Testimony of
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on

The State of Technological Innovation Related to the Electric Grid

Before the
Committee on Energy and Natural Resources
United States Senate

March 17, 2015

Good morning Chair Murkowski and Ranking Member Cantwell, members of the Committee and fellow panelists. My name is Lisa M. Barton, and I am Executive Vice President of Transmission for American Electric Power (AEP). I also serve on the board of directors of Reliability First Corporation, the regional reliability organization for a 13-state region stretching from Wisconsin to Virginia. Thank you for inviting me to testify today.

AEP is one of the largest electric utilities in the United States, delivering electricity to more than 5.3 million customers in 11 states. AEP owns nearly 38,000 megawatts (MW) of generating capacity in the U.S., and owns and operates the nation's largest electricity transmission system, with 40,000 miles of transmission lines. AEP's network includes more 765-kilovolt (kV) extra-high voltage transmission lines than all other U.S. transmission systems combined. AEP's transmission system directly or indirectly serves about 10 percent of the electricity demand in the Eastern Interconnection, and approximately 11 percent of the electricity demand in ERCOT, the transmission system that covers much of Texas. AEP's headquarters are in Columbus, Ohio.

Today's hearing seeks to evaluate the state of technological innovation related to the electric grid. In my testimony, I will describe AEP's experience with a number of advanced grid technologies. I hope to leave you with three key messages today:

- **<u>A robust grid is a critical enabler of generation diversity, new storage and demand-side technologies</u>**. Just as the nation's robust data network serves as a foundation to modern communications and provides an enabling function for various technologies across the communication sector, the nation's high-voltage electric grid serves a similar role with respect to enabling diversity in generation and distributed energy technologies. The electric grid aggregates generation and demand-side technologies and ensures that resources, from whatever source derived, are delivered to customers in a cost-effective, efficient and reliable manner.

- **<u>Maintaining a reliable and resilient grid is critical to economic and national security</u>**. The reliability provided by the integrated electric grid serves as the foundation of our economy; it provides stable electricity service necessary for our economic well-being. As policy makers examine and evaluate the potential for new electricity technologies such as solar, wind, distributed generation, grid-scale battery technologies and micro grids, it is critical to appreciate how the system works to maintain the high level of reliability and affordability that we currently enjoy. Integrated appropriately, advancements in generation, grid and end-use technology will over time serve to strengthen the robustness of the network by providing greater diversity in resources and better responsiveness in the grid itself, supporting reliable delivery of power to all consumers.

- **<u>To maximize the beneficial impact of new technologies, policymakers should avoid picking winners and losers and allow the market to identify the best solutions for a particular circumstance</u>**. Today, we are seeing new technology being applied and implemented all along the value chain from generation, through transmission and distribution, to homes and businesses. Technologies that are targeted to address deficiencies in reliability, improve system efficiencies, reduce the cost to consumers or diversify generation resources should be applied as the specific system needs and circumstances dictate. The choice among competing technologies should be driven by relative performance and cost.

I. The Grid of the Future Will Be More Flexible and Adaptable for the Benefit of Consumers and the U.S. Economy

A key element of any "utility of the future" model will be a modern, efficient grid that not only handles new generation and end-use technologies but also enhances the efficiency of the existing grid. To succeed in the future, our industry not only must continue doing what it does today in terms of enhancing and improving reliability and connectivity, it also must enable the integration of new technologies. As our customers are able to more fully utilize the electric grid as a technology integration network, they will realize its full value.

The electrification of the U.S. started with smaller generators and isolated utilities; over time, these resources were networked together through the increasingly integrated grid that we know today. The integrated grid that has developed over the last century served to increase reliability, resiliency and efficiency. No longer did a neighborhood need to rely on one local source of power - it could rely on larger, more efficient units that were more cost-effective and diversified when integrated together. Diversification in the source, location and type of generation today continues with the integration of wind and solar generation and micro grids.

