Building the Foundation for the Smart Grid

Association of State Energy Research and Technology Transfer Institutions
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Purpose

This paper is the result of efforts by the Association of State Energy Research and Technology Transfer Institutions (ASERTTI), and specifically members of ASERTTI's Buildings Committee, to assess the smart grid's potential to improve building energy efficiency; identify key technology needs; and catalog policies, regulations, and practices needed to propel the market for smart grid technologies that will advance building energy efficiency.

ASERTTI's Buildings Committee seeks to leverage the findings of this report to continue, and expand, its efforts to:

- Implement and demonstrate emerging smart energy building technologies in commercial, industrial, and residential facilities throughout the U.S.;
- Promote a regulatory framework and market environment that allows and encourages utilities, third-party service providers, and researchers to be actively engaged in smart grid innovation;
- Encourage establishment of financing mechanisms for research, development, demonstration, and deployment (RDD&D) of smart energy building technologies throughout the U.S.;
- Enhance coordination among national, state, and local smart grid initiatives, including through partnerships with the Zero Energy Commercial Buildings Consortium, the New Buildings Institute, and state energy offices.

A poster representation of this paper was presented at the 2012 ACEEE Summer Study on Energy Efficiency in Buildings on August 14, 2012, and can be viewed here: http://asertti.org/committees/buildings/.

Introduction

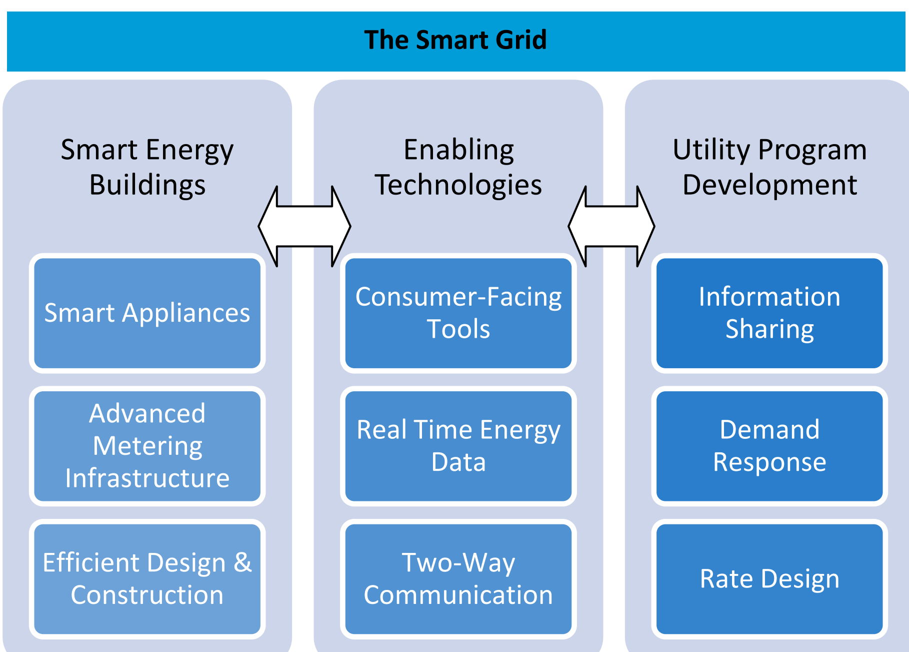
The U.S. Department of Energy (DOE) defines smart grid as "a class of technology people are using to bring utility electricity delivery systems into the 21st century, using computer-based remote control and automation. These systems are made possible by two-way communication technology and computer processing . . . from the power plants and wind farms all the way to the consumers of electricity in homes and businesses."[1] The implementation of sophisticated metering, communications, and control technologies promises to improve the overall reliability and operation of the grid; simplify the addition of distributed generation (DG), including renewable energy; and achieve system-wide efficiencies. Many of the smart grid's efficiency benefits will be realized throughout the grid's transmission and distribution systems. Energy efficiency benefits will also be achieved "in front of the meter" at customer facilities. Advanced metering infrastructure (AMI), applied in combination with smart grid-enabled devices and informational tools has the potential to improve the energy efficiency of residential, commercial, and industrial buildings throughout the country. Enhanced building energy efficiency will be realized in several ways:

