and private microgrids nested within a utility microgrid. They will act as new responsive loads or provide ancillary services in the retail market.

Advanced analytics that leverage exponential growth in data will play a critical role.

Safeguards will mitigate and protect against cyber, physical, and other threats. This will include a combination of smart grid technologies, trained utility personnel, improved business processes, and physical and information technology and communications infrastructure upgrades. Microgrids may also provide some resilience and recovery benefits.

The Most Critical Technical Challenge in the Next 15 Years

At the National Summit, participants were asked their opinions on the most critical technology challenge that will need to be addressed in the next 15 years. They identified the management of DERs and achieving cost-effective energy storage as the biggest challenges. (See Figure 3, which shows the polling results from National Summit participants, echoing discussions in the regional workshops.)

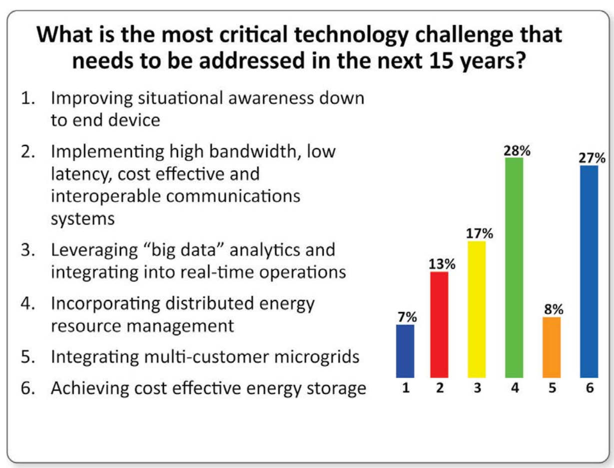

Figure 3. National Summit polling results – critical technology challenges

The existing distribution grid infrastructure will be leveraged to enable positive interactions with the current and subsequent generations of consumers. Distribution companies will find ways to make it easy to use the distribution network. A few consumers may leave the grid, but others will find value in staying connected. By staying connected, consumers could rely on their own energy sources to meet their typical usage requirements but rely on the grid during very hot days or during a series of cloudy days. This would prevent consumers from having to purchase additional equipment or larger systems to meet 100% of their energy needs, which can be costly. Therefore, in areas where this evolves, it is critical to design the right pricing and rules so all consumers (DER and non-DER owners) share the cost of maintaining and operating the grid in a fair and equitable manner.

In some jurisdictions (e.g., states, municipalities, and cooperative boards), the distribution grid will become the enabling platform for a retail electric marketplace and will enable wholesale-to-retail transactions and retail-to-wholesale transactions. These jurisdictions (whether regulated by public utility commissions or boards) will need to define the services provided and how the retail market platform operator is compensated. Cost and pricing will need to be unbundled to provide accurate signals for the component cost of distribution and transmission and infrastructure as well as to set pricing for enhanced and ancillary services.

Evolution of Utility Business Models

The utility business model of today will adapt in order to achieve the vision of the future grid. Utility operating environments are changing. Consumers and third parties will play an increasingly significant role. As new methods become available for meeting and managing energy choices, it will be critical to ensure that the overall infrastructure that supports these choices is available and reliable, and that the public good is considered. Utility business models must adapt to this changing environment while ensuring a value proposition for all consumers and society. Any cross-subsidization between prosumers and other consumers can be rightfully a contentious issue, and therefore any decisions made should involve consumer groups, utilities, and governing boards/regulators, as applicable.

Grid owners and operators will be equitably compensated for the value they provide. They will be compensated for achieving the desired outcomes, which may or may not include volume-based transactions. Examples of this results-based compensation approach include the following:

- Being agnostic about supply.
- Being able to integrate all types of generation.
- Enabling consumers to provide services back to the grid.
- Facilitating a retail market for consumers and third-party providers to buy and sell services.
- Offering enhanced or optional services, such as microgrid services and other DER support services.
- Increasing grid efficiency.
- Optimizing asset utilization.
- Supporting/implementing public policies, such as increasing renewable clean generation.
- Maintaining a safe and reliable grid.
- Enabling highly reliable and resilient energy services to consumers.
- Identifying the most cost-effective ways of achieving these outcomes.

Transmission and distribution utilities will compensate consumers and/or third parties for ancillary services that they provide back to the grid at the retail level. In addition to power, prosumers and third parties could use smart technologies to provide other services, such as frequency support, power factor support, spinning reserves, and demand response.

Utilities will need both positive and negative incentives related to achieving targeted performance levels. In order to promote innovation, if performance-based rates are adopted/implemented, those performance measures will need to include both positive incentives for meeting performance targets as well as negative incentives for when they are not met.

Transmission and distribution utilities, in many instances, may shift from being only commodity providers to being customized consumer services providers that will no longer be wholly compensated based on the use of kilowatts and kilowatt-hours to calculate their charges.[6] Their compensation will be based at least in part on a fee schedule or pricing plan that is directly tied to the services delivered. (See Figure 4, which shows the polling results from National Summit participants, echoing discussions in the regional workshops.)

[6] In integrated utilities, the same concept will apply for the transmission and distribution business units.

Transmission and distribution utilities could buy and sell a portfolio of services (through a retail market exchange) to consumers and third parties. The move to the services approach likely will challenge utilities and regulators to rethink current paradigms and norms. For example, new metering technologies could enable a basic level of service as well as an enhanced level of service. (See text box for examples.)

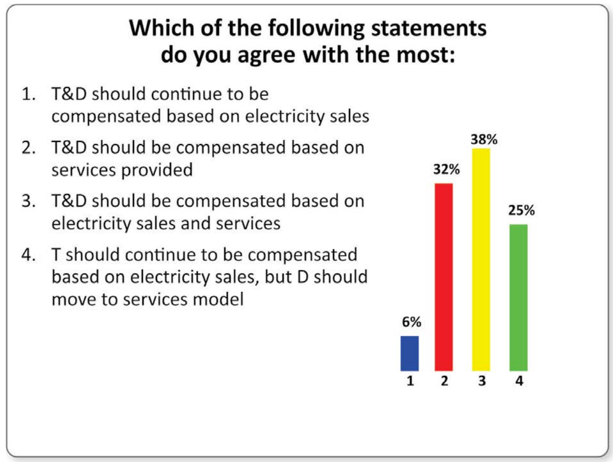

Figure 4. National Summit polling results – transmission and distribution compensation

Utilities will develop a broader understanding of consumer behaviors and desires in order to offer services that meet consumer needs. Utilities, in general, have been operating in an environment where consumers had (or wanted) few options and, therefore, the utilities could meet their load requirements with little need to understand individual consumers' behaviors or desires. However, now utilities will need to understand consumers' different expectations and desires—some will be very active in managing their energy use and choice; others will just want to flip the switch and have their lights come on—and design products and services accordingly.

