ELECTRIC POWER
RESEARCH INSTITUTE

EPRI Smart Grid Demonstration Update

An EPRI Progress Report | **April 2012**

ABOUT THE NEWSLETTER

The EPRI Smart Grid Demonstration Initiative is a seven-year collaborative research effort focused on design, implementation, and assessment of field demonstrations to address prevalent challenges with **integrating distributed energy resources** in grid and market operations to create a "Virtual Power Plant." This newsletter provides periodic updates on the project, relevant industry news, and events.

PROJECT UPDATE

March 2012 Smart Grid Demonstration Advisory Meeting Overview

Things—and attendees—were looking up at the March 6-8, 2012 smart grid advisory meeting hosted by CenterPoint Energy in Houston, Texas. The CenterPoint project team continued the tradition of leading a great tour as part of the meeting program, sharing results on the smart grid equipment and systems they have installed to date, as well as lessons gleaned through their deployment process, such as their "Top 10 Keys to Success."

Photos on the next page offer a glimpse of CenterPoint's impressive **smart grid exhibition**, which includes a light and sound show depicting how the smart grid operates during an outage caused by a Texas-scale thunder storm. The exhibition is an interactive experience, displaying actual smart grid equipment, as well as a table-top-scale representation of a residential neighborhood. Room-scale and table-top scale displays feature mock distribution lines that glow with different colored lights to demonstrate how the smart grid can enhance outage prevention and restoration services.

On the right, Ed Kamiab of Southern California Edison and the CenterPoint tour guide review the table-top model which is housed in a room-sized exhibit showing how a smart grid works.

Below is a view of the table-top model that shows distribution-system function during an outage.

Presentations at the meeting also focused on results of smart grid projects. **Case studies** were detailed by utility presenters, covering energy storage for photovoltaic-system smoothing, the outcome of simulations of charging and discharge strategies for community energy storage, smart meter monitoring for capacitor bank dispatch, methods for testing energy storage systems, remote dispatch of demand response and distributed energy resources, and more. Highlights of several of these sessions are in the Smart Grid Demonstration Project Updates that follow.

EPRI presentations addressed smart grid strategic issues. Jared Green talked about **distribution management system** issues**,** including preliminary results of a survey of members regarding their plans to implement a DMS. (Note that an EPRI DMS Interest Group has been formed, led by Bob Uluski. Contact is ruluski@epri.com. Smart grid members are encouraged to participate in this no-fee group.)

Glen Chason reported on assessments of **cyber security for field equipment**, including distributed energy resources and devices that have remote access. Glen is asking for information from utility operations personnel on their experience with cyber security so that he can determine how measures can be put into place that will be practical for field application. Glen Chason can be reached at gchason@epri.com for members wanting more information or to participate in this project.

A training session on **cost/benefit analysis methods** was also presented as an optional part of the meeting. EPRI's Jeff Roark served as instructor on how various types of cost/benefit analyses are performed by different types of industries, leading into a review of how utilities are conducting analyses specifically for smart grid projects. This training was video taped and members will be notified when the cost/benefit DVD is available for their use.

Cost/benefit analysis was also a topic in the main meeting sessions, as EPRI Technical Executive Bernie Neenan solicited utility input on a project to determine smart grid benefits—and help identify a common language and common method for tracing technology effects and monetizing them. Smart Grid Demonstration Initiative members interested in doing an early application of EPRI's cost/benefit analysis should see the reports *Methodological Approach for Estimating the Benefits and Costs of Smart Grid Demonstration Projects* (product # 1020342) and *Guidebook for Cost/Benefit Analysis of Smart Grid Demonstration Projects* (product # 1021423). Contact Bernie Neenan at bneenan@epri.com.

Roundtable sessions also spurred discussion of results as well as topics about which utilities are seeking more information and experience. A small sample includes: What experiences are members having with DMS vendors? How are companies coordinating between IT and distribution personnel for cyber security? Has anyone had experience developing communications systems with public entities for rural areas? What evaluation methods are acceptable by regulators for volt/VAR projects?

The most useful means of technology transfer and documenting smart grid demonstration results was another roundtable subject. Matt Wakefield, Smart Grid Senior Program Manager at EPRI, asked for input on the concept of EPRI producing concise reports along with face-to-face visits to utilities to present smart grid research findings. The presentations would be delivered to two separate groups on site: executives and technical personnel. Senior Project Manager Gale Horst noted that EPRI is experimenting with eBook/iBook type electronic formats for smart grid material, and hopes to a have a sample for review at a smart grid advisory meeting later this year.