The transmission system evolved over time to be the aggregator of generation and an efficient distributor of energy to load centers. While originally designed for the movement of conventional power resources to distribution systems, the grid has evolved to integrate variable energy resources such as wind and solar. For example, the AEP 765-kV and 345-kV extra-high voltage transmission lines initially were planned to integrate AEP-owned generation with AEP load. Today, those lines provide 9,300 MW of transfer capacity from western PJM and MISO to eastern PJM, supporting all types of resources, including wind. In the future, the grid will need to evolve further and be more intelligent and responsive, better able to manage two-way flows of power and information. This will support further integration of distributed energy resources – such as rooftop solar and micro grids – as well as larger-scale intermittent generation resources such as wind and solar in a cost-effective and reliable manner.

A smarter grid will be especially important to accommodate the coming changes in how and when customers use electricity, providing consumers with more information and choices with respect to energy consumption. The demands on today's grid have changed from a few decades ago, and the demands in the future will continue to be shaped by consumer consumption patterns, which are in turn shaped by new technologies such as smart appliances, plug-in electric vehicles, and customers managing their electric use with mobile devices. The continued evolution of the grid to incorporate new technologies is essential and will provide for a more flexible, resilient and interactive grid to advance evolving societal needs.

II. Reliable, Affordable Electric Service Depends on a Robust and Resilient Backbone Transmission Grid

New electric technologies such as micro grids, distributed generation, demand response and other localized solutions will complement rather than replace conventional generation and the transmission network that brings that power to homes and businesses every day. Today's system provides a tremendous amount of resiliency whereby customers are no longer exposed to outages associated with the loss of a single transmission line or a generating station; rather the grid ensures reliable power even during times when there are maintenance or storm-related outages of major system components.

AEP strongly supports implementation of technologies that, working together, improve the resiliency, functionality, reliability and operability of the grid. When all is said and done, maintaining an adequate level of generation resources, in combination with a robust grid, is necessary to ensure reliability is maintained.

The importance of maintaining the reliability of service provided by the system as policies change was recently demonstrated by Germany's efforts to promote renewable generation, where implementation had the unintended consequence of forcing conventional generation out of the mix to the detriment of reliability. As a consequence, Germany's Federal Ministry of Economics & Technology issued a New Energy Policy in 2012 recognizing that "Conventional power stations will remain indispensable to our electricity supply in the years ahead. This is because they can do what most renewable energy sources cannot: provide a reliable supply of power precisely when it is needed."[1]

[1] Federal Ministry of Economics and Technology, Germany's New Energy Policy – Claims and Challenges (July 2012), *available at* http://www.diha.al/fileadmin/ahk_albanien/Dokumente/Germanys_New_Energy_Policy.pdf.

III. New Environmental Requirements Will Require Additional Transmission Investments

One of the largest drivers of transmission investments is large scale changes in the location and type of generation resources on the system. As units retire and new resources are added to the system, investments in transmission are needed to ensure that the grid continues to function as the reliable aggregator of generation. It is clear that the implementation of the Environmental Protection Agency's Clean Power Plan will require significant transmission construction to interconnect the new natural gas generation that will be required, to interconnect location-constrained resources such as wind and centralized solar power, and to preserve grid stability given the retirement of coal-fueled units. To maintain the level of reliability and system resiliency we enjoy today, the retired generation cannot simply be replaced with distributed generation alone; transmission investments will be needed.

While constructing this new transmission infrastructure provides an opportunity to expand and update the current grid, this work, like all electric infrastructure development, takes time. It will require significant lead times to obtain approvals, permits, and rights-of-way, and to complete construction. Let me bring to your attention an excellent law review article written by two former Federal Energy Regulatory Commission regulators on the difficulties surrounding transmission development, *Regulatory Federalism and Development of Electric Transmission: A Brewing Storm*.[2] The article proposes a balanced approach to state-federal and state-to-state jurisdictional disagreements that often impede transmission development.

IV. AEP's Experience with Key Grid Technology Innovations

Like any design challenge, aligning the solution with the problem encountered is essential. AEP's service territory covers 11 states, and we own transmission assets in 13 states. The diversity of our service territory has been the mother of invention and many innovative technologies have been utilized by AEP to tailor the solution to the need. Innovations that we have advanced include:

A. BOLD™ - Moving More Electric Power over Greater Distances with Fewer Losses

Breakthrough Overhead Line Design™ (BOLD™) is a new type of transmission line developed by AEP that utilizes a more compact and efficient configuration, featuring a single arch shaped tubular cross arm that supports the circuits. As a result, BOLD™ towers are 33% shorter than the standard transmission pole and utilize less right-of-way than higher voltage facilities that would transport the same amount of power. It offers a high capacity, reliable solution to many of the nation's transmission challenges. BOLD™ can effectively deliver large blocks of power over long distances, connecting

