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SMART GRIDS/SMART METERS

By: Kevin McCarthy, Principal Analyst
Lee R. Hansen, Legislative Analyst II

SUMMARY

This report describes smart gird technologies, including smart meters, that allow for (1) two-way communication of electric consumption and related data between an electric company and its customers and (2) the computerized automation of the electrical grid. The report describes the potential benefits of these technologies, which include quicker service restoration after outages, reduced peak electric demand, and better integration of renewable energy systems with the grid. It also discusses issues raised by these technologies, particularly with regard to smart meters, including their cost and privacy and safety concerns. The report describes smart grid initiatives in Connecticut, California, Illinois, and Maine and a variety of utility smart grid programs. In Connecticut, the Public Utilities Regulatory Authority (PURA, formerly the Department of Public Utility Control) decided not to approve a comprehensive deployment of smart meters in 2011.

The information regarding smart grid technology is drawn from the U.S. Department of Energy's (DOE) smart grid information website, www.smartgrid.gov. Much of the information about state initiatives is taken from an analysis published by DOE's Energy Information Administration (EIA) in November 2011, available at http://www.eia.gov/analysis/studies/electricity/pdf/smartggrid.pdf

Sandra Norman-Eady, Director
Phone (860) 240-8400
FAX (860) 240-8881
http://www.cga.ct.gov/olr

Connecticut General Assembly
Office of Legislative Research

Room 5300
Legislative Office Building
Hartford, CT 06106-1591
Olr@cga.ct.gov

and a 2012 summary of legislative action on smart grids compiled by the National Conference of State Legislatures, available at http://www.ncsl.org/issues-research/energyhome/smart-grid-state-action-update.aspx.

THE SMART GRID AND POTENTIAL BENEFITS

The term "smart grid" refers to an array of technologies that allow for two-way communications and computerized automation of the electrical grid system. These technologies could affect nearly every aspect of the grid including the transmission system that carries power from generators to substations, the distribution systems that carries power from substations to consumers, consumer appliances, power usage, and rates. Although many smart grid technologies are still being developed and others have only recently begun being deployed, DOE's Office of Electricity Delivery and Energy Reliability maintains that the smart grid could ultimately lead to:

1. more efficient electricity transmission,
2. faster service restorations after outages,
3. reduced operations and management costs leading to lower consumer costs,
4. reduced peak demand, and
5. increased integration of large-scale and customer-owned renewable energy systems with the grid.

Transmission Technology

DOE compares the electrical transmission system to a system of interconnected streams. Power flows through the transmission system along the path of least resistance, finding multiple paths between the power plants and customers. Grid operators generally know which lines are in service and when relays have opened to protect lines against faults, but they have limited capability to control flow. They also have limited information about how the power is flowing through the grid.

The smart grid could add new measurement and control capabilities to the transmission system that could increase its reliability. Currently, measurements are taken on the grid once every two or four seconds. New technologies called sample voltage and current many times per second, providing a more accurate real-time snapshot of the grid's operation.

Smart grid software could also allow for more automated "self-healing" control of the grid that would monitor the grid in real time for potential disturbances and take action to check the disturbances. Such monitoring software could automatically act to dampen out oscillations in the power grid or reroute power to avoid inefficient flows of current or overloading a transmission line.

Distribution Technology

The smart grid's increased measurement and control capabilities could also bring benefits to the grid's power distribution level, particularly regarding power outage detection and response. According to the DOE, a combination of smart meters, which can relay consumer usage data back to utilities, and sensors placed throughout the distribution system could let utilities pinpoint a power outage's source almost immediately instead of having to rely on customer phone calls. An automated switching system could also act on the outage information and quickly reroute power so that as few customers as possible are affected.

Consumer Technology

Smart meters, smart appliances, and home energy management systems could allow consumers to exercise more control of their energy use. Smart meters allow consumers to see how much electricity they are using and how much it costs in real time. Smart appliances can be programmed to take energy efficient measures automatically or upon a receiving a remote signal (e.g. an air conditioner extending its cycle time to reduce load during peak demand times).

Home energy management systems give consumers access to the information from smart meters and control of their smart appliances. Incorporated into a smart phone, the management system could give consumers constant access to their home's real-time energy usage and the ability to control it remotely. Combined with time-of-use pricing, which would make electricity more expensive during periods of high demand and less expensive during periods of low demand, the systems could allow consumers to save money by automatically or remotely turning off appliances when rates are high or automatically starting them when rates are low (e.g. a dishwasher or laundry machine programmed to run in the middle of the night).

