IEEE Power & Energy Society 2014 Innovative Smart Grid Technologies Conference

Summary of DOE Sessions on the Recovery Act Smart Grid Projects

1. Introduction and Summary

Under the American Recovery and Reinvestment Act of 2009, the U.S. Department of Energy and the electricity industry have jointly invested about $7.9 billion in 99 cost-shared Smart Grid Investment Grant projects, and about $1.6 billion in 32 Smart Grid Demonstration Program projects to modernize the electric grid, strengthen cybersecurity, improve interoperability, and collect an unprecedented level of data on smart grid operations.

On February 19-21, 2014 the Institute for Electrical and Electronic Engineers (IEEE) Power & Energy Society (PES) held its fifth annual **Innovative Smart Grid Technologies Conference** (ISGT) conference. There were more than 500 participants from 41 countries.

The U.S. Department of Energy (DOE) was invited to organize a series of six panel sessions (see Table 1) featuring presentations on the results of **smart grid projects** under the American Recovery and Reinvestment Act of 2009 (Recovery Act). The presentations involved 17 projects from both the Smart Grid Investment Grant (SGIG – 14 projects) and Smart Grid Demonstration Programs (SGDP – 3 projects).

The purpose of this report is to summarize the information presented during the sessions and the key points raised during the group discussions that followed the presentations. Table 1 presents several of the key points from the discussions.

DOE was also invited to organize a panel in the plenary session to explore “New Frontiers of Smart Grid.” The purpose of this panel was to set the stage for the conference by framing what the next decade of smart grid development might look like. The presentations focused on emerging challenges that now limit efforts to create a more modern grid and the new opportunities that are being pursued. There were six presentations:

- **DOE Perspectives**
- **San Diego Gas and Electric Perspectives**
- **Pacific Northwest National Laboratory Perspectives**
- **S&C Electric Perspectives**
- **ConEd Perspectives**
- **National Rural Electric Cooperative Association Perspectives**

Table 1. Summary of Key Points	
Session 1. Integration of Distributed Energy Resources (DER)	• Technical challenges remain but these can be addressed as utilities gain further experience and greater numbers of DER systems are installed.
Session 2. Systems Integration for Grid Operations and Business Processes	• Many utilities are installing smart grid technologies and systems for the first time and are finding data management, communication and control system architectures, and cybersecurity issues to be commonplace.
Session 3. Voltage and Volt-Ampere Reactive (VAR) Optimization	• Conservation voltage reduction (CVR) is a proven strategy that has been made more certain in its results with the deployment of smart grid technologies and has been applied successfully to reduce overall fuel consumption and environmental emissions, lower customer bills, reduce power consumption during peak periods, and defer investments in new distribution equipment.
Session 4. Customer-Facing Programs	• While still in their early stages, many utilities are using in-home displays and web portals successfully in getting customers more involved in management of their electricity consumption and costs.
Session 5. Designing and Deploying Smart Grid Projects	• Communications infrastructure – be it wireless, power line carrier, fiber optic, or architectures that consist of all three – is a foundation for smart grid development and building sufficient capacity to enable near- and long-term applications is an important consideration in designing smart grid projects.
Session 6. Electric Reliability and Infrastructure Resiliency	• Employing better methodologies for valuing the financial benefits of reliability improvements is one of the keys for making the business case for new investments in fault location, isolation, and service restoration technologies and systems.

2. Integration of Distributed Energy Resources

The session on integration of distributed energy resources (DER) focused on requirements and control techniques associated with the effective integration of DER into grid operations. DERs include: renewable energy (solar and wind), energy storage devices, electric vehicles (EVs), demand response, and other types of distributed generation. The session shared approaches and lessons-learned from efforts to integrate DERs into distribution systems, as well as advanced operational and market models and tools for planning and managing these technologies and systems. The session also addressed the needs for management of bi-directional power flows, voltages and reactive power levels, and achieving effective balance of local generation and demand through means such as microgrids.

