

INTERNATIONAL COLLABORATION OF SMART GRID DEMONSTRATION PROJECTS INTEGRATING DISTRIBUTED ENERGY RESOURCES

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ABSTRACT

The Electric Power Research Institute (EPRI) Smart Grid Demonstration Initiative is a multi-year international collaborative demonstrating the integration of Distributed Energy Resources (DER) including include demand response, storage, distributed generation, and renewable generation in large scale demonstration projects. The initiatives goals are to advance widespread, efficient, and cost-effective deployment of utility and customer-side technologies in the distribution system and to enhance overall power system operations. Large Scale host-site projects apply EPRI's IntelliGrid methodology to define requirements for technologies, communication, information, and control infrastructures that support integration of DER. Operations experience, integration issues, benefits analysis, and lessons learned will reveal the full range of standards and interoperability requirements needed to support the industry. Gaps revealed will identify critical areas of future smart grid research.

In the past three years, EPRI and collaborating electric utilities have made significant progress in developing a foundation of tools and references while performing research to support the advancement of integration of Distributed Energy Resources (DER) in large scale demonstrations. Extracting knowledge from not only the individual projects, but also across multiple projects where similar research is being performed, is underway. Public updates related to this initiative are available at www.smartgrid.epri.com.

INTRODUCTION

Achieving significant carbon emissions reductions in the U.S. electricity sector will involve contributions from a portfolio of integrated solutions from efficiency to a broad range of Distributed Energy Resources (DER) including renewable generation, demand response, energy storage, and distributed generation. The widespread, efficient and cost-effective deployment of these technologies poses significant challenges beyond the development and enhancement of the technologies themselves including requiring end-to-end system integration in the distribution system as well as overall power system operations. Beyond the smart grid systems development and testing, customer engagement methods and technology play as a component of emissions reductions and grid efficiency.

To address these challenges, EPRI initiated a smart grid demonstration project in 2008 with several goals in mind including defining the role and business case of DER, requirements to integrate DER with system operations, and evaluate and advance standards development to facilitate widespread integration of DER. The main objective of the demonstrations is to identify approaches for interoperability and integration that can be used on a system-wide scale to help standardize the use of DER as part of overall system operations and control. The project applies EPRI's IntelliGrid® methodology to define requirements for the technologies themselves as well as the communication, information, and control infrastructures that support integration of the technologies.



Figure 1: EPRI Smart Grid Demonstration Initiative – Integrating Distributed Energy Resources

The goals and objectives of this initiative are being achieved by a collaborative group of electric utilities around the world taking advantage of the large number of smart grid projects occurring and pooling together designs, experiences, case studies and benefits analysis in a coordinated fashion to accelerate lessons learned and gap identification to advance the industry. The electric utility industry is in a unique position compared to other competitive industries where they can work cooperatively together since, in large part, they do not compete directly with one another. EPRI's collaborative research model has been successful in advancing research and development in the electric power industry since 1973 and is now being applied in the same fashion for large scale demonstration projects where the industry can all benefit from industry consensus and shared knowledge on integration techniques

leveraging communication standards that helps achieve interoperability.

Interoperability, or the ability of systems to easily inter-operate, is critical to in order to reach the level of penetration necessary for distributed resources to have the expected impact for mitigating carbon emissions. Industry consensus on the use of common standards will foster a competitive environment that unleashes innovation where the winners will be best-in-class, least cost solutions. The utilities in this initiative are applying all existing standards and identifies additional standards necessary in order to achieve the interoperability required at all levels of the system.

Unfortunately, interoperability cannot realistically be achieved by a single entity and requires collaboration from numerous organizations including utilities, regulatory bodies, standards bodies, vendors and more. The approach of structured regional utility demonstrations designed to promote and evaluate integration of distributed resources at all levels of power system operations will further smart grid

interoperability.

This demonstration initiative is taking advantage of investments in infrastructure being made by the 20 collaborating utilities combined with knowledge shared from similar smart grid activities that to create a robust research platform. Eleven concurrent large scale demonstration projects are underway that were designed to integrate both utility-side and customer-side DER technologies that can be rolled up to integrate into a “virtual power plant.”

SMART GRID DEMONSTRATION HOST-SITES

All members of the initiative are “Collaborators” and some are also “Host-Site Collaborators.” Collaborators are interested in achieving the initiative’s goals and funding research that will help achieve those goals. Utilities that want to become host-sites must deploy challenging large-scale projects that are used as research platforms where information and lessons learned are shared. The demonstration host-site projects must meet six criteria.