The smart grid could also benefit consumers with home energy generation systems, such as rooftop solar electric systems or small wind turbines. When these consumers produce more energy than they consume, net metering laws in Connecticut and other states allow them to return energy to the larger grid and "run the meter backward" as compensation for their excess supply. A smart grid with real-time usage data and time-of-use pricing could allow utilities to pay time-of-use rates to home generators, encouraging more home energy generation during times of peak demand.

POTENTIAL ISSUES

As noted above, expanding the use of information technology in the grid has a variety of potential economic and environmental benefits. Nonetheless, the development of smart grids and, in particular, smart meters has raised a number of economic, privacy, and safety issues.

Economic

It is unclear whether smart meters will produce cost savings, as their proponents believe. As reported in the May 30, 2011 edition of *Crain's Business Chicago*, an independent evaluation found that fewer than 9% of about 8,000 randomly selected Commonwealth Edison customers used their newly installed smart meters to save money by adjusting thermostats or turning off appliances during the afternoon or on hot days, even though the company imposed higher rates or offered rebates during peak demand hours to encourage consumers to conserve.

As discussed below, in Connecticut a number of parties challenged the introduction of smart meters, questioning their economic benefits particularly in light of the fact that ratepayers were still paying for the most recent round of meters.

Some are also concerned about the accuracy of smart meters. In California, hundreds of utility company customers complained to the Public Utilities Commission, most often about unexpectedly high meter readings.

Privacy

The smart grid creates new data collection, communication, and information sharing capabilities regarding energy use that raise a variety of privacy concerns. These include the privacy of personal information; the ability of individuals to make their own choices about what they do

and to keep certain personal behaviors from being shared with others; and surveillance, monitoring, or censorship by electric companies or others.

Historically, electric utilities only had access to total consumption data for their individual customers. In contrast, with smart meters, utilities can:

1. estimate how many people live in a house by watching the number of cycles of the hot water heater,

2. know when the residents are home by the energy cycle of the TV, and

3. know when the residents wake up by the energy signature of the coffee maker or toaster.

In guidelines published in 2010, the National Institute of Standards and Technology (NIST) noted that smart grid technologies, particularly smart meters and smart appliances, create new privacy risks and concerns that may not be addressed adequately by the existing business policies and practices of utilities and third-party smart grid providers. It stated that most consumers probably do not understand their privacy exposures or their options for mitigating those exposures within the smart grid. In addition, law enforcement agencies might use the detailed energy consumption data as a form of surveillance.

Safety

The development of the smart grid raises a number of safety issues. The NIST guidelines note that criminals could use the data communicated by smart meters to (1) identify the best times for a burglary; (2) determine if residents are present; (3) identify assets that might be present; or (4) commit fraud, identity theft, or corporate espionage.

Some also express concern about physical safety. Smart meters, like other electronic devices, create radiofrequency emissions, which some have asserted cause a variety of health problems. These include seizures, migraines, sleeping disorders, and heart problems such as arrhythmia. There has been extensive research on this subject, with most studies finding little if any risk.

INITIATIVES IN CONNECTICUT

In 2009, approximately 3,000 Connecticut Light and Power (CL&P) customers (1,500 commercial and industrial customers and 1,500 residential customers) from Hartford and Stamford participated in the pilot Plan-it Wise Energy Program, which included smart meters and pricing plans with different rates for peak and non-peak periods (dynamic pricing). The program's objectives were to gain insight into customer interest and response patterns for dynamic pricing rates and four enabling technologies, including smart thermostats, smart switches, Energy Orb, and a Power Cost Monitor. The program tested three time of use rates, each with a high and low ratios of peak- and off-peak prices.

CL&P subsequently proposed deploying advanced metering infrastructure (AMI) system-wide starting in December 2012 with a four-year implementation. The project would progress through information technology development for dynamic pricing and on-bill hourly energy usage analytics, with dynamic pricing available to all customers by 2016. Technology for increasing efficiencies in outage detection, theft detection, and remote service activation would be developed through 2017.