Examples of Potential Services That Could Be Bought and Sold by Transmission and Distribution Utilities

- Basic service (e.g., 30 amps)
- Enhanced service
- Ancillary services
- Frequency response
- Microgrids
- Clean (green) power
- Backup service
- High-reliability service

Consumers—and all stakeholders—will need to understand the true cost and value of electricity components/services and their impact on increasing or decreasing that cost in order to optimize their choices in buying and managing their energy, should they choose to do so.

Accurate, clear, and direct price signals to consumers and devices are needed. This would allow consumers to evaluate prices and make informed short- and long-term decisions. The transition to this model will need to include efforts to educate consumers so they can understand and embrace this new approach of the grid as an enabler that will give them more control and choice over how they meet their electricity needs.

Costs would need to be disaggregated into logical and accurate components to enable a services fee structure. Subsidies and socialized costs that are built into today's rate structures will need to be revisited. Both implicit and explicit subsidies must be investigated. Some of these socialized costs will require tough questions to be asked, and a new social compact will need to be established. Consumer advocates will be a key voice representing consumers at the table to develop a new social compact in each jurisdiction. Business models must still account for infrastructure development costs and provide an incentive for entities to build and maintain infrastructure in the future.

To enable this new cost-based services methodology, additional data will be required. Transparency and a more granular understanding of the costs of services will be essential. This will also require the ability to measure and verify performance associated with these new services, both those provided by utilities and those provided by consumers or third parties.

A market structure, such as a retail market exchange, is one option that would allow utilities, consumers, and third parties to buy and sell services at fair market value in some areas. Currently, some jurisdictions (such as New York and Hawaii) are actively exploring options for establishing a retail market platform to accommodate the increasing deployment of DERs.

Distribution utilities could facilitate and manage the retail market exchanges. Their current infrastructure, knowledge of system conditions, and role in the electricity value chain make them the most logical choice to facilitate these exchanges. However, structuring their role to ensure full open markets will require thoughtful consideration and planning, with checks and balances to guarantee fair access to all parties. This option is currently being debated in the New York Public Service Commission Reforming the Energy Vision (NY REV) Proceeding. (See Figure 5, which shows the polling results from National Summit participants, echoing discussions in the regional workshops.)

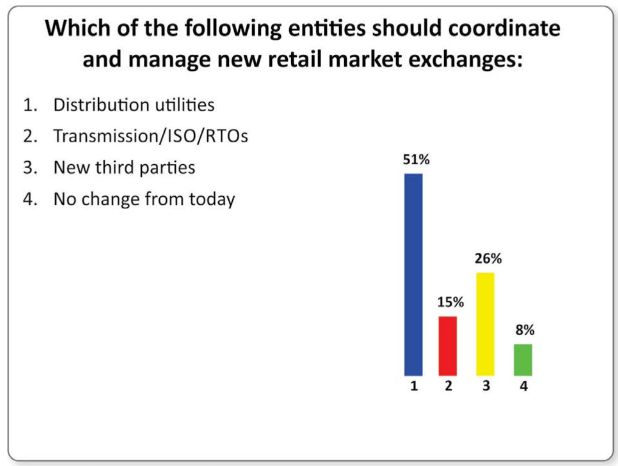

Figure 5. National Summit polling results – coordinating and managing retail market exchanges

Seamless coordination between wholesale and retail markets will be needed. This will require defining the boundaries of each market as well as how the markets will be integrated. This is essential to ensure that robust retail markets are enabled and leveraged to manage cost and the complexity of the future grid, including optimizing the wholesale market.

Workforce needs must be considered when determining the role of the utility. Due to changing technologies and workforce functions, the workforce requires different skill sets than have been needed to this point. A workforce with the right combination of information technology and operational technology skills to support the grid's new functions must be developed. Grid operators, particularly at the distribution level, will need further education to manage the increasing complexity of operations. In addition, as the grid becomes more automated, utilities may not require as many field resources to manage their day-to-day operations. The challenge will then become how to plan for mid-level to large-scale extreme events (e.g., weather, geological, and security) and how to hire and train the necessary personnel. All of this must be managed under a dynamic and evolving environment while accounting for the large portion of the current workforce that is expected to retire within the next 5–10 years, taking with it significant institutional knowledge.

Evolution of Regulatory Models

As non-regulated distributed generation (e.g., rooftop solar, multi-customer and community microgrids, and combined heat and power) and other DERs (e.g., electric vehicles and energy storage) become more prevalent, the process for planning for regulated assets (i.e., central generation and transmission and distribution infrastructure) will become more challenging. Central generation will continue to play an important role in the electric system of the future; however, it will not make up the entire generation mix. Although utilities may end up owning and operating at least a portion of the DERs, they will not own or operate all of them. Because decisions for non-utility-owned or operated DERs will not be made within the framework of a utility integrated resource plan, it will be important for utilities and regulators to be aware of these assets and account for the capabilities and limitations of such installations. This awareness will help utilities and regulators prevent overbuilding of central generation and the associated grid infrastructure, reducing the risk of stranded assets in the regulated space.

New regulatory models must balance the public good with the needs/desires of individuals. There will be new ways for consumers to meet and manage their electric needs. Third parties will offer consumers options for meeting and managing their needs; this will have implications not just for those consumers who utilize third-party services, but also for other consumers and society as a whole. Individual consumers will make their decisions based on their personal needs and desires; they cannot be expected to consider the overall system "good." The overall system "good" is currently addressed through today's regulatory structure with the application of least-cost planning methodologies that can be applied across the entire electric value chain. New regulatory models must take this into account to ensure a balance between meeting individual consumers' desires and maintaining the overall system. In addition, a substantial number of consumers will be unable to participate in microgrid or DER offerings (e.g., consumers who rent their living space, live in buildings that cannot accommodate DER installations, or cannot afford the upfront investments). New policies must serve the desires of both those who can and those who cannot leverage these new technologies. Policy makers must ensure that a new "electricity divide" is not created between the two groups. Furthermore, the regulatory mandate for low-cost, reliable energy should be kept, but an additional incentive to reward innovation for the benefit of consumers should be added—any existing regulatory barriers to innovation should be eliminated, while maintaining the positive aspects of the current system.