Primary Integrated Technologies & Applications	Smart Grid Demonstration Members																		
	Host Site Collaborators											Collaborators							
	AEP	Con Ed	Duke	EDF	ESB	Exelon	FE	KCP&L	PNM	SCE	Southern	Ameren	CHG&E	Entergy	SPP	SRP	TVA	WPS	
Distributed Energy Resources	Demand Response Technologies																		
	Electric Vehicles																		
	Thermal Energy Storage																		
	Electric Storage <= 100 kWh (Utility Local Storage, Customer Storage,...)																		
	Electric Storage > 100 kWh (Typically at substations or near renewables.)																		
	Solar Photovoltaic																		
	Wind Generation																		
	Conservation Voltage Reduction (volt/var management and related)																		
	Distributed Generation (Microturbine, Fuel Cell, Diesel Generator, Biogas,...)																		
	Customer Domain (SEP, BACnet, HomePlug, WiFi, etc.)																		
Communications and Standards	Transmission & Distribution (IEC 61850, 60870, DNP3, IEEE 1547)																		
	Operations Domain (IEC 61968/61970, MultiSpeak, OpenADR,...)																		
	Cyber Security (Authentication, Certificates, Encryption, Intrusion Detection,...)																		
	AMI or AMR																		
	RF Mesh or Tower																		
	Public or Private Internet																		
	Cellular Based (1xRTT, GPRS, EVDO, CDMA, 3G, LTE, 4G,...)																		
	WiMAX (IEEE 802.16) Communications																		
	Programs	Price Based (RTP, DA, CPP, PTR, TOU, Block,...)																	
		Incentive Based (DR, DLC, Ancillary Services, Interruptible, Bidding,...)																	
Ops & Planning	Integration with System Operations (RT Visibility of DER, DMS Integration)																		
	Integration with System Planning (Visibility of DER in planning,...)																		
	Modeling and/or Simulation Tools																		



Figure 2: Smart Grid Demonstration Members & Host-Site Attributes

Note: At the time this paper was authored (January 2011), CenterPoint and Hydro-Québec have also joined the initiative (not shown in Figure 2) and several other utilities are pending members.

1. Application of critical integration technologies and standards. The project applies existing and emerging technologies and standards for distributed resource integration (e.g., common object models, communications

interfaces, etc.). There is a strong emphasis on avoiding proprietary communications and integration techniques.

2. Integration of multiple distributed resource types. The project integrates multiple resource types (e.g., demand

response, energy storage, distributed generation, and renewable generation) at system and/or customer levels.

3. Incorporation of dynamic rates or other approaches for connecting retail customers with wholesale conditions. The project applies dynamic rates or event notification as a means for customer or resource participation. It must include some mechanism to manage resources based on market and/or reliability information to effectively link supply and demand. These retail connections take on a variety of forms and methods to include the customer and consumer technology via both information and automation.

4. Integration into system planning and operations. The project has full integration or critical steps to achieving full integration of distributed resources into system operations, planning and forecasting including using modeling and simulation tools. Simulation tools are allowing pre-deployment lessons that enable critical understanding of the operations and interactions of technologies. Where necessary, modifications can be designed prior to investment and deployment of technologies.

5. Compatibility with initiative goals and approach. The project is compatible with EPRI's underlying initiative approach and goals to enable high penetration of DER and commit to sharing information, lessons learned and gaps with the members of the initiative and the electric power industry.

6. Utilizing additional funding sources (e.g., internal, government state and/or federal, other research organizations, academia, etc.). The project utilizes additional sources of external funding applied for or already secured to ensure a well funded project such that research goals can be achieved.

TWO YEAR SUMMARY OF RESULTS

In the past two years, EPRI and collaborating electric utilities have made significant progress in developing a foundation of tools and references while performing research to support the advancement of integration of distributed energy resources in large scale demonstrations (http://my.epri.com/portal/server.pt?Product_id=000000000001021497).

Extracting knowledge from not only the individual projects, but also across multiple projects where similar research is being performed, is underway.

Project Overview - Work Performed Since 2008

Task 1: Development of Analytic Methods and Tools

Task 2: Integration Technologies and Systems Development

Task 3: Host-Site Demonstration Selection and Research

Task 4: Technology and Knowledge Transfer

An early part of the project included a heavy emphasis on Tasks 1 and 2 to provide a foundation of resources to be utilized not only by the host-site projects, but also as long-term resources for smart grid projects being deployed now or in the future. The timing of the U.S. Department of Energy (DOE) Smart Grid Stimulus projects enabled EPRI to coordinate several research activities with them such as the joint development of a "Methodological Approach for Estimating the Benefits and Costs of Smart Grid Demonstration Projects", EPRI Report 1020342 http://my.epri.com/portal/server.pt?Abstract_id=000000000001020342 published in January 2010.