After a public comment period, the Department of Public Utility Control (DPUC, now PURA) was expected to issue its final ruling approving or rejecting the plans by April 6, 2011. Businesses and state officials expressed concerns about the upfront costs of CL&P's smart meters. In addition, the AMI industry was continuing to address issues such as security and privacy and ratepayers were not enthusiastic about new meter technology. The attorney general indicated that the $492 million cost of the project was too high considering the project benefits are still unknown, with the estimated $600 million in savings depending heavily on customer response to the programs. The attorney general asked DPUC to deny the full scale smart meter proposal, arguing that the upgrade should be postponed until the existing mechanical meters require replacement. Privacy issues surrounding customer electricity consumption data also emerged as a concern. Some critics argued that a utility should make it clear in the project plans that the data will only be used for better cost controls and efficiencies in the system.

Though no final decision was issued on whether to approve the project or not, PURA (successor to DPUC under PA 11-80) issued a draft decision (docket 05-10-03RE04) on August 29, 2011 that would have denied CL&P permission to deploy smart meters across the state. According to the draft decision, the low benefit-cost ratio of CL&P's proposal, the low monthly savings over a 20-year meter life, the risks to

customers of not achieving projected savings, a 14-year payback period, and the uncertainty of customer desire for and use of dynamic pricing rates needed to achieve estimated savings justified denying the full implementation of the AMI meter system as proposed by CL&P. Instead, it recommended that CL&P begin installing smart meters at a more moderate pace once industry standards for AMI meters and infrastructure are developed and CL&P selected a specific AMI technology to install. The draft decision also called for CL&P to provide the authority with four reports throughout 2012 and 2013 describing the latest advancements in AMI technology.

PURA suspended further action while the newly-created Department of Energy and Environmental Protection, as required by PA 11-80, establishes state energy policy and implements a variety of new clean energy and energy efficiency programs.

RECENT DEVELOPMENTS IN OTHER STATES

Legislative and Regulatory

Many states have taken steps to address smart grid issues. Among the most active have been California, Illinois, and Maine.

California. In 2010, the legislature adopted SB 17, which required electric companies and municipal electric utilities to develop smart grid deployment plans. It directed the Public Utilities Commission (PUC) to determine the requirements for these plans consistent with the policies set forth in the act and federal law. The PUC subsequently provided criteria for the use and development of smart grids and the review of the utilities' plans.

In 2011, the legislature passed SB 674, which bars electric companies from sharing, disclosing, or otherwise making accessible to any third-party a customer's electrical consumption meter data without the customer's consent. Also in 2011, the PUC issued an order to protect the privacy and security of customer usage data. Electric companies, their contractors, and third parties who receive electricity usage data from the companies are subject to the new rules. Among other things, the order gives customers the right to access and control their data, requires the companies to minimize their data collection, and restricts how the data can be used and disclosed.

California and several other states, including Maine, Nevada and Oregon, allow customers to opt out of having a smart meter installed, but with an additional fee to cover the cost of having a meter reader check

usage. For example, California electric company customers who participate in the opt-out option are assessed an initial fee of $75 and a monthly charge of $10 ($10 and $5, respectively, for certain low-income customers).

Illinois. As described in OLR Report 2012-R-0403, in 2011, Illinois adopted legislation (Ill. PA 097-0616) that allows the state's two major electric utilities to be subject to performance-based ratemaking (PBR), rather than traditional ratemaking, for their distribution rates if they make substantial investments in infrastructure, including in smart meters, and meet other requirements.

To be eligible for PBR, Commonwealth Edison, which serves Chicago and the rest of northern Illinois, must invest an estimated $1.5 billion over ten years to upgrade and modernize its transmission and distribution systems and in smart grid electric system upgrades. Ameren, which serves most of the rest of the state, must invest an estimated $360 million over a 10-year period.

The act also has extensive provisions regarding AMI. Each utility must (1) develop an AMI deployment plan; (2) provide funding for programs and projects that support innovative technologies or other methods to modernize the grid; (3) establish a rebate program to reduce peak use; and (4) create or designate a test bed for testing smart grid technologies.

Each participating utility must file an AMI deployment plan with the Illinois Commerce Commission. The plan must provide for investment over a 10-year period that is sufficient to implement the plan across the utility's service territory. It must, among other things, contain:

1. an AMI strategy that describes how the utility evaluates and ranks technology choices to create customer value;

2. a deployment schedule and plan that provides for deployment of AMI to all Ameren customers and 62% of Commonwealth Edison's customers;

3. annual milestones and metrics to measure the plan's success in enabling smart grid functions and enhancing consumer benefits from AMI; and

4. a consumer education plan.