[2] James J. Hoecker & Douglas W. Smith, Regulatory Federalism and Development of Electric Transmission: A Brewing Storm?, 35 Energy L.J. 71 (2014), *available at* http://www.felj.org/sites/default/files/docs/elj351/16-71-Hoecker-Smith_Final%205.13.14.pdf.

remote renewable generation projects to the power grid and load centers while boosting the load capacity of extra-high-voltage lines by 50 percent or more and requiring no more right-of-way than traditional 345-kV lines. This technology can also be used to increase capacity in the same right-of-way when replacing existing older lines with BOLD™ technology.

The BOLD™ design can mitigate the need for additional transmission lines. Furthermore, BOLD™ offers lower magnetic field strengths, reduced energy losses and greater aesthetic appeal. This technology is best applied in areas where there are right-of-way constraints, the need to increase the amount of power being moved or where there is a desire not to introduce higher voltages. AEP is piloting this technology in Indiana with a project that will be in service in 2016.

B. Variable Frequency Transformer

The Variable Frequency Transformer (VFT) is a controllable bi-directional power flow control device used to transmit electricity between two systems similar to a back-to-back high-voltage direct current (HVDC) converter. The VFT is based on the combination of hydro generator and transformer technologies. AEP deployed the first application of the VFT in the United States to address reliability problems in a load pocket near Laredo, Texas. The VFT was utilized by AEP to tie the Mexico and Texas grids together asynchronously in support of the Laredo load pocket. The transmission into the Laredo area, at the time, was no longer capable of supporting the load and the condition was made worse with the shutdown of the generation within the load pocket. The long-term solution is ultimately the completion of a new 345-kV transmission line into the area, but a short-term solution was also required. The VFT technology provides a controlled transmission path between the U.S. and Mexican electrical grids, improving reliability and permitting power exchanges, which was not possible with conventional technologies.

C. Phase Shifting Transformers

The Phase Shifting Transformers (PST) are a special type of transformer that is connected in series with the transmission line to control the flow of power between the sending end and receiving end of a line. Today, AEP employs PSTs to balance the power flows on the transmission system to avoid thermal overloads on transmission lines and more efficiently and effectively utilize the capacity of the grid. This not only improves the reliability of the system, but it also provides the system operator with additional flexibility to manage the maintenance of the system. Use of this technology is applicable in areas where the transmission system is weak and there is a need to change power flows to better balance flows across large geographic areas. Using this technology allows for larger transmission investments to be deferred into the future, giving AEP the flexibility to utilize capital more efficiently in other areas of the transmission system.

D. Drop-in Control Modules

AEP has designed and expanded the use of prefabricated drop-in control modules (DICM) to meet rising customer demand, especially from the oil and gas industry, and to provide grid reliability as coal units retire. A DICM is a factory-built module made to meet AEP specifications that houses all the communication and control technology for the station. It can be placed into service in eight to ten weeks, which is half the time needed to build a traditional control room. Although prefabricated control rooms are not new, AEP designed its units to be more flexible and expandable. Our extensive use of DICMs began in 2011, and we are currently seeking a patent for a DICM expansion concept. They are reliable, save time and have proven to be a cost-efficient solution. Since 2011, AEP Transmission has installed more than 200 DICMs throughout our service territory. Our goal is to install 2,000 over the next 20 years. Use of this technology addresses aging infrastructure, future reliability compliance, physical security and situational awareness.

E. Energy Storage-Battery Technology

In 2006, AEP was the first utility in North America to deploy a megawatt-scale sodium sulfur (NaS) battery at its Chemical Station in Charleston, WV. In 2009, AEP's Electric Transmission Texas installed two 2.4-megawatt NaS batteries in Presidio, Texas, to provide transmission backup in the event of a transmission line outage. Presidio is a small, remote community bordering Mexico along the Rio Grande River – the only load at the end of a single radial transmission line. Previously, when Presidio's line encountered an outage, the town had an immediate blackout and its only alternative electricity could come from Mexico.