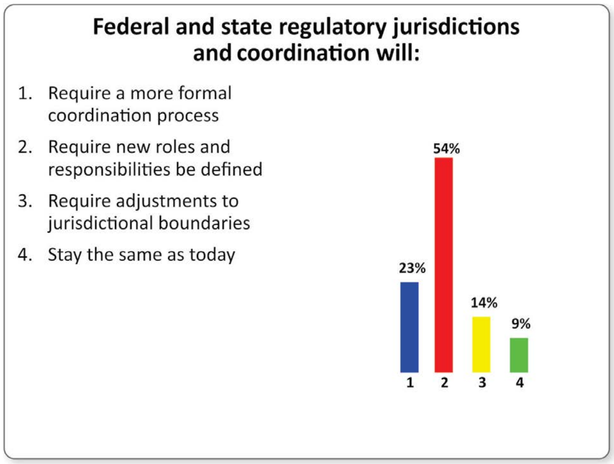

Figure 6. National Summit polling results – regulatory jurisdiction

The increasing interdependencies of transmission and distribution operations will create jurisdictional uncertainty that will need to be refined and clarified, and better coordination between federal and state regulatory entities will be needed. New roles and responsibilities will need to be defined. (See Figure 6, which shows the polling results from National Summit participants, echoing discussions in the regional workshops.)

There will need to be a clear delineation of consumers' and prosumers' obligations to the grid as well as utilities' obligations to customers. Development and integration of non-utility microgrids into the larger grid requires clarification regarding the utility's traditional obligation to serve all consumers within its service territory. Some of the questions that will need to be addressed include the following: What happens if a microgrid owner goes out of business? What happens if a consumer in a multi-customer microgrid does not want service from the microgrid? If the microgrid has reliability issues or needs to be replaced, what are the choices and obligations of the consumers served by that microgrid?

It will be critical to address utilities' obligation to serve islanded customers. If a microgrid owner chooses to operate in isolation from the utility grid (i.e., in island mode), the obligation of the utility with regard to the microgrid customers will need to be outlined.

It will be important to determine how utilities will be allowed to participate in offering DER services. Today, many states are debating how DERs will be positioned within their state. There is a significant desire in many of these states to establish DER assets and services as unregulated, open-market assets and services. However, many utilities have expressed interest in providing DERs and DER-related services in their service territories. Whether utilities will be allowed to participate and, if so, whether it will be as regulated or unregulated participants must be determined. In addition, the appropriate rules for governing utilities' participation must be developed. (See Figure 7, which shows the polling results from National Summit participants, echoing discussions in the regional workshops.)

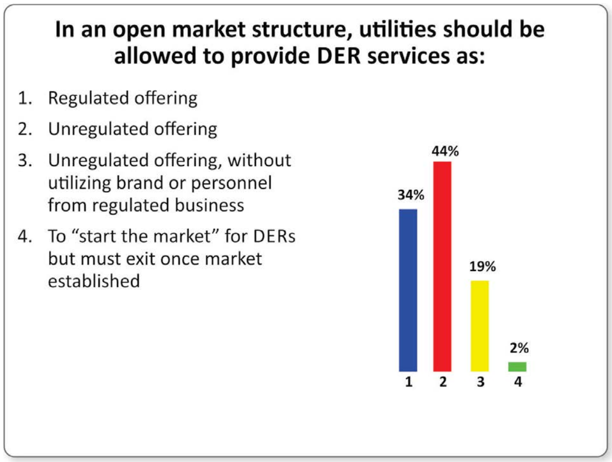

Figure 7. National Summit polling results – utilities providing DER services

There will be new third-party unregulated entities, resulting in the need to develop new roles and responsibilities and to define future regulated and unregulated components. The differences in roles and responsibilities of new and traditional parties will need to be understood and incorporated into utility planning. New roles and responsibilities will also be needed regarding consumer-owned generation and storage, multi-customer/community microgrids, new responsive loads, and ancillary services in the retail market (where relevant), along with other issues that are yet to emerge.

Regulatory certainty and clarity is needed. In this time of significant industry transformation, utilities (grid owners and operators) and their investors are reluctant to invest in the grid infrastructure and systems needed to support the transformation without certainty around cost recovery and a sustainable business model in the future. Clarity regarding this issue is needed on two fronts: (1) The "what"—Will profitability be based on the traditional method of capital deployed and a specified rate of return on equity, or will it be based on delivering value and high performance measured against a set of defined criteria or metrics? (2) The "how"—How will the allowed cost be recovered? Will pricing be based on volumetric-based rates or pricing for products and services, or a combination of both? Utilities and regulators are used to long timelines for recovery of capital investments—generally 30 years. Many of the new assets will have significantly shorter asset lives, and with a reduction in volumetric sales either due to increased energy efficiency or the deployment of DERs, a new approach will be required.

Physics is not driven by economics. Not only will regulators and policy makers have to consider the changes in the types of investments being made, the limitations dictated by the laws of physics and their impact on grid operations will also need to be considered and heeded.

Planning the Transition: Recommendations for a Path Forward

Throughout the regional workshops and the National Summit, participants continually noted the value of participating in frank, open discussions with a cross section of industry stakeholders so that different perspectives could be heard, debated, and understood. Continuing to convene stakeholders from across the entire electricity infrastructure ecosystem will be critical throughout this transformational period. Stakeholders involved must include utilities (investor-owned, municipals, and cooperatives), associations, third-party providers/innovators, regulators (state and federal), policy makers, vendors, consumer advocates, and consultants. A neutral party will be needed to help convene this ecosystem of stakeholders to ensure that the public good is considered and not lost as policies and investments are made during the transition. Failing to consider the public good introduces the risk of leaving some consumers—such as low-income consumers—behind and creating a new "electricity divide." As neutral, unbiased entities, federal agencies can serve to convene and facilitate multi-stakeholder collaboration initiatives. Many key stakeholders, particularly state regulatory personnel and consumer advocates, do not have sufficient resources to participate regularly in multi-stakeholder processes; therefore, to ensure their participation, federal agencies should allocate sufficient funding to assist with these expenses.