During the DER session presentations were given by **Pepco Holdings, Inc.** (PHI), **Center for the Commercialization of Electric Technologies** (CCET), and **Battelle, Pacific Northwest Division**. The three presentations covered:

- PHI – **“ Preparing for Greater Penetration of Distributed Energy Resources through Advances in the Grid, Energy Resource Control and Modeling,”**
- CCET – **“ Challenges and Solutions for Wind Integration in ERCOT,”** and
- Battelle – **“Integration of Distributed Energy Resources Using Transactive Control.”**

The key points raised during the discussions that followed these presentations include:

- Technical challenges remain but they can be overcome with additional experience and larger numbers of DER installations. Challenges includes tools for managing large volume of data, voltage regulation for two-way power flows from photovoltaic (PV) installations, designing appropriate communication and control architectures, and addressing uncertainties associated with policies and regulations.
- Futures plans for DER integration will involve expanded deployment of smart grid systems for a variety of applications including synchrophasor technologies for integration of wind generation in wholesale power markets, voltage and volt-ampere reactive (VAR) controls for managing ever increasing numbers of rooftop PV arrays, and advanced metering infrastructure for time-based rates for demand response and pricing strategies for electric vehicles.
- Advanced concepts such as transactive energy and microgrids are being demonstrated across the country (and around the world) hold promise for enabling greater levels of DER adoption. Application of energy storage systems can play a key role.

3. Systems Integration for Grid Operations and Business Processes

The session on systems integration focused on sharing insights and best practices associated with efforts by utilities to apply and integrate systems used for operations and business processes, especially as smart grid technologies advance opportunities to better utilize and manage digital information. These systems include meter data management systems (MDMS), outage management systems (OMS), customer information management systems (CIS), distribution management systems (DMS), and geographic management systems (GIS), as well as others. The discussion covered topics to help utilities make better investment decisions given the myriad of options for systems integration and the potential to improve business practices.

During the systems integration session, presentations were given by the **National Rural Electric Cooperative Association** (NRECA) and **Kansas City Power and Light** (KCPL). The two presentations covered:

- NRECA – **“ Evolution of Grid Analytics,”** and
- KCPL – **“Enabling SmartGrid Functions through End-to-End Systems Interoperability.”**

The key points raised during the discussions that followed these presentations include:

- Many utilities are installing smart grid technologies and systems for the first time and are finding many "transition" issues with integrating new with existing equipment. Data management, communication and control system architectures, and cybersecurity stand out among the integration challenges that must be addressed.
- There is an ongoing need for industry standards for interoperability and for wide dissemination of best practices based on project experiences so lessons learned can be replicated and common pitfalls can be avoided.
- The costs, time, and level-of-effort to accomplish systems integrations effectively is frequently underestimated and could be as high at 20% or more of a project's total cost so there is incentive to learn from experiences and reduce system integration costs to 10% or less.

4. Voltage and Volt-Ampere Reactive (VAR) Optimization

The session on Volt/VAR optimization focused on the various technologies and strategies for optimizing and controlling voltage/VAR levels within distribution circuits. To date, utilities are applying a variety of technologies and control schemes (e.g., distributed and centralized controls) to reduce line losses and improve energy efficiency through the application of conservation voltage reduction (CVR) techniques. The session examined lessons learned and best practices associated with these approaches and explored strategies for assessing the business case for CVR.

During the Volt/VAR optimization session presentations were given by Applied Energy Group (AEG), **Indianapolis Power and Light** (IP&L), **Avista**, and **American Electric Power** (AEP). The four presentations covered:

- AEG – **" Conservation Voltage Reduction (CVR) as an Energy Efficiency Resource,"**
- IP&L – **" Peak Demand Management through CVR,"**
- Avista – **" CVR – Quantifying Savings,"** and
- AEP – **"A mer i can El ect ri c Pow er 's Exp eri en ce w i th Volt/VA R Op ti mi zati on . "**

The key points raised during the discussions that followed these presentations include:

- CVR is a proven strategy that has been made more certain in its results with the deployment of automated capacitor banks, load tap changers, and voltage controllers. It has been applied successfully to reduce overall fuel consumption and environmental emissions, lower customer bills, reduce power consumption during peak periods, defer investments in new distribution equipment, and improve asset utilization.