In terms of the smart grid, this meeting was “not my first rodeo” for meeting participants, but many literally went to their first rodeo when the advisors continued lively, informal exchange while rooting for steer wrestlers and ropers at the Houston Rodeo on the evening of March 7.

The next Smart Grid Advisory Meeting is June 12 – 14, 2012 and will be hosted by Southern California Edison at a location famous for people riding the waves, not bulls: Newport Beach, California. The program will be conducted in the same format as previous advisory gatherings, including an optional training on IEC 61850, the standard for communication networks and systems in substations.

Smart Grid Demonstration Host-Site Updates

This issue features news from host utilities AEP, Duke Energy, Ergon Energy, ESB Networks, Exelon/PECO, Hydro-Quebec, Kansas City Power & Light, and Southern Company.

American Electric Power (AEP) Smart Grid Demonstration Update

AEP is preparing a case study to document what the utility has learned from a simulation of community energy storage (CES) charging and discharging strategies. Three load leveling strategies were simulated: peak shaving, load following, and schedule-based reductions. Each strategy was found to have pros and cons, which are summarized in the chart below

The **peak shaving strategy** uses a known (enforced) peak trigger value. In an ideal implementation this will provide a known, and therefore predictable, limitation of the peak day load. This limits losses from the use of the inverter and extends the life of the battery when compared with the other two strategies.

On the con side, the battery may not have enough energy to operate through the peak, thus challenging one of the listed “pros” of having a known peak limitation. The risk is that required kWh will exceed the stored kWh of the battery and the CES fleet will not have a sufficient stored charge to shave the peak. To manage this risk would require review and revision as the demand on the transformer as it changes over time.

	Pros	Cons
Peak Shaving	• Fixed kW peak • Operation directly targets peak demand periods	• Risk that required kWh will exceed the stored kWh • Requires periodic review of control settings
Load Following	• Operation directly targets peak demand periods • Reduced risk that the required kWh exceeds stored kWh	• Peak demand limit is variable • Dependent upon load shape characteristics • Requires periodic review of control settings
Schedule Based	• Control settings require minimal periodic updates • No additional monitoring • Central control not required	• No preset demand limit • Battery fully discharged each day to ensure reduction of the peak • Long shallow discharge profile required to confidently reduce peak

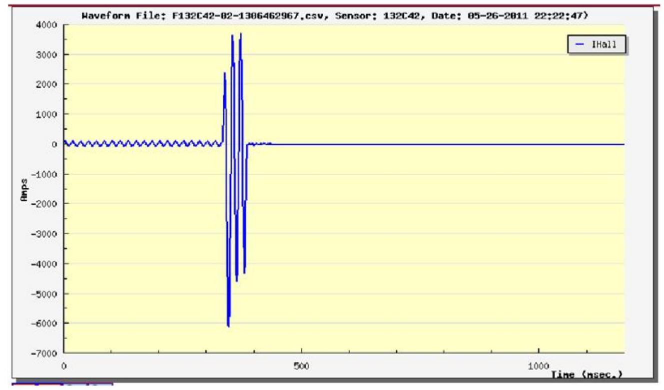
The **load following strategy**, second row of the chart, seeks to reduce the peak whenever needed during peak demand periods. The load following algorithm reduces the risk of running out of energy storage and results in more likelihood of having enough power to operate through the peak demand period since it dynamically adjusts the peak threshold. However, unlike the peak shaving strategy, the trigger point and the maximum demand on the transformer is a variable amount. This method is dependent upon load shape characteristics and it can be difficult to provide good settings that combine time with the load shape. Although there is still the need for periodic review of the settings/algorithm, reviews can be less frequent.

The third dispatch algorithm examined was a **schedule-based strategy**. This has the advantage of being a simpler implementation since no feedback is needed from the circuit, and triggering does not require a central dispatch function and monitoring. Each CES unit is dispatched autonomously according to the programmed day and time. However, this strategy will discharge on a need-it-or-not basis irrespective of the load on a given day and time. There is no limit specified on the load/demand and the battery cycles each day, which will shorten the life of the battery. This is also a loss of efficiency and will tend to leave less battery capacity for utilization as a reliability resource. The schedule-based strategy is generally set up with a shallow discharge rate to extend the period of time for discharge and to ensure that the discharge time includes the peak.