Energy storage via battery technology has long been viewed as a game changer for the electricity industry, if it could be implemented cost-effectively. Currently, the electricity infrastructure is built to address peak loads, recognizing significant fluctuations in energy consumption throughout the day and throughout the year. If cost-effective energy storage devices such as batteries became commercially available, they could effectively change the existing planning parameters and applications of our assets in a profound manner. For example, if storage technology can be cost-effectively combined with intermittent renewable generation such as wind and solar, it can mitigate the problem of output variability when renewable generation portfolios are significant. In most circumstances, the cost of energy storage currently exceeds what the market will support. Storage costs need to come down, and that can only happen with increased research and development, and greater market penetration. Deployment of energy storage can also face regulatory barriers, because it offers multiple types of services. For instance, a battery project may be a low-cost alternative to a transmission/distribution upgrade, may have value in energy markets, and may provide ancillary services, but capturing this range of values may not be practical given regulatory treatments.

F. Volt Var Optimization – an Intelligent Energy Efficiency Opportunity

Volt-Var Optimization (VVO) is technology that manages voltage as power moves from a substation to household appliances. VVO reduces demand and energy by 2-3 percent and sometimes more on a reliable basis at the customer's meter, which lowers customer bills. It does not require any changes to a consumer's equipment or behavior. Verifiable benefits are realized immediately upon deployment. This cost-effective technology provides for flexible implementation, because it can be used on a stand-alone basis or as part of a larger smart grid deployment. The technology is not proprietary; several suppliers manufacture the necessary equipment and software.

VVO increases the efficiency of the distribution system, reduces the need for distribution capital investments, and reduces air emissions associated with avoided energy production. It also provides a platform for future grid modernization that will deliver greater visibility and control of distribution system operations and improved reliability with relatively small incremental investment. In order to be successfully deployed, investment in this technology needs to be supported though the state regulatory processes.

G. Solar Pilot by AEP's Indiana Michigan Power Company

On February 4, 2015, the Indiana Utility Regulatory Commission approved the application of AEP's Indiana Michigan Power Company (I&M) to build, own and operate a Clean Energy Solar Pilot Project. The pilot project will consist of four to five separate solar facilities totaling nearly 16 MW, most of which will be on or near existing and future substation properties. Locating them in this way helps to minimize the cost of delivering the energy to the transmission grid. The addition of zero-carbon solar also meets the increasing interest of customers who want to use more renewable energy to meet their needs.

H. AEP Ohio gridSMART® Demonstration Project

This demonstration project tested a number of energy-saving programs. The heart of the gridSMART® Demonstration Project is the smart meter, a digital electric meter equipped with two-way communications technology. With the installation of the smart meter, AEP Ohio was able to develop and offer many innovative customer services and programs. Because smart meters are able to communicate in real-time, the company is better equipped to detect power outage locations, improve reliability, and provide faster response to certain customer service requests such as meter reading and service connections.

One project goal was to develop programs that would help customers manage their electricity use and save money. Some of the programs AEP Ohio tested include SMART Shift, a time-of-day rate plan that helped customers save money by moving electricity use to off-peak times, and SMART Cooling℠, an air-conditioning conservation program that helped reduce peak demand during the summer months. In addition to smart meters, the company was able to test other smart grid technologies, such as:

- Distribution Automation Circuit Reconfiguration (DACR) – A system that allows the automatic re-routing of electricity during service interruption, limiting the scale of outages.

- Volt Var Optimization – Technology that manages voltage as power moves from substations to household appliances.

- Smart Appliances – Clothes washers, dryers, refrigerators and other appliances that can work with smart meters to respond to high energy demand and operate all or parts of the appliance when costs are lower.

V. Conclusion

Whatever the technology future holds for the electricity sector, a robust integrated electric grid will be essential to providing reliable and affordable delivery of electricity to the nation's consumers. Ongoing investments will be needed to reshape the grid in light of changes to the generation mix driven by regulatory requirements and market forces. These enhancements will further the robustness of the grid and enable greater implementation of advanced grid technologies, which should be incorporated wherever they can cost-effectively enhance the flexibility and reliability of the grid.

Thank you for the opportunity to address you on these important issues. I would be happy to respond to any questions.