- **Improved consumer feedback about energy use and prices.** Research has shown that greater awareness of energy use among consumers results in reduced consumption.[2]

- **Utility implementation of dynamic electricity pricing and demand response (DR) programs.** While DR programs are primarily aimed at reducing peak loads, they also result in energy conservation.
- **"Continuous Commissioning" of end-use equipment**, enabled by two-way communication between the utility and customer's facility.
- **The design and implementation of more effective energy efficiency programs** will be achieved through improved evaluation, measurement, and verification (EM&V) capabilities, enabled by the smart grid.

The smart grid presents an opportunity to improve the efficiency of the U.S. building stock. However, results will not be realized without supportive policies to encourage utility participation, as well as appropriate programs and technologies to engage end-users of all customer classes: residential, commercial, and industrial. The full potential of smart grid will be realized through a strategy that coordinates key stakeholder involvement: consumers, utilities, government, technology providers, and research institutions. This paper emphasizes the critical issues associated with the development of smart energy buildings and customer engagement that will require pathways for greater research, investment, and market development to enable and enhance the smart grid. Figure 1 below provides an overview of three key elements for developing a smart grid that will support building efficiency: smart energy buildings, enabling technologies, and utility programs for consumers.

Figure 1: Critical Elements to Enable the Smart Grid



Background

Several factors are necessary for building energy efficiency improvements to be achieved through the smart grid: deployment of advanced metering infrastructure; implementation of dynamic electricity pricing; and the development of, and consumer access to, enabling technologies. These ingredients, when made available to building owners, managers, and tenants, will enable the smart grid to provide significant energy efficiency benefits to end-users.

The full deployment of smart grid technologies and the expanded opportunities for building energy efficiency improvements will be enabled through the development of "smart energy buildings," which we define as buildings that incorporate best practices in design and construction, as well as advanced technologies, in order to maximize energy efficiency. A smart energy building can be described in terms of three layers. First, it is constructed using energy-efficient materials and design techniques. Second, it engages in two-way communication with the electric grid via advanced metering infrastructure. Third, it incorporates enabling technologies, such as automated demand response appliances, to facilitate improved management and control of building energy use. Ultimately, the smart energy building is a vision for the ideal, energy-efficient building of the future.

Advanced Metering Infrastructure

The term "smart grid" describes the integration of advanced information technologies with the U.S. electricity grid. Essentially, the smart grid can be thought of as the marriage of modern information technology and the electric system.[3] Buildings play a central role in smart grid deployment as the host of two-way communications equipment to collect and share energy data; they are the connecting point between the grid and sources of demand. The Zero Energy Commercial Building Consortium (CBC) has explained that "the key to the smart grid is to fully and dynamically integrate customers, their loads, and information about their usage into the operation of the grid."[4]

The first step of this integration process is the installation of smart meters on customer facilities. Smart meters are installed along with systems that enable two-way communication between the meter and the utility. This equipment is referred to as advanced metering infrastructure (AMI). The smart meter serves as the point of connection between a building and the smart grid. Smart meters are more technologically advanced than traditional electricity meters in that they record a customer's energy consumption in time intervals of an hour or less and communicate that information to the customer's electricity provider at least once a day, if not more frequently.[5]

In May 2012, the Institute of Electric Efficiency (IEE) reported that 36 million smart meters had been installed across the U.S., representing nearly 33 percent of all U.S. households. IEE estimates that by 2015, 65 million smart meters will be deployed in more than half of the homes across the country.[6] This latest assessment indicates that utilities are making significant progress with the installation of AMI, assisted in no small part by federal funding. Of the 36 million smart meters installed, at least 10.8 million (or 30%) were provided to customers through the U.S. Department of Energy's (DOE's) Smart Grid Investment Grant program, funded under the 2009 American Recovery and Reinvestment Act

(ARRA).[7] The current trend suggests that smart meters and their associated communications systems are rapidly replacing traditional electricity meters throughout the U.S.