The demonstration part of the project (Task 3) employs the analytical and technical framework in Task 1 coordinated with the new development activities in Task 2. Since mid 2008, the team has been identifying the large-scale host-site projects and as those projects are progressing, EPRI has been able to perform research and provide early results to the collaboration. As of January 2011, EPRI has selected eleven host-site projects and has a solid picture of project activities enabling the collaborative to prioritize ongoing and engage all members of the initiative more fully whether they are a host site or not.

The experience gained from a wide variety of technologies and systems supplies data to models and methods to address barriers and lessons learned, and are combined in Task 4, Technology and Knowledge Transfer. This is accomplished in the form of newsletters, webcasts, reports and face-to-face meetings. One of the key mechanisms's for Technology and Knowledge Transfer is The Smart Grid Resource Center is the EPRI web-site where public information regarding EPRI Smart Grid research is posted not just from the Smart Grid Demonstration, but also information from other EPRI smart grid programs (www.smartgrid.epri.com). For the most recent up-to-date information on the initiative, a newsletter is published approximately five times per year and available on the home page of the web-site. This newsletter provides updates on each host-site, strategic smart grid topics as well as updates on relevant industry news and events.

Another important aspect of the web-site is the use case repository. EPRI is coordinating with electric utilities and stakeholders around the world to house and populate a growing smart grid use case repository. As new smart grid applications are being designed and implemented, the process of determining the systems functional requirements is commonly accomplished in a use case process. EPRI uses the IntelliGrid Methodology to develop use cases and the repository (www.smartgrid.epri.com/Repository/Repository.aspx) currently has over 160 use cases. With generous contributions of real use cases, electric utilities and

stakeholders can leverage use cases developed by others to help design and evaluate the requirements of their systems. This is a great example where collaboration and sharing of information will help to achieve the goals of this initiative as all the use cases are publicly available at no charge and new contributions are continuously added.

2011-2014 ACTIVITIES

With eleven well defined large-scale demonstration host-site projects, it is important to proactively work across the projects to advance learning from similar activities from project to project. To facilitate this effort, the members reviewed the criteria and attributes of each host-site along with their internal strategic smart grid needs to identify the top priority research topics to collaborate on in 2011. A formalized process determined the top 4 research priorities for collaboration across projects and member activities in 2011. Continued research in all host-sites will continue, but additional emphasis will be placed on the top four strategic topics in 2011. The top strategic topics for 2011 selected by the members in 2011 are:

- Conservation Voltage Reduction (CVR) and Volt/VAR Optimization (VVO)
- Distribution Management System (DMS) Integration and Visualization
- Energy Storage Monetization
- Consumer Behavior and Engagement

Members identified research goals to report out at during the next three Smart Grid Demonstration Advisory Meetings in March, June and October. And at the October meeting, this strategic topic selection process will be repeated in 2011, 2012 and 2013 to enable research to be focused on the top priorities of the members of the initiative.

Now that the project is in 2011 and many of the host-site projects are past the planning stage and in the deployment stage, we can begin a stronger emphasis on extracting lessons learned from the projects. One of the challenges in this initiative is that there is so many activities occurring, it is difficult to distill the methodologies, analytical tools and research results into an easy-to-find reference. As an example, this initiative has published over 60 reports for its members which can be overwhelming. To address this issue, a "Smart Grid Reference Guide to Integration of Distributed Energy Resources" is under development. The first edition will be published in 2011 with updates in 2012, 2013, and 2014 to capture and summarize all the information in the project in a consolidated resource.

SUMMARY

The collaborative model is a distinct aspect of EPRI research, but applying this approach to multiple large-scale

demonstration projects is relatively new. Utility companies have embraced the approach and as a result, in 2010 EPRI extended the smart grid demonstration initiative through 2014 and is accepting new members through 2011.

Because electric utilities, in large part, do not compete directly with each other, common problems can effectively be addressed across a large number of projects with minimal intellectual property risk. While no single project can realistically test every technical scenario related to integrating DER, having multiple demonstration projects with common goals enables more research scenarios to be explored to advance DER integration interoperability. With EPRI providing research leadership across host-sites, a consistent and scientific approach helps to ensure results are extendable to all utility members, even for utility members who are not host-sites. The result is additional value from the sharing of research plans, lessons learned and gaps.