- Some utilities are beginning to evaluate CVR as an energy efficiency resource and include it in their integrated resource plans. Technical challenges remain in pursuing this approach including the development of consistent and widely adopted definitions of costs and benefits and validated measurement and evaluation methodologies for evaluating CVR impacts. Institutional challenges include the need for incentive and funding mechanisms to capture the full energy savings potential of CVR and enable a more certain path for cost recovery.
- State policies are an important driver for CVR. For example, states with energy efficiency resource standards are providing more favorable policies and regulations for encouraging CVR then are those states without such standards.

5. Customer-Facing Programs

The session on customer-facing programs focused on strategies and operational experiences with implementing these programs including information and education, time-based rates, energy efficiency, and load management from projects that include deployment of automated metering infrastructure (AMI) and customer systems such as in-home displays (IHDs), programmable control thermostats (PCTs), and web portals.

During the customer-facing programs session presentations were given by **Central Maine Power** (CMP) **Reliant Energy**, and **Entergy New Orleans** (ENO). The three presentations covered:

- CMP – **" Transforming the Customer Experience with AMI,"**
- Reliant – "Engaging Customers Through Smart Meter Data,"[1] and
- ENO – **" Smart Grid Technologies Focusing on Low Income Customers."**

The key points raised during the discussions that followed these presentations include:

- Getting customers to use more detailed information on their energy consumption and costs from smart meters is becoming an important goal for utilities; many utilities are hopeful to engage their customers in more of a partnership by raising awareness of electricity use patterns, and providing incentives for demand management through efforts such as time-based rate and pre-pay programs.
- The deployment of IHDs and web portals are two of the strategies being implemented by utilities and these efforts have had mixed success. For example, customers do not typically access their web portal very often without prodding by their utilities. In fact, utilities that have pro-active programs to push data to their customers are finding greater levels of customer interest and engagement. Another effective strategy is to

[1] No slides were used in this presentation.

offer customer training programs to acquaint them with how IHDs and web portals can be used to the customer's advantage.

- Many utilities consider their customer engagement efforts to be in the early stages of market development and expect technologies for providing information to customers to evolve substantially over the next several years. Changes are expected to piggy-back on IT and social media developments found in other sectors, and use newly developed smart-grid communications infrastructure to involve customers in other areas including outage management and voltage controls.

6. Designing and Deploying Smart Grid Projects

The session on designing and deploying smart grid projects focused on sharing insights and lessons learned regarding how smart grid projects are organized and deployed and providing recommendations on best approaches for designing and implementing them. Smart grid projects involve numerous skills and capabilities that often require the involvement of personnel across utility organizational structures and experts external to the organization. In addition, they require marshaling capabilities that might be new to a utility, such as in the areas of communications infrastructure, data management and integrated systems, business process design, customer participation, and cybersecurity. This session explored how these long-term, multi-disciplinary projects were implemented and what could have been done differently with hindsight.

During the smart grid project design session presentations were given by **Electric Power Board** of Chattanooga (EPB), **Independent System Operator – New England** (ISO-NE), **PJM Interconnection**, and **PHI**. The four presentations covered:

- EPB – **" How Ch att an ooga's Self-Healing Grid is Delivering 60% Reliability Improvements,"**
- ISO-NE – **" Architectural Design of the Next Generation Synchrophasor Applications,"**
- PJM – **"The Deployment of the PJM Synchrophasor Project and Lessons Learned,"** and
- PHI – **" PHI's Smar t Gr id Pr ogr am, Man age men t A p pr oach, and Lesso n s Lear n ed ."**

The key points raised during the discussions that followed these presentations include:

- Communications infrastructure – be it wireless, power line carrier, fiber optic, or architectures that consist of all three – is a foundation for smart grid development and building sufficient capacity to enable near- and long-term applications is an important consideration in designing smart grid projects, particularly those that involve large-scale deployments of technologies and systems.