Smart Electricity Pricing

In addition to communicating energy use data between a facility and an energy provider, smart meters also communicate real-time information about electricity prices. If permitted by regulators, utilities can implement dynamic electricity pricing, which are prices that vary over time and reflect the true price of electricity at that particular time, based on demand. The intention behind dynamic pricing is to set prices for customers that more accurately reflect the actual variation in electricity prices that utilities pay on the wholesale market. This has the potential to radically alter the way consumers think about and use electricity because it enables the utility to send clear economic signals to end-users.

While there are a number of approaches to time-varying electricity rates, each with its unique pricing pattern, the overall goal is the same: provide consumers with an economic signal that encourages them to decrease energy use when prices are high, ultimately resulting in reductions in peak demand. Dynamic pricing is one tool that supports the implementation of demand response (DR) programs, which refers to a broader set of policies and programs designed to encourage customers to shift their energy use away from peak demand periods.[8]

Enabling Technologies

By definition, a smart meter facilitates nearly real-time communication about energy use and prices between a utility and a customer's facility. However, a smart meter itself does not communicate directly with its customer. The exchange of energy information between the consumer and the AMI is facilitated by additional tools, or "enabling technologies," that translate energy consumption and pricing data into actionable information that can influence consumer energy use. Because smart meters collect data in a digital format, it can be shared easily across platforms, presenting limitless possibilities for data analysis, display, and exchange.

Enabling technologies come in many forms, varying from simple to complex, and from manually-controlled to fully-automated. Examples of enabling technologies include: in-home displays (IHDs) that show real-time energy consumption and cost information; online software and mobile apps that allow consumers to analyze their energy use data; and smart-grid compatible devices, such as thermostats or dishwashers, that can be programmed to automatically respond to electricity price signals. Appliances or other energy-consuming devices that can be programmed to respond to pricing signals without manual control are capable of "automated demand response." Types of enabling technologies vary for customers in the residential, commercial, and industrial markets. Residential users may find value in a mobile app, whereas a commercial building manger may need a solution that integrates smart meter data with an existing building energy management system.

A sample of enabling technologies available today:

EnergyAxis in-home display[9]


GE's Nucleus energy manager software[10]

Tendril's Energize Online Web app[11]

Furthermore, new energy information technologies are creating smart energy building systems that make automatic adjustments in response to detected feedback. The potential now exists to install nearly fully-automated, smart grid-enabled, building energy management systems that respond to detected changes at a facility and pricing signals from the grid. Just as the smart meter is the link between a building and the smart grid, enabling technologies are the link between the smart meter and the consumer. By communicating not simply data, but actionable information, enabling technologies facilitate increased consumer awareness and improved control of energy use.

Building Energy Efficiency

Integration of smart grid technologies with buildings has the potential to lead to increased energy efficiency through several pathways, each dependent upon the availability of appropriate technologies, end-user engagement, and supportive policies and programs.

Improved Energy Use Feedback

The rapid deployment of AMI allows utilities to efficiently collect and communicate energy use and price data at an extremely high level of granularity. Every smart meter installed in the U.S. is continually recording the amount and price of energy being used at a particular time and place. This constant collection and flow of data between utilities and customer facilities is unprecedented and holds enormous potential. True efficiency benefits will be realized when this data is provided to enabling technologies that perform analyses yielding digestible, actionable information for consumers. The end result is that through access to real-time energy use information, end-users will be empowered to make informed decisions about energy use, and ultimately motivated to reduce overall consumption. Thus, energy efficiency improvements can be expected in buildings that are equipped with AMI and enabling technologies.