With the many interdependencies and increasing complexity of the nation's electric system, it is clear that a holistic and systematic approach is needed for developing solutions to achieve the vision of our future grid. Common themes and issues emerged from the discussions at the "Future of the Grid: Evolving to Meet America's Needs" regional workshops and National Summit. Synthesis and analysis by the OE/GWA team of the input from all participants has resulted in a set of clear and compelling recommendations.

Due to the magnitude of the transformation and the vital role of electricity to America's way of life, a smooth and deliberate transition is imperative. In that regard, to focus industry activities and to enable better collaboration among stakeholders, it is essential for DOE to make implementation of the following recommendations and the identified actions for accomplishing them a priority. In addition, it will be important to leverage—and where necessary realign—DOE activities in support of these ambitious goals.

RECOMMENDATION #1: Establish clear and comprehensive guiding principles, along with a unifying architecture,[7] that can be applied at regional, state, and local levels to guide modernization of the electric grid.

Guiding Principles

These guiding principles will provide direction throughout the transition to meet changing societal and technical needs while maintaining a reliable, resilient, affordable, and secure electric grid. The nation's electric system drives the national economy and serves both societal and individual consumers' needs. Guiding principles will be instrumental in maintaining the balance between these three interests. They will be overarching and non-prescriptive in order to give direction while also allowing for considerations of the specific operating conditions and needs at the consumer, state, and regional levels; the paths to reaching the future grid will not be the same—one size does not fit all.

[7] Architecture: A system architecture is a model of a (complex) system whose purpose is to help think about the overall shape of the system, its attributes, and how the parts interact.

The guiding principles will address issues such as universal services, equitable rates, reliability metrics, resilience, distributed resource integration, data privacy, and cyber/physical security objectives. The principles should be reviewed and reevaluated periodically (every 1–2 years) to reflect technological and societal changes.

Action: The U.S. Department of Energy, through the Office of Electricity Delivery and Energy Reliability, should partner with the private sector to launch a multi-stakeholder initiative to develop national guiding principles for the future electric grid to frame the transition from the current electric system to the vision of the future grid in 2030. This should be completed by the spring of 2015.

Unifying Architecture

With 50 states, the District of Columbia, and individual boards and local governments having jurisdiction over the electric retail market (i.e., the distribution grid), there will be differences in the role of the grid, utility business models, state regulatory models, and utility operating conditions. A unifying architecture and the attendant standards will be needed to ensure the systems and markets can effectively interoperate across these different structures. A unifying architecture that provides the functional specifications but does not dictate the method will be critical to increasing flexibility, decreasing the potential for stranded assets, lowering costs, and allowing for innovation while giving companies a standard foundation from which to develop their products and services.

Action: Utilizing the DOE Energy Policy and Systems Analysis architecture policy effort as a foundation, along with OE's expertise in this area, DOE, in coordination with the National Institute of Standards and Technology and other entities, should establish a multi-stakeholder task force to develop a unifying architecture. This should be completed by the end of 2015.

RECOMMENDATION #2: Create a framework for guiding investments to transition from today's grid to the future grid.

Transition Framework

This transition framework will provide a holistic perspective on how all aspects of the electric system work together, what foundational investments will be needed to achieve the full capabilities of the vision, the linkages between technologies, and the time frames for implementation. The transition framework will map the industry-vetted foundational investments to their capabilities and roles in achieving the vision of the future grid, as well as outline whether the investments will need to be pursued in a particular order. Additionally, the transition framework will highlight interdependencies between investments, be aligned around medium- and long-term goals, outline priorities, and identify technology constraints and time frames for deployment. The transition framework and the associated foundational investments can inform state and regional roadmapping efforts and specific utility investments; however, not all investments will need to be pursued by each region, state, or utility. The transition framework should be reviewed and reevaluated periodically to take into account technological advancements and societal changes.

Action: DOE should partner with the private sector to launch a multi-stakeholder initiative that incorporates the guiding principles and unifying architecture to develop the transition framework. Development of elements of the transition framework, such as a list of foundational investments and linkages between technologies, should begin immediately, and the final framework should be completed by mid-2016.

Valuation Metrics

A set of standardized industry metrics and a common method for measuring them needs to be developed. This will allow stakeholders to consistently value and evaluate the operational performance (e.g., reliability, quality of service, power quality, and carbon reduction) of service providers across the country. States, regions, regulators, boards, and/or utilities would establish the specific target levels. A common approach that is agreed upon and adopted would (1) allow for the determination of a baseline for performance; (2) allow for benchmarking; (3) give regulators, boards, and governments methods to measure performance based on the target levels they specify; and (4) provide utilities well-accepted methods for valuing nontraditional investments in their business cases.

Action: Drawing on the results obtained from American Recovery and Reinvestment Act investments, as well as leveraging work at the national laboratories, DOE should partner with industry to identify key metrics and develop common methodologies for measuring these metrics. As the regulatory bodies governing electricity delivery, the National Association of Regulatory Utility Commissioners and the Federal Energy Regulatory Commission will be key partners in this process. While this will be an iterative process, the list of initial metrics should be established by the end of 2015, and standardized methods for calculating them should be completed by the end of 2016. A time frame should be established by which the metrics could be implemented into reportable U.S. Energy Information Administration data by 2020.

Regional/State Roadmaps

Regional and/or state roadmaps that leverage and are informed by the guiding principles, unifying architecture, and transition framework should be developed based on the region's/state's specific priorities, current capabilities, and citizens' needs. These roadmaps should take into account existing electric system components (e.g., nuclear generation in the Southeast and hydropower in the Northwest). State roadmaps can provide direction and long-term investment strategies, and by utilizing the list of foundational investments in the transition framework, they can guide utility-specific investments. Additionally, state roadmaps can outline a pricing methodology to ensure investments are not stranded. When developing roadmaps, states should consider how an optimized, flexible grid—and the associated investments to achieve it—can help meet the U.S. Environmental Protection Agency's Clean Power Plan Section 111(d) requirements. Utilities will need to create business and technology deployment plans that align with state and regional roadmaps and outline the specific actions/investments necessary for achieving the vision of the future grid.

What Are Roadmaps?