The plan must secure the privacy of personal information (including information about electric usage) and give consumers the right to determine whether their personal energy information will be disclosed to third parties. Utilities, their contractors or agents, and any third party who acquires personal information by working on smart grid technologies may not disclose it for unrelated commercial purposes. Utilities must comply with the consumer privacy requirements of the state personal information protection law. If a utility earns money by selling non-personal information obtained through smart grid technology, it must use this money to offset its revenue requirements. Commonwealth Edison's plan anticipates that it will install 4.1 million advanced meters. Ameren plans to install approximately 750,000 advanced meters.

Within 60 days after the commission approves a utility's AMI plan, the utility must file a proposed tariff that offers a voluntary market-based peak time rebate program to all residential retail customers with advanced meters.

Maine. In 2010, the legislature passed HB 1079, establishing a state policy on smart grid infrastructure. The policy goals include:

1. deployment and integration into the electric system of demand response technologies, demand-side resources, and energy-efficiency resources;

2. deployment of smart grid technologies, including real-time, automated, interactive technologies that optimize the operation of energy-consuming appliances and devices, for purposes of metering and communications concerning grid operation and status and distribution system operations;

3. deployment and integration into the electric system of advanced electric storage and peak-reduction technologies, including plug-in electric and hybrid electric vehicles; and

4. identification and elimination of barriers to the adoption of smart grid functions and associated infrastructure, technology, and applications.

In 2011, the legislature passed HB 563, which requires the state's PUC to establish the terms and conditions under which a utility may install wireless smart meters. The customer must be allowed to decline the installation of the wireless smart meter or have a wired smart meter installed instead. The act requires the PUC to address regulatory gaps between federal and state law regarding smart meters, customer data, and cyber security.

In 2011, customers challenged the smart meter program before the PUC. They argued that Central Maine Power (CMP), a major electric company, had no right to install the meters on private property without the owner's permission. They claimed that the installation violated their property rights. The PUC denied the property ownership-based claims because it found that the CMP terms and conditions of service clearly indicated that it could access customers' property to install meters.

The PUC held that CMP adequately claimed that a customer's failure to allow a smart meter on their property would economically harm CMP by (1) increasing the time needed to restore power after storms and (2) continuing inefficient energy allocation to customers using traditional meters. The PUC did require CMP to allow customers to refuse to have smart meters installed on their premises but allowed it to charge a fee for opting out of the program.

A group of customers then claimed that the opt-out fee violated their rights under the Fourth and Fifth Amendments of the U.S. Constitution. The PUC ruled that it had no jurisdiction to consider the constitutional claims and CMP subsequently implemented a tiered opt-out fee.

The customers appealed the PUC's decision to the Maine Supreme Court on a variety of grounds. In a decision issued on July 12, 2012, the court refused to consider the constitutional challenges and found that the provision allowing customers to opt out from having smart meters installed at their premises rendered their privacy claims moot. The court also found that the PUC was within its rights to allow CMP to place smart meters on customers' properties and affirmed its power to implement the opt-out fees. On the other hand, the court agreed with the plaintiffs that the PUC should not have dismissed the portion of the complaint against CMP addressing health and safety issues, and the PUC subsequently voted to investigate the safety of the meters.

Utility Programs

A large number of utilities have implemented smart meter or smart grid programs, in Austin Energy and Oncor in Texas; Duke Energy, which serves North and South Carolina, and Ohio among other states; and San Diego Gas and Electric (SDGE) in California.

Austin Energy. Austin's municipal electric utility began its Pecan Street smart grid project in February 2011. The first phase of the project began in the Mueller neighborhood and will integrate multiple smart grid technologies over the next five years. The home smart grid systems being used in this phase capture minute-to-minute energy usage for the whole home and six major appliances or systems. The installed cost per home has been $341 ($241 for equipment plus $100 for installation). The first phase included 100 homes, 11 of which have rooftop solar photovoltaic systems. Subsequently, the project deployed the same smart grid technologies in a second group of 100 homes in a different neighborhood that are at least 10 years old. Eventually, the installation and testing of smart meter technology will take place in a larger group of up to 1,000 residential and 75 commercial customers.

Oncor. Oncor's Smart Texas program arose out of state legislative efforts in 2007 to encourage smart meter deployment. The utility's automated metering system (similar to AMI) includes the installation of smart meters for all 3.4 million customers in its service area in Dallas, Fort Worth, and nearby communities. Oncor is recovering the costs of deployment through a monthly service charge of $2.19 per account, assessed on residential customers by their electric supplier.