In upcoming weeks, additional simulations will be run to learn how the system responds when several new technologies are deployed concurrently, including the CES units.

Duke Smart Grid Demonstration Update

Duke is beginning to incorporate Tollgrade line sensors and data from its own communication nodes into its outage management system (OMS). The line sensor has the ability to provide real-time fault detection and location, as well as continuous load and power quality monitoring. An example of a waveform before, during, and after a fault is shown in the graph to the right. The line sensor, along with a management system, provides fault, event, operations and asset management analytics.



Duke's communications node, which the utility uses for all of its smart grid devices, also reports loss of power to the OMS. The picture to the right shows an installation of a communications node. Since the management system knows the GPS circuit location of all 70,000 of these nodes, the OMS can quickly locate segments of grid with power outages.

With fault location data from the sensors and the outage event message from the communication nodes feeding into the OMS, Duke is beginning to transform the way its operations department responds to outages. The days of waiting for the phone to ring with a customer notifying Duke of an outage—or even an outage indication from the breaker-open status alarm on the system operator's SCADA screen—is fading into the past. Today, Duke knows instantly when an outage occurs and the approximate location of the fault.

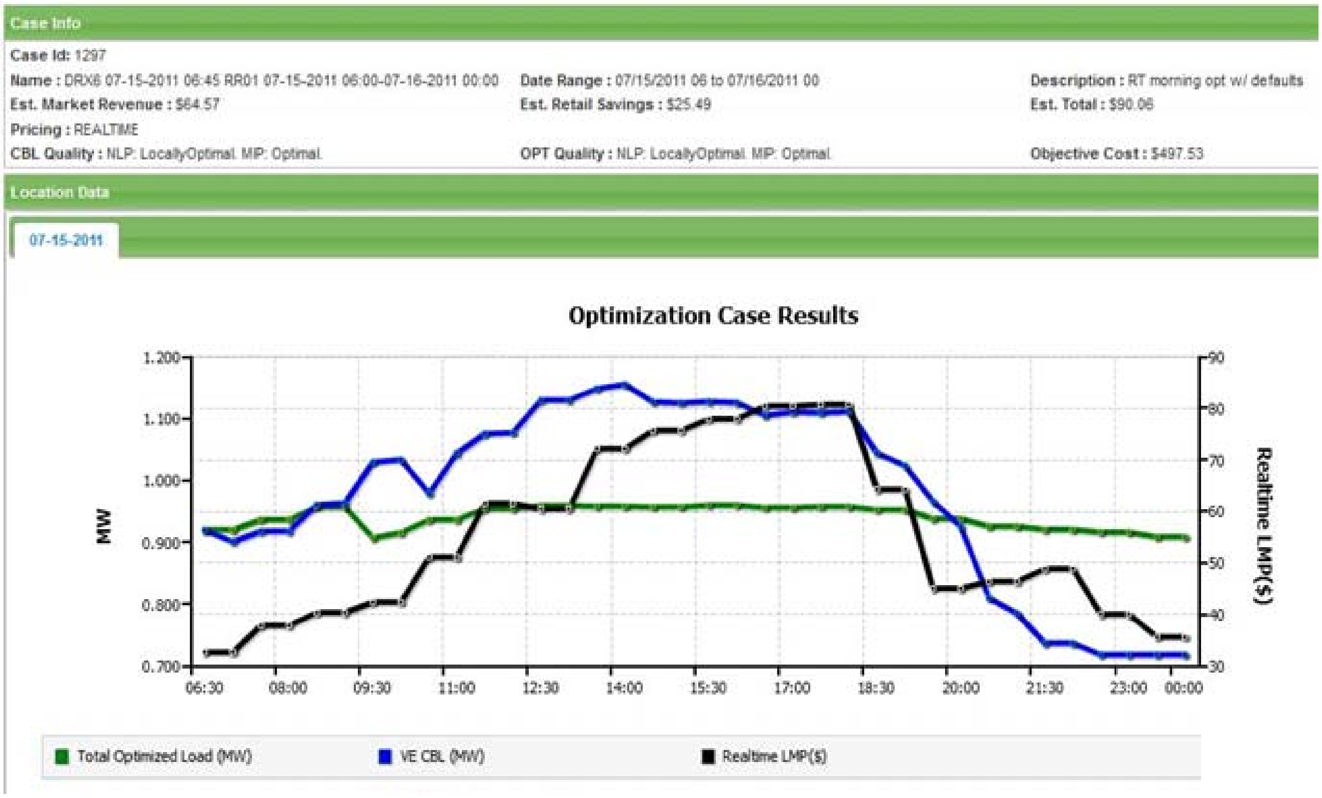
Exelon/PECO Smart Grid Demonstration Update