Roadmaps are a strategy and resource planning and management tool that help entities leverage investments, inspire and engage partners, coordinate efforts, and keep operational activity aligned with desired outcomes. Roadmaps provide a framework for helping stakeholders with diverse expertise and purviews coordinate resources in order to achieve both individual and shared goals. They identify challenges, key stakeholders, a path forward, roles for the key stakeholders, and mechanisms for ensuring that progress stays on track.

Each jurisdiction (e.g., region, state, or locality) should have a roadmap that addresses technology, policy/business models, and minimum requirements for grid operations specific to that jurisdiction's priorities for its future grid.

Action: Regions (either geographic or based on market structures) and states should leverage the transition framework, guiding principles, and unifying architecture to develop regional/state roadmaps that define their priorities and path to their specific future grid. DOE should provide technical assistance to facilitate roadmap development, as desired or required.

How National Initiatives Can Inform State and Regional Roadmapping Efforts

States and regions can leverage national initiatives such as the guiding principles, unifying architecture, and list of foundational investments in the transition framework to develop state/ regional roadmaps that identify and prioritize key functional capabilities to guide utility-specific investments. In addition, national initiatives can inform communication flows—across states and from states to federal entities and vice versa—throughout the transition process. DOE can facilitate these communication flows among the various stakeholders involved in the development of the future grid.

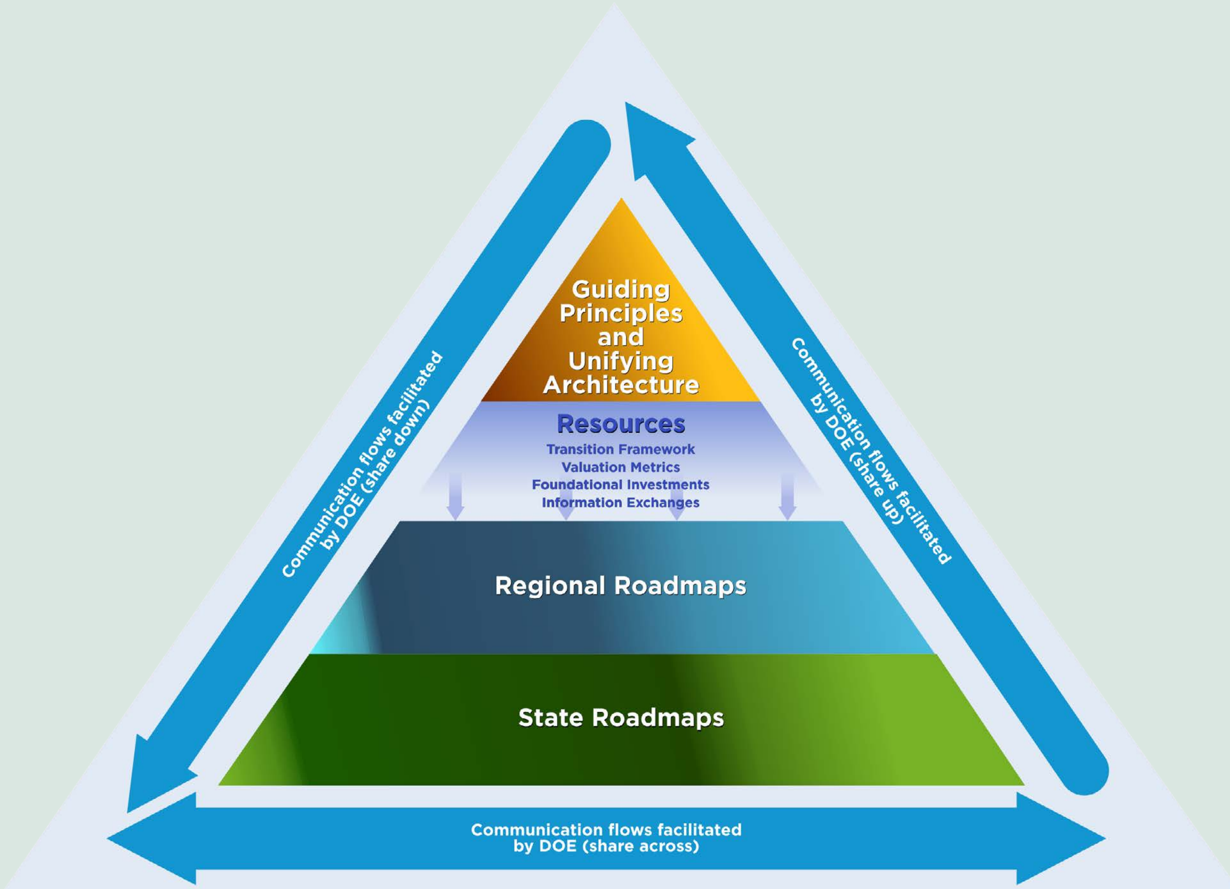

Figure 8. National initiatives can inform state and regional roadmapping efforts

RECOMMENDATION #3: Drive solutions through stakeholder engagement and education.

A process will be needed for educating industry, policy, and regulatory stakeholders throughout the transition. Education will be critical for these stakeholders to stay abreast of the rapidly changing landscape and to understand the nuances of operations and how policies and regulations will affect utility operations. It will be critical for stakeholders to learn from each other and from existing and past efforts.

Addressing Common Challenges

Due to the interdependencies of the open-market components and the regulated components of the future electric system, this transition cannot be left to market forces alone. Transitioning to the future grid will not be an easy process. There will be numerous challenges that will have to be overcome. Some of these will be unique to individual regions, states, and utilities, but there will also be common challenges across all jurisdictions. To enable more optimal, cost-effective solutions, these common issues will need to be shared, discussed, and debated. "Cross-pollination," which involves stakeholders from one jurisdiction hearing the perspective of stakeholders from another jurisdiction, will be instrumental in breaking down stakeholder silos that can unintentionally occur. Convening stakeholders in a collaborative environment for open, frank discussions will be instrumental in helping to develop innovative solutions. Examples of important topics to address include the following:

- Single-/multi-customer microgrid policies, rules, and societal implications, including interconnection rules and obligation to serve.
- Ancillary services at the distribution level.
- Regulated versus unregulated services at the distribution level.
- Rate reform: volumetric versus a fee-based structure, cross subsidies, etc.

Action: DOE should partner with the private sector to convene regional workshops to address common challenges faced by industry, leveraging public-private partnerships when appropriate.