An EIA analysis notes that Oncor's smart grid rollout has not been a total success. Complaints about the accuracy of the meters, though low in overall number, have been widely publicized. In addition, a lawsuit filed in 2010 alleged that smart meters incorrectly inflated measured electricity use, although the lawsuit was dismissed on technical grounds, as the Texas PUC was deemed to have jurisdiction. The Texas PUC commissioned a study in July 2010 that found that smart meters have been mostly accurate. The study conducted independent accuracy tests on 5,627 advanced meters in use by Oncor and two other utilities in the state. It found that 99.96% of the 5,627 meters were accurate. According to filings with the PUC, as of September 2010, over 1.3 million meters had been installed with a documented failure rate of 0.06%. However, the utility still faces a challenge to convince customers that the meters will benefit them.

Duke Energy. In 2009, DOE awarded Duke Energy $200 million in federal American Recovery and Reinvestment Act funding for smart grid projects in Ohio and another $4 million for projects in the Carolinas. The projects in each state include the development of an interoperable, two-way communications network, deployment of smart meters, distribution system automation, dynamic pricing programs, and deployment of supporting technologies for plug-in electric vehicles.

By 2009, Duke Energy Ohio installed 60,000 smart electric meters, 40,000 smart gas meters, and 4,000 communication nodes in Ohio. By 2014, a total of 700,000 smart electric and 450,000 smart gas meters will be installed. The Ohio PUC approved a rate increase of 49¢ more per month for residential customers to pay for these projects.

In the summer of 2010, Duke Energy expanded its home energy management pilot to include customers with smart meters in Ohio. The home energy management system allows the customer to manage consumption according to pre-set energy usage settings and preferences, alterable at any time through a web portal.

In February 2011, the Ohio PUC opened case number 11-0277-GE-UNC, to begin a discussion of customer privacy protection and customer data access issues associated with the smart grid.

In North Carolina and South Carolina, the company is implementing pilot programs. Smart meters are mandatory for all customers and the company also conducts meter testing after installation. Duke Energy indicates that the meters will not have the capability of immediately alerting the utility when there is a power outage; customers still must call to report outages.

In a 2009 pilot program conducted in Charlotte, North Carolina, Duke Energy tested the capabilities of its home energy management system with 100 residential customers. Duke Energy account executives assisted industrial customers individually with energy management in the past, including capital investment decisions. If fully implemented for all customers, this would increase the number of one-on-one customer relationships from the thousands to millions.

The call center Duke established to provide support for the system received roughly five to eight calls each month from customers with questions about using the system. It was discovered that customers needed more robust training to use the system effectively. In the summer of 2010, Duke expanded its home energy management pilot to include more customers with smart meters in North Carolina.

The system consists of a countertop, touch screen device, supported on an Internet protocol-based, open system network. Duke planned to include manufacturers of household products like appliances, electrical outlets, air conditioners, water heaters, and plug-in electric vehicles to create a suite of products compatible with the Energy Management Solution. More than 150 residential customers tested the first-generation home energy management system in 2009 and 2010.

SDG&E. SDG&E began planning its smart meter rollout in 2005. The first installations began in 2009 and were nearly complete by 2010, with about 1.8 million electric and gas smart meters deployed. The California PUC approved a budget of $572 million in 2007. Since that time, SDG&E has won additional funding, including $28.1 million in American Recovery and Reinvestment Act funds for a $60-million communication improvement initiative. Additionally, $7.5 million in federal funding and $3 million in state funding are going towards the utility's Micro Grid Demonstration Project, which is developing sensors, communications, and control equipment technologies for a potential future utility-wide rollout. The project also includes a focus on linking intermittent generation to a smart grid infrastructure. SDG&E hopes to allow residents with rooftop solar panels, for example, to sell generation to the grid at peak hours.

The initiative has given priority to the installation of smart meters, using small pilots such as the Micro Grid Demonstration Project to study the effectiveness of other infrastructure technologies that could be installed later, rather than implementing technologies that are not yet proven which could quickly become obsolete. Variable-pricing programs employing smart meters have not been used, except for business customers, but this may change in the future.

SDG&E estimates that the cost of smart grid deployments from 2006 to 2020 will total approximately $3.5 to $3.6 billion, including previously authorized programs (equivalent to about $2,500 per customer). It estimates that benefits associated with smart grid deployments will total between $3.8 billion and $7.1 billion, including estimated societal and environmental benefits of between $760 million and $1.9 billion.

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