PECO (an Exelon Company) is a participant in a U.S. Department of Energy Smart Grid Project undertaken to manage and optimize building loads at Drexel University. A key goal is to create a "Smart-Campus" microgrid demonstration that is capable of providing lower electricity costs and lower peak demand. The project technology includes an intelligent network to manage energy use by balancing building operational needs with grid operations and costs. The sophisticated infrastructure created through this project prepares Drexel University for the smart grid shift, and is intended to serve as a model for replication in other markets

Tasks completed include planning and topological models, a dynamic load model and simulation, and a resource model. The system is integrated with Drexel's building automation system, which is used to manage six buildings on the campus. The set of buildings participate in PJM's Real-Time Energy Market. Cumulative demand response (DR) achieved between June 1, 2010 and December 31, 2011 is 89.13 MWh for an estimated ten percent savings for the managed buildings. (See figure below for an example of a one-day savings opportunity.)

In addition to demand response and building management, the intelligent network was designed to be able to integrate renewable energy sources with building systems, both managed by the same control system. This could include renewables such as solar generation and battery storage.

Through this full spectrum solution, Drexel University will be able to take advantage of energy savings, monetize their energy assets, and position themselves for the smart grid.



Displayed above is an optimized case from Viridity's **VPower**tm, an energy monitoring system used at Drexel University, showing the opportunity for demand response supply savings on a particular day, as well as revenue potential if recommended actions to the building and energy assets are taken.

To learn more about the PECO Drexel project, members of the EPRI Smart Grid Demonstration Initiative can access a recording of the Exelon March 12, 2012 "deep-dive" webcast via www.epri.com on the Smart Grid Demonstration Program Cockpit.

Kansas City Power and Light Smart Grid Demonstration Update

KCP&L is deploying customer-facing smart grid technologies as part of their demonstration, including in-home displays and programmable communicating thermostats. This is being done in the Green Impact Zone of Kansas City, Missouri, which is a 150-block area of the city that suffers from severe abandonment and economic decline. KCP&L is also targeting an area called the Blue Zone, a section that is more representative of demographics in Kansas City.

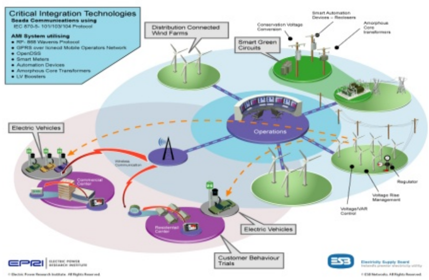
Customers are often hard to reach and engage, especially in the Green Zone, where they are sometimes suspicious of utilities. To better understand customers and their expectations, KCP&L has used a number of grassroots outreach channels and market research methods, such as door knockers, community-sponsored events, focus groups and telephone surveys.

Here's what KCP&L found using these approaches in 2011:

- Customers expect a 23% average savings on their energy bill with new tools.
- Saving money on their bills is the #1 issue in both the Blue and Green Zones, while control over energy usage is the #2 issue in the Green Zone and the environment is #2 for customers in the Blue Zone.
- Customer enrollment does not equal customer engagement; some customers did not understand what the in-home display tool was used for when they received it.
- Two out of three customers are renters; such a transient population may need additional engagement and may not be eligible for all smart grid products.
- After hearing about smart grid product descriptions, only 51% of the customers said they would be interested in receiving one.

Currently KCP&L is working with Navigant and EPRI to finalize a synchronized market research and evaluation plan.

ESB Network Smart Grid Demonstration Update



ESB Networks has explored the potential of the advanced reactive power control capabilities of modern wind turbines to actively control terminal voltages at the point of common coupling. These turbines have a reactive power capability decoupled from real power generation.

A section of distribution network that connects two wind farms and which is free of load customers was used to demonstrate this technology. The project was carried out on an iterative basis, with actual demonstration data being analysed in the Energy Research Centre at University College Dublin in conjunction with EPRI. The data was combined with simulation studies to inform next stage set points and operational parameters. Throughout the year the wind farm operators have put into effect five different modes of operation as outlined in the table below.