Studies have consistently demonstrated that when consumers become more aware of their energy use, they reduce their consumption. A 2006 literature review found that direct feedback about energy use via the meter or display devices led to energy savings of five to 15 percent among residential consumers.[12] A 2009 review of twelve utility pilot programs in North America confirmed the relationship between energy feedback and conservation; the study revealed that consumers who actively used an IHD reduced electricity consumption by an average of seven percent.[13] These assessments are supported by findings from a 2010 meta-review of advanced metering initiatives, suggesting that real-time plus ("plus" meaning that additional, useful energy information is provided, not simply consumption data) feedback programs are likely to generate average annual household energy savings of approximately six percent.[14] Research findings suggest that direct feedback about energy use is enough to induce energy efficient behavior in residential consumers. Similar studies have not been carried out in the commercial or industrial sectors.

The Electric Power Research Institute (EPRI) assesses that direct energy use feedback, made possible by smart grid and enabling technologies, has the potential to deliver energy savings of five percent for the residential sector and 2.5 percent for the commercial and industrial sectors in buildings where the technologies are installed and applied.[15]

Dynamic Electricity Pricing and Demand Response Programs

Implementing a combination of smart grid-enabled technologies and dynamic electricity pricing will change the way U.S. consumers think about and use electricity in their buildings. Research has shown that time-varying electricity pricing is one of the most effective DR techniques in practice today.[16] The primary goal of dynamic pricing is the shifting of consumer energy use away from times of peak demand, not necessarily customer energy efficiency (i.e. the use of less energy overall). Consumers responding to dynamic pricing could shift their energy use to different times of the day, which would not lead to an overall reduction in energy use at the building level. Nevertheless, research supports a connection between dynamic pricing and conservation.

A 2005 review of demand response programs conducted by King and Delurey found that dynamic pricing programs yielded an average 4 percent reduction in energy use among residential participants. For programs that included information/feedback components, the effects were even more pronounced, with users reducing energy use by about 11 percent.[17] A 2007 update to the report provided further support, suggesting an energy savings effect of three to five percent for pricing-based demand response programs.[18] While dynamic pricing models may not intend to reduce overall energy use for consumers, research indicates that they have actually been quite effective in this regard. Indeed, similar results have been exhibited among commercial customers. PG&E found that 65 kWh of energy savings could be expected for each KW of peak demand reduction attained by commercial customers in California participating in the utility's auto-DR programs.[19] Thus, the implementation of demand response programs, facilitated by smart grid technologies, are likely to result in overall energy savings, in addition to reductions in peak energy use at residential, commercial, and industrial buildings.

Continuous Commissioning

EPRI has highlighted the potential impact of smart grid technologies on commercial building efficiency through the practice of continuous commissioning. Commissioning is the documented process of ensuring that building systems and equipment are performing efficiently. It is best practice to commission major equipment, such as chillers, boilers, and refrigeration equipment when initially installed. This equipment should be re-commissioned after a defined period of time, to ensure that its performance aligns with any changes to the building's operation.

In order to commission existing equipment, building managers must engage in a lengthy process of manually inspecting and testing end-use devices. Smart grid and enabling technologies present the possibility of practically automating this process, making it easier for building managers to maintain equipment at the optimal settings for maximum energy efficiency. AMI allows for two-way communication between utilities and customer facilities. By integrating the smart grid communication technology with on-premise energy management and control systems, utilities would be able to monitor the performance of customer equipment.[20] If the utility detects that equipment is not performing up to specifications, it can alert the facility manager who can address the problem immediately.