Sharing Lessons Learned

It will be essential for industry to share lessons learned and learn from each other as solutions are developed and technologies are deployed. Collaborative multi-stakeholder exchanges are one avenue for sharing this information. Knowledge and collaboration from these exchanges will provide additional insight as states, regions, and utilities make policy or investment decisions. Participation in collaborative information exchanges could also inform the state/regional roadmap development process. Areas of focus could include innovative approaches and applications of legislation, regulation, and technology.

Action: Using various methods and approaches, federal agencies, in partnership with states and regions, should facilitate collaborative exchanges to leverage lessons learned in order to expedite and lower the cost of modernizing the electric system.

Education

Consumers will need to understand the changes that will take place during the transition to the future grid. They will need to be educated about the value of energy and how to use it wisely. Consumers will need to be informed about their options for energy use in order to understand, accept, and manage the changes in how they will receive and pay for electricity. It will be important that consistent messages are provided from multiple sources to avoid confusion and to garner trust. National-level education will provide the umbrella for empowering an energy-conscious culture. Regulators and utilities will play important roles in consumer education: regulators can help consumers understand why investments are necessary and beneficial, and utilities will need to educate consumers on the specific offerings available to them. As an integral part of this strategy, utilities will need to keep consumers at the forefront as changes are implemented and consumers become more involved. Utilities will need to incorporate marketing and educations efforts to (1) better understand consumer preferences so products and services can be created that meet their needs/desires, and (2) explain to consumers the options available to them and the accompanying benefits and value. It will be imperative to educate consumers in their language, not in technical language. Funding for education will be essential.

Action: DOE should launch a national education campaign that lays the foundation for state and regional grid modernization efforts and builds a greater awareness of the need and value of grid modernization, resilience, security, and other pressing energy issues, ultimately resulting in an energy-conscious culture.

RECOMMENDATION #4: Address technology challenges and limitations through robust research and analysis.

As the grid is modernized and more deployments take place, gaps in technology will surface and the limitations of current technology will be exposed. Robust research and analysis will be critical to developing the future technologies with the required capabilities, providing valuable insight as specific investments are evaluated.

Action: DOE should partner with the Electric Power Research Institute and other relevant research organizations to actively identify and address technology needs and gaps. Coordinating relevant national laboratory research across DOE through a consortium is a good start. However, DOE must strive to have all grid-related research, public and private, in alignment with current and future technology needs through ongoing industry engagement in the identification, prioritization, and execution of grid-related research and development.

Conclusion

The electricity industry, including the electric grid, is facing a considerable transformation—one that will only increase in magnitude and importance in the future. This transformation creates new challenges, but with those challenges come tremendous opportunities for better shaping the electric grid into a more reliable, resilient, and affordable grid that can continue to serve as the foundation for the nation's economy and the enabling platform for meeting society's needs.

The complete range of stakeholders—including utilities, regulators, policy makers, renewable energy providers, consumer advocates, academia, and third-party innovators—helped to develop an industry-driven vision of the future grid during the "Future of the Grid: Evolving to Meet America's Needs" initiative, facilitated by OE and GWA. This vision, which identifies the challenges to be addressed during the transition to the future grid, was refined during the initiative's National Summit. Workshop and National Summit input, along with OE and GWA analysis, was used to develop the actions necessary during the transition.

This vision for the future grid cannot be achieved without planning, collaboration, and discipline. There is a need for high-level guiding principles and a unifying architecture to ensure that all stakeholders are working toward the same goals. Collaboration among the ecosystem of relevant entities will be necessary so that everyone understands each other's points of view and develops a mindset of evaluating changes in terms of their impact on the entire system, not just on specific silos. All electricity industry stakeholders will need to work together to develop a path forward.

It is essential that resources and effort are committed now in order to realize the vision of the future grid of 2030; waiting is not an option. How the electricity industry responds to the evolution of the grid will have profound impacts on grid reliability, transmission and distribution operations, security, resilience, consumer choice, and equity between consumers, as well as—more broadly—the American economy and way of life.

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Appendix A: Regional Workshop and National Summit Participating Organizations

1 Energy Systems
ABB
Accenture
Advanced Energy
Advanced Energy Economy
Alstom Grid
American Electric Power
American Public Power Association
Arizona Public Service
Attorney General of Washington
Austin Energy
Bandera Electric Cooperative
Bonneville Power Administration
Brattle Group
BRIDGE Energy Group
California Independent System Operator
Center for the Commercialization of Electric Technologies
CenterPoint Energy
CGI Group Inc.
Cisco Systems, Inc.
Civergy, Inc.
Clean Line Energy Partners
Colorado State University College of Engineering
Commonwealth Edison Company
Comverge
Consolidated Edison
Consortium for Building Energy Innovation
Consumers Energy
CoServ Electric
CPS Energy
CUB Policy Center
Davies Consulting
DNV GL
Duke Energy
Duke University
Duke University, Nicholas Institute
EDD
Electric Power Research Institute
Electric Reliability Council of Texas
Elster
Energy Central
Energy Future Coalition
EnergyUnited EMC
EnerNex, LLC
Environmental Defense Fund
Ernst & Young LLP
Eugene Water and Electric Board
Exelon
Federal Energy Regulatory Commission
FirstEnergy Service Company
Florida Power & Light Company
GE Digital Energy
General MicroGrids, Inc.
Georgia Transmission Corporation
Great Plains Institute
Great River Energy
Grid Connections, LLC
Hawaii Public Utilities Commission
HP Enterprise Services, LLC
Iberdrola USA
IBM
Illinois Institute of Technology
IncSys
Intel Corporation
Intelligent Energy Solutions, LLC
ISO-New England
ITC Holdings Corp.
Itron
Landis+Gyr
Lockheed Martin
Maryland Energy Administration
Maryland Office of People's Counsel
Massachusetts Department of Public Utilities
Midcontinent Independent System Operator, Inc.
Modern Energy Insights
Modern Grid Solutions
Narrow Gate Energy
National Academy of Sciences
National Association of Regulatory Utility Commissioners
National Association of State Energy Officials
National Energy Technology Laboratory
National Grid

National Renewable Energy Laboratory

National Rural Electric Cooperative Association

Navigant Consulting, Inc.

Navista

New West Technologies

New York Independent System Operator

New York State Public Service Commission

New York State Smart Grid Consortium

New York University School of Law

Newport Consulting

Nexans – The Valley Group

North Carolina Electric Membership Corporation

North Carolina Solar Center

North Carolina State University

North Carolina Utilities Commission

Northeast Public Power Association

Northeast Utilities

Norton White Energy

Office of Consumer Counsel, Connecticut

OGE Energy Corp.