Stage	Dates	Knockawarriga Windfarm	Tournafulla 2 Windfarm	Trien Substation OLTC
0	7 Jan 2011 – 7 Feb 2011	PF 0.95 importing	PF 0.95 importing	Fixed tap
1	7 Feb – 3 March 2011	PF 0.95 importing	PF 0.95 importing	Auto tap
2	12 April – 13 May 2011	PF 0.95 importing	Constant-V 42.2 kV, 4% droop	Auto tap
3	17 May – 24 June 2011	Constant-V 41.7 kV, 1% droop	PF 0.95 importing	Auto tap
4	30 June – 9 Jan 2012	Constant-V 41.7kV, 2% droop	Constant-V 41.7kV, 2% droop	Auto tap
5	9 Jan - ongoing	Constant-V 41.7kV, 2% droop	Constant-V 41.7kV, 2% droop	Fixed tap

PF = power factor   kV = kilovolt   OLTC = on-load tap changer   V = volt

Among the conclusions of the study is that the constant voltage mode of operation:

- Can deliver a constant voltage through variation of VAR (volt ampere reactive) output, independent of megawatt (MW) generation.
- Can increase network hosting capacity.
- Can reduce network losses.
- Can reduce VAR absorption by embedded generators.
- Can reduce operational challenges posed by renewable generation.
- Cannot do all the above simultaneously to the full extent, so tradeoffs are required.

ESB also found a number of factors that affect controller function:

- Network parameters and set points have a significant influence on the operation of the controller.
- The use of the voltage operation mode may not be part of the SCADA configuration and therefore re-configuration may be required.
- Different controllers are designed to offer different reactive control capabilities, and beyond that, the tuning of the controller may need increased oversight at the commissioning stage if general implementation of this control functionality is to be relied upon.

The publication of the full case study for this element of ESB Networks Smart Grid Project, which is part of their Integration of Renewables work stream, is imminent.

Ergon Smart Grid Demonstration Update

A recent addition to the EPRI Smart Grid Demonstration Initiative, Ergon Energy hosted EPRI program managers Brian D. Green and Jared Green, along Stephen Ward, EPRI ‘s country manager, on March 19 - 22, 2012 in Australia.

The EPRI team traveled to the city of Townsville in Queensland, Australia, the first site for the Ergon demonstration, which Ergon has dubbed Energy Sense Communities (ESC). The EPRI contingent also visited Brisbane and Rockhampton to meet with different members of the Ergon Energy team, briefing them on the resources available through EPRI’s smart grid collaborative, and learning of upcoming Ergon smart grid activities.

Ergon is testing technology and customer solutions to determine their energy impact and cost effectiveness. Specific projects coming up include a test of conservation voltage reduction (CVR), integration of residential photovoltaic systems, and residential advanced metering infrastructure (AMI). Three main components of the program are Smart Network, Smart Business and Smart Residential. Watch for the next newsletter when we hope to have the Ergon host-site graphic depicting all the elements of their smart grid effort. The company is preparing an electronic version that will allow viewers to click and zoom in for details on each part of their smart grid demonstration.

Hydro-Québec Smart Grid Demonstration Update

Volt-VAR Control (VVC) and Distribution Automation (DA) projects are being conducted by Hydro-Quebec that are providing the utility with reasons to be excited about the benefits of the smart grid. Both efforts are on track to meet or exceed expectations. The VVC project is expected to reduce total energy consumption in Quebec by approximately 2% or 2 TWh by 2015.

The distribution automation project is on track to exceed the goal of reducing the average interruption time for customers by at least 15 minutes by 2015. In addition, in the same time frame, Hydro-Quebec anticipates that distributed automation will halve the number of customers who have an average interruption time of greater than 4 hours.