- Comprehensive smart grid projects – those that encompass transmission, distribution, and end-use – are complex undertakings that often require utilities to work across organizational units and involve elevation of IT and cybersecurity functions in new ways. Business practices for standard activities such as billing or outage management sometimes have to be redesigned which causes disruptions that can ripple through a utility. A focus on training and use of cross-functional teams can effectively address these issues.
- Deployment of synchrophasor technologies creates unique challenges of their own including needs for managing large volumes of data, deciphering data quality issues, making the data available to grid operators in forms they can use for improving management of the grid, and accomplishing application development and training programs so that synchrophasor investments can realize their full potential.

7. Electric Reliability and Infrastructure Resiliency

The session on reliability and resiliency focused on methods used to enhance the reliability and resiliency of distribution grids, including lessons learned and insights gained through the deployment of various technologies, such as those associated with fault location, isolation and system restoration (e.g., automated feeder switching and the application of smart meters), the monitoring of equipment health, islanding (microgrids), and systems used for communications, control and information management. The discussion keyed on better understanding of associated costs and benefits of various technologies so that utilities and their regulators can optimize investment strategies to reach reliability and resiliency goals.

During the reliability and resiliency session presentation were given by **CMP**, **EPB**, **PECO**, and **PHI**. The four presentations covered:

- CMP – **" Putting a Value on Reliability,"**
- EPB – **" How Ch att an ooga's Sel f -Healing Grid is Delivering 60% Reliability Improvements,"**
- PECO – **" PECO Delivers a Reliable and Resilient Smart Grid,"** and
- PHI – **" Realizing the Reliability Benefits of Distribution Automation Projects: Early Impacts and Lessons Learned."**

The key points raised during the discussions that followed these presentations include:

- Smart grid strategies to improve reliability such as automated feeder switching, equipment health monitoring, and advanced outage management systems work well and have demonstrated capabilities for achieving fewer and shorter outages. Employing better methodologies for valuing the financial benefits of these improvements is one of the keys for making the business case for new investments in fault location, isolation, and service restoration technologies and systems. There is need to update the data and tools developed by DOE and Lawrence Berkeley National Laboratory for estimating outage costs and value of service.

- Longer-term outages from major weather events appear to becoming more commonplace and there are needs for utilities to document more comprehensively storm impacts and restoration improvements from smart grid systems. Metrics for grid resiliency are needed that are comparable to IEEE's reliability indices, and there is value in compiling and publishing statistics on these metrics to improve electric system planning and operations models and processes.
- Workforce training is needed for both engineers and maintenance personnel to address design, deployment, and repair issues for smart grid systems such as automated feeder switches and other sensors and controllers. New capabilities are needed that combine expertise in both electric and communications systems.

8. Where to Find More Information

To learn more about national efforts to modernize the electric grid, visit the DOE Office of Electricity Delivery and Energy Reliability's website and www.smartgrid.gov. DOE has published several reports that contain findings on topics similar to those addressed in the presentations; web links to these reports are listed in Table 2.

Table 2. Web Links to Related DOE Information and Reports	
SGIG and SGDP progress and results	i. Deployment Status ii. Progress Report II, October 2013 iii. Progress Report I, July 2012 iv. SGIG Case Studies
Customer service advancements	v. Lessons Learned: Customer Engagement, Updated January, 2014 vi. Quantifying the Impacts of Time-based Rates, Enabling Technologies, and Other Treatments in Consumer Behavior Studies: Protocols and Guidelines, July 2013 vii. Voices of Experience, Insights into Smart Grid Customer Engagement, July 2013 viii. Analysis of Enrollment Patterns In Time-Based Rate Programs, July, 2013 ix. Demand Reduction from the Application of AMI, Pricing Programs, and Customer Based Systems – Initial Results, December, 2012
Smart meter operational improvements	x. O&M Savings from AMI – Initial Results, December, 2012

Distribution automation	**xi.** **xii.**	**Reliability Improvements from Application of Distribution Automation Technologies – Initial Results, December, 2012** **Application of Automated Controls for Voltage and Reactive**
Synchrophasor technologies	**xiii.**	**Synchrophasor Technologies and their Deployment in Recovery Act Smart Grid Programs, August 2013**
Cybersecurity	**xiv.** **xv.**	**2012 DOE Smart Grid Cybersecurity Information Exchange, December 2012** **Electricity Subsector Cybersecurity Capability Maturity Model, May 2012**,