Old Dominion Electric Cooperative

Oncor Electric Delivery Company LLC

Oneida-Madison Electric Cooperative, Inc.

Oregon Department of Energy – State of Oregon

OSIsoft

Pacific Gas and Electric Company

Pacific Northwest National Laboratory

PECO Energy Company

Pedernales Electric Cooperative, Inc.

Pepco Holdings, Inc.

Perfect Power Institute

Philadelphia Industrial Development Corporation

PJM Interconnection, LLC

PNGC Power

Public Policy Consulting

Public Service Commission of Wisconsin

Public Service Enterprise Group

Puget Sound Energy

Quanta Technology

RES Americas

Research Triangle Cleantech Cluster

Robert Bosch, LLC

RockPort Capital Partners

San Diego Gas & Electric

Santee Cooper

Schweitzer Engineering Laboratories

Seattle City Light

Sempra Energy

Siemens

Silver Spring Networks

Simple Energy

Smart Cities Council

Smart Grid Interoperability Panel

SmartSenseCom, Inc.

Snohomish County Public Utility District

Southern Company

Southwest Power Pool

Spirae, LLC

Stantec Consulting Services Inc.

University of Minnesota, Technological Leadership Institute

Tendril

Tennessee Valley Authority

Texas Electric Cooperatives

The Association for Demand Response & Smart Grid

The Glarus Group

To the Point

Tollgrade Communications, Inc.

Tucson Electric Power

TXU Energy

U.S. Department of Commerce

U.S. Department of Energy

U.S. Environmental Protection Agency

U.S. Trade and Development Agency

UniEnergy Technologies

Unitil

University of California, San Diego

University of North Carolina at Charlotte

University of Vermont

University of Washington

Utilities Telecom Council

Verizon

Vermont Electric Cooperative

Vermont Electric Power Company

Vermont Energy Investment Corporation

Walmart

Washington State Department of Commerce – Energy Office

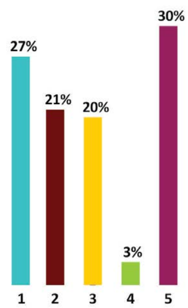
Washington Utilities & Transportation Commission

Western Area Power Administration

Appendix B: National Summit Polling Results

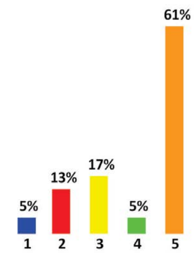
Please indicate the category you fall in:

1. Utility
2. Service Provider
3. Government
4. Regulator
5. Other



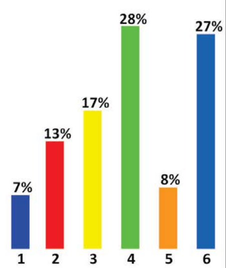
In 2030, your vision for distribution operations is:

1. Performs the same function as today
2. Builds, manages and maintains the physical infrastructure only
3. Becomes the balancing authority for distribution grid
4. Operates a robust retail market exchange
5. Both 3 & 4



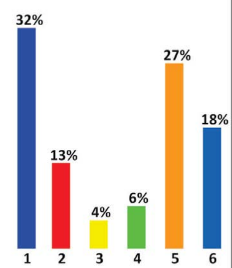
What is the most critical technology challenge that needs to be addressed in the next 15 years?

1. Improving situational awareness down to end device
2. Implementing high bandwidth, low latency, cost effective and interoperable communications systems
3. Leveraging "big data" analytics and integrating into real-time operations
4. Incorporating distributed energy resource management
5. Integrating multi-customer microgrids
6. Achieving cost effective energy storage



What is the most urgent technological challenge today?

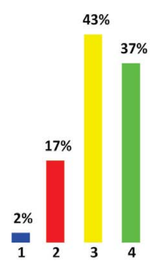
1. Dealing with intermittency of renewable generation
2. Dealing with extreme weather events
3. Incorporating advanced weather modeling into operations
4. Reducing peak demand
5. Dealing with "big data"
6. Meeting environmental mandates



How many years will it take from project start to finish for distribution utilities to install and implement systems and tools to effectively manage significant DERs?

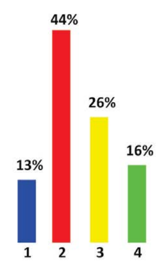
1. 0-2 years
2. 3-5 years
3. 6-8 years
4. More than 8 years

NOTE: DERs defined to include all distributed energy resources including DR and responsive loads



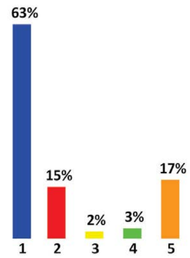
In 2030, your vision is that transmission operations:

1. Operates T grid and only has visibility of D grid at connection points (i.e., today's model)
2. Operates T grid and has visibility of entire D grid down to DERs
3. Has balancing authority for the entire T&D grids, therefore directly control of DERs
4. None of the above



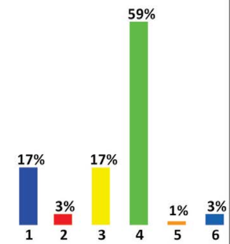
Cost effective energy storage will:

1. Provide the flexibility needed to manage and optimize the grid
2. Mitigate renewable intermittency issues
3. Result in significant stranded assets
4. Eliminate the need for a grid long term
5. All of the above



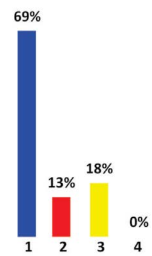
In 2030, your vision for the future electric market structure is:

1. Looks similar to today
2. Optimal market design emerges and is the same across all states
3. Only ISO/RTO markets will have retail market exchanges
4. States will establish new retail market exchanges independent of ISO/RTO or vertically integrated market structure
5. No market structure needed – grid will go away and all generation will be "local"
6. T grid will go away and the D grid will support a robust network of connected microgrids



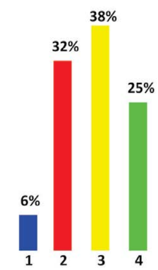
In 2030, you envision multi-customer and community microgrids:

1. Having a positive impact on the grid
2. Having a negative impact the grid
3. Having no significant impact on the grid
4. Eliminating the need for the grid