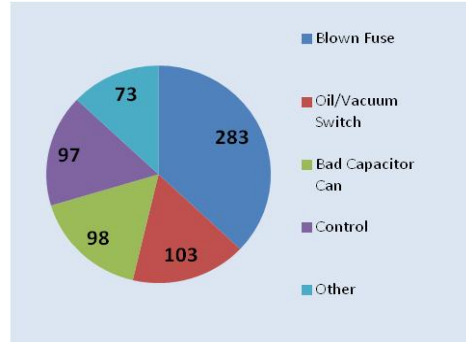
The primary objective of the Volt-VAR Control project is to provide dynamic voltage control to ensure a high level of reliability while operating the system at a lower voltage to achieve greater efficiency. Reducing the voltage along the distribution feeder at a lower acceptable voltage range, known as conservation voltage reduction (CVR), reduces the electric power demand. This achieves savings not only on the utility side of the meter, but also on the customer side. The amount saved by end use equipment is quantified as CVR factor, which is the percent change in load resulting from a 1% change in voltage. VVC tests have concluded that Hydro-Quebec can expect an energy reduction of 0.4% for a 1% voltage reduction on a typical feeder. This CVR factor of 0.4 is an average; CVR factors range can between 0.97 and 0.06, depending on load classes and seasons of the year, as shown in the table below.

Type	Summer CVR Factor	Winter CVR Factor
Residential. all electric	0.67	0.06
Residential, not all electric	0.67	0.12
Commercial	0.97	0.80
Small industrial	0.10	0.10
OVERALL	0.67	0.20

Hydro-Quebec plans to deploy VVC on 149 substations (37% of the total number of substations) by 2015 to achieve the desired energy reduction.

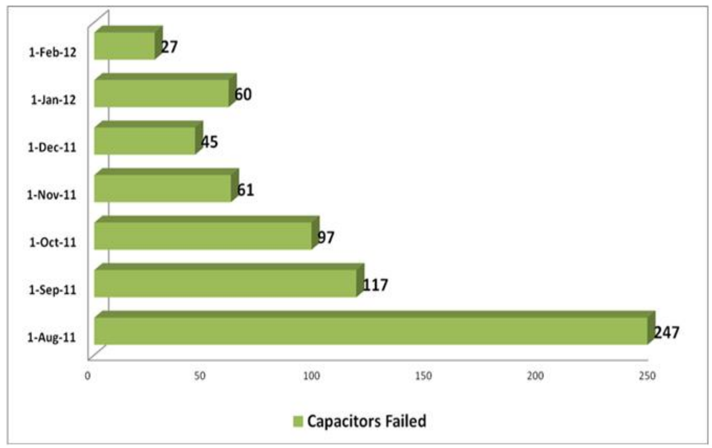
The Hydro-Quebec Distribution Automation project could meet its goals two years earlier than anticipated. The project involves adding 3,600 automated switches, 3,000 of which have been installed thus far. To select the best location to install each switch, a CYMDIST-RAM software evaluation was conducted on the feeders. This assessment helped to determine an associated $/hour value of interruptions avoided. These values were assigned to each automation zone to prioritize the order in which the automated switches would be installed. So far, Hydro-Quebec estimates that 23 minutes have been shaved off the average interruption time for Quebec customers. In addition, the number of customers with an average interruption of greater than 4 hours has been cut in half since the project began in 2005. If these results hold true, Hydro-Quebec will have exceeded its reliability goals two years earlier than expected.

Southern Company Smart Grid Demonstration Update



Southern Company's AMI capacitor bank monitoring effort, described in the February issue of this newsletter, has yielded considerable data on grid conditions and the health of capacitors. Over the past several months, 6400 recently installed monitors have revealed the status of a number of components, uncovering problems that Southern Company has categorized according to type:

- Blown fuses – improper fuse size or bad capacitors
- Oil and vacuum switches – incorrect closing and opening or damaged switches
- Bad capacitors – capacitors with an internal failure
- Control – controller failure or malfunction
- Other – Switch barrels welded shut, bad control cables, or loose electrical connections



The graph on the upper right shows the breakdown of each type of issue, covering a period of 6-7 months.

The chart at bottom right displays the number of problems per month over the same time period, all labeled as "capacitors failed."

A key benefit of monitoring the health of the each capacitor bank is that Southern Company can quickly detect and resolve VAR imbalances. With a large deployment of both fixed and switched capacitor banks, Southern Company has to address not only load imbalances on their substations but also VAR imbalances. A VAR imbalance causes voltage variations between the three phases that can negatively impact system reliability and efficiency—as well as degrade power transformers.

Per Dexter Lewis, a Southern Company Research Engineer, "Previously, when technicians physically inspected the capacitors once a year, we might find blown fuses, and we could compute VAR flow. But these annual inspections are costly, and if something happens after the inspection, we don't know about it for another year."

E-Energy Smart Grid Trial Releases Interim Results

The booklet Smart Energy made in Germany - Interim results of the E-Energy pilot projects towards the Internet of Energy is now available. The 42-page document reviews the status of six pilot programs being conducted in different regions of Germany by syndicates of organizations. The projects are in the trial phase and will be conducted through 2012.

The research priority of the German program is integrating renewable energy with the help of newly developed information and communication systems. Germany currently derives 17% of its energy from renewables, and has set a target to reach 35% by 2020 and 80% by 2050.

The pilots are engaging in a number of projects likely to be of interest to Smart Grid Demonstration Initiative members:

- Grid management.
- Automated demand response.
- Tests of rates including time-variable rates, consumption-based rates, day-ahead real time pricing, and event rates.
- Use of thermal storage.
- Customer response to information systems such as in-home displays and iPad apps.
- Marketing and dispatch of wind energy and other renewable sources

.
Details on experimental design are not provided in this publication, but contacts of research leaders are listed for follow-up. The website www.e-energy.de/en also includes contacts.

Deliverables Published Since Last Newsletter

Product ID	Name	Published
1024592	Strategic Intelligence Update – Smart Grid Conferences and Events	28-Mar12
1024501	Kansas City Power &Light Company Smart Grid Host Site 2011 Progress Report	28-Feb-12
1024865	The Effect on Electricity Consumption of the Commonwealth Edison Customer Application Program: Phase 2 Supplemental Information	09-Feb-12

KEY EPRI SMART GRID DATES

Smart Grid Demonstration Advisory Meeting – June 12-14, 2012

When/Where: Hosted by Southern California Edison (SCE) in Westminster, California (near Huntington Beach, where the Power Delivery & Utilization [PDU] Advisory Meeting was held earlier this year). Lodging will be at the Hyatt Regency in Newport Beach.

Agenda: The June meeting will feature a tour of SCE smart grid projects and will also cover case studies from the demonstration presented by members. An optional training program on IEC 61850 will be presented the first morning of the event.

Photo courtesy of TripAdvisor

Schedule of Upcoming EPRI Smart Grid Demonstration Advisory Meetings

2012	March 6-8	**Meeting hosted by CenterPoint Energy, in Houston, Texas (See story front page)**
	June 12–14	Meeting hosted by **Southern California Edison**, in Westminster and Newport Beach, California
	October 16-18	Meeting hosted by **Sacramento Municipal Utility District**, in Sacramento, California
2013	March	Meeting host TBD
	June/July	Meeting hosted by **ComEd** in Chicago (Tentative)
	October	Meeting hosted by **Hydro-Quebec** in Montreal, Canada (Tentative)
2014	3 Meetings	Meeting hosts TBD

All Smart Grid Demonstration Members (not just host-sites) are invited to host future meetings. Members interested in hosting should contact Matt Wakefield (mwakefield@epri.com) or Gale Horst (ghorst@epri.com).

2012 Smart Grid Demonstration Host-Site "Deep Dive" Webcasts

Throughout 2012, host site utilities will provide an update on their projects.

2012 Smart Grid Demonstration Host-Site Webcast Schedule (3rd Thursday of the month at 11am (Eastern) for 1 ½ to 3 hours)

- February 2, Hydro-Québec **(COMPLETE)**
- February 23, ESB Networks **(COMPLETE)**
- March 15, Exelon **(COMPLETE)**
- May 17, Electricité de France
- June 21, American Electric Power
- July 19, PNM Resources
- August 16, Southern California Edison
- September 27, Southern Company
- October 25, Duke Energy
- November 15, Consolidated Edison
- December 20, Kansas City Power & Light

ELECTRIC POWER RESEARCH INSTITUTE

A continuous thank you to the 23 member utilities of EPRI's Smart Grid Demonstration Initiative

American Electric Power | Ameren | Central Hudson Gas & Electric | CenterPoint Energy | Consolidated Edison | Duke Energy Electricité de France | Entergy | Ergon | ESB Networks | Exelon (ComEd & PECO) | HECO | Hydro-Québec | FirstEnergy | KCP&L | PNM Resources | Sacramento Municipal Utility District | Southern California Edison | Southern Company | Southwest Power Pool | Salt River Project| Tennessee Valley Authority | Wisconsin Public Service Corporation

---

Together...Shaping the Future of Electricity®

EPRI | 942 CORRIDOR PARK BLVD. | KNOXVILLE, TN 37932 | WWW.EPRI.COM