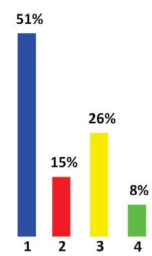
Which of the following statements do you agree with the most:

1. T&D should continue to be compensated based on electricity sales
2. T&D should be compensated based on services provided
3. T&D should be compensated based on electricity sales and services
4. T should continue to be compensated based on electricity sales, but D should move to services model



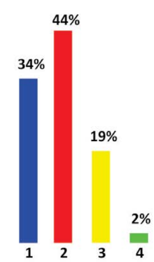
Which of the following entities should coordinate and manage new retail market exchanges:

1. Distribution utilities
2. Transmission/ISO/RTOs
3. New third parties
4. No change from today



In an open market structure, utilities should be allowed to provide DER services as:

1. Regulated offering
2. Unregulated offering
3. Unregulated offering, without utilizing brand or personnel from regulated business
4. To "start the market" for DERs but must exit once market established

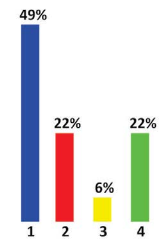


Which is the highest risk scenario in transitioning utility pricing to a products and services model:

1. Debating change but continuing with status quo
2. Transitioning to a services pricing model and eliminating all policy related cross subsidies built into today's rates
3. Transitioning to services pricing model while continuing current policy related cross subsidies

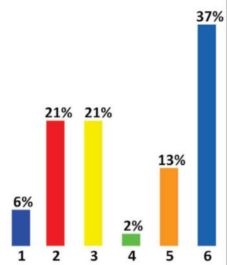
Which is the best approach to transition to pricing models for energy related products and services:

1. Coordinated effort between FERC and State regulators
2. Individual states transition with no regional or federal coordination
3. Only transition to new pricing in deregulated markets
4. Transition as a region based on market structure



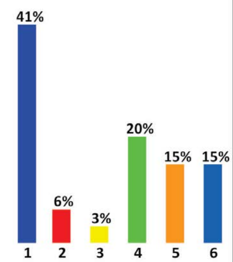
Which do you believe will be the "forcing function" for utility business model change:

1. Financial markets
2. Utility management reacting to future revenue projections
3. Third-party products and services providers
4. Policy makers
5. Regulators
6. Customer's expectation/choices



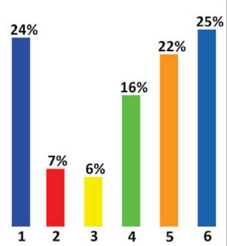
What will be the most challenging element of evolving regulation at the state level:

1. Establishing new pricing structures and addressing societal policy issues (i.e., cross subsidies, obligation to serve)
2. Establishing retail market rules
3. Establishing DER interconnect rules
4. Emerging unregulated market for DER and "behind the meter" products and services
5. Stranded assets created in transition
6. Educating and engaging customers in the change



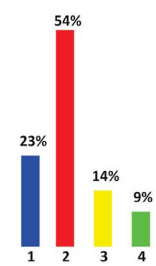
What will be the most challenging element of evolving regulation at the federal level:

1. Dealing with emerging retail market exchanges
2. Planning for DERs
3. Dealing with stranded asset issues
4. Transitioning pricing model/rate structures for transmission services
5. Cybersecurity across the entire grid
6. Grid reliability



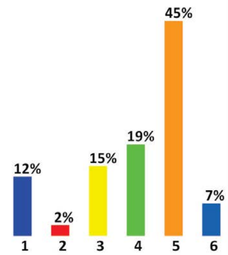
Federal and state regulatory jurisdictions and coordination will:

1. Require a more formal coordination process
2. Require new roles and responsibilities be defined
3. Require adjustments to jurisdictional boundaries
4. Stay the same as today



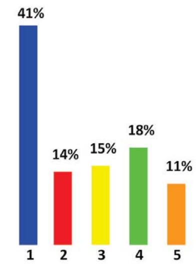
What do you see as the biggest barrier to evolving grid operations?

1. Lack of a clear vision for the future electric system
2. Lack of national policy to achieve the vision
3. Lack of a business model to support the transition
4. Lack of a regulatory model to support the transition
5. All of the above
6. None of the above



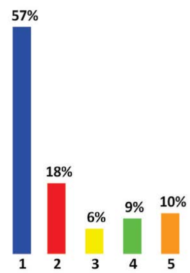
The first step in the transition should be:

1. Aligning on a vision for the future electric system
2. Defining what will be regulated and what will be market driven
3. Defining the new utility business model
4. Developing a coordinated approach to overseeing this transition
5. None of the above



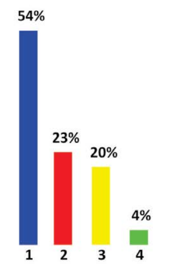
How important is developing a national "architecture" for how all the components of the new electric system will work and exchange information?

1. High priority
2. Medium priority
3. Low priority
4. Already being done
5. Not needed



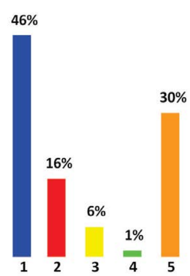
How important is it to develop roadmaps for this transition to help guide the process?

1. High priority
2. Medium priority
3. Low priority
4. Already have in our state/company



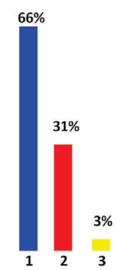
How important will it be to define a roadmap for the entire grid at the federal level?

1. High priority
2. Medium priority
3. Low priority
4. No national roadmap only state level roadmap
5. No national roadmap only regional and state roadmap



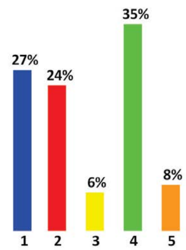
How critical will it be to engage customers in this transition?

1. Top priority – critical
2. Medium priority – important but not urgent
3. Low priority – not important and not urgent



Where does the industry stand in addressing cyber security?

1. Current efforts and collaboration between industry and government are working – no additional action needed
2. Need additional policy and regulation at the federal level
3. Need additional policy and regulation at the state level
4. Need additional focus and leadership by industry
5. Need additional focus by individual companies



What is the biggest risk if we don't get this right?

1. Significant impact to our national economy
2. Significant impact to the cost of electricity
3. Significant impact to the reliability and resiliency of electric service in U.S.
4. Will create a new "electricity divide" in U.S.
5. No big risk – everything will work out over time