Continuous commissioning has the potential to provide significant benefits in large commercial buildings (over 100,000 square feet), due to its potential to be particularly cost-effective. EPRI estimates that in 2030, continuous commissioning will result in energy savings of nine percent in large commercial buildings.[21]

Better Energy Efficiency Programs

The smart grid is likely to have an indirect impact on building energy efficiency through enhanced measurement and verification (M&V) capabilities. Two-way communication between utilities and customer facilities will enable improved M&V of energy savings achieved through utility programs. EPRI has suggested that more accurate verification of program impacts will provide utility planners with strong evidence to support the inclusion of energy efficiency and DR into integrated resource plans. Thus, improved M&V capabilities presented by the smart grid have the potential to expand the deployment of energy efficiency programs across the country.[22]

Today, the energy savings of utility energy efficiency programs are often estimated because it is not possible or cost-effective to collect data from participants to verify actual savings. AMI enables the utility to precisely measure energy use at customer facilities and identify changes attributable to an energy efficiency program. For example, consider a utility rebate offered for electric water heaters at commercial facilities. With smart grid infrastructure in place, the utility could sub-meter the water heaters of participants to accurately measure energy savings achieved. Those programs proven to be effective through enhanced M&V techniques would likely be expanded and even replicated by other energy providers.

Next Steps: A Strategic Framework for a Smart Grid Market

The smart grid will play a key role in achieving the goal of an energy-efficient U.S. building stock. However, in order for this goal to be realized in the near term, a strategic framework is needed that will act as the catalyst for the development and deployment of smart grid technologies, as well as the growth of the market for these technologies. This framework should include the following:

1. ***Research opportunities on smart grid, smart energy buildings and consumer behavior –*** Funding mechanisms to support research exploring the smart grid, smart energy building technologies, and consumer behavior
2. ***Policies and regulations that support energy efficiency and the smart grid –*** Implementation of policies and regulations that encourage energy efficiency and smart grid technology deployment among customers and utilities
3. ***Rate design that allows dynamic electricity pricing –*** Implementation of policies and regulations that allow for dynamic pricing rate designs
4. ***Consumer access to energy information –*** Policies enabling consumers access to an open, competitive market of tools and technologies that enable them to make informed energy-use decisions

1. Research & Development (R&D) for Smart Grid Advancement

Continued and expanded R&D opportunities are essential for the deployment of technologies and programs that result in actual energy efficiency benefits for buildings. The CBC has noted that, "smart grid design should be based on behavioral research as well as technological advances, and utilities should match their technologies to the needs of their customers."[23] Consumer-facing smart grid technologies, as with any type of commercial product, will need to be designed with the end-user in mind. Sufficient research and testing will be required to ensure that a tool effectively delivers the intended services and meets the needs of the customer.

In addition to research related to the technical aspects of products, further investigation addressing the energy use habits and motivations influencing residential, commercial, and industrial users will be particularly valuable for new product development. Support for R&D activities will help to ensure high quality consumer tools and to increase the chances of their success at advancing energy efficiency. Stakeholders that are invested in consumer engagement with the smart grid should seek to support R&D efforts that incorporate energy use behavior, consumer-facing smart grid applications, and customer preferences.

The residential sector has been the focus of many studies demonstrating the impact of energy use awareness on consumption patterns. However, the commercial and industrial sectors have not been examined in the same depth. Enabling technologies are being developed and deployed in commercial and industrial facilities, with the goal of providing facility managers and end users with energy use information to guide building operation practices. Whether these technologies are stand-alone or integrated with existing energy management systems, it is imperative that they meet the needs of the customer. For this reason, further research should address the impact of energy use information in the commercial and industrial sectors. Findings would serve to inform the development of enabling technologies that best achieve the desired goals of energy efficiency and cost savings among commercial and industrial customers.

In order to achieve a national smart grid in the coming decades, a significant increase in both private and public investment for R&D and infrastructure deployment will be necessary. In March 2011, EPRI released a valuable report that established the investment levels over a 20-year period that will create a national smart grid system resulting in a positive benefit-to-cost ratio between 2.8 and 6.0. The report, entitled *Estimating the Costs and Benefits of the Smart Grid: A Preliminary Estimate of the Investment Requirements and the Resultant Benefits of a Fully Functioning Smart Grid*, found that a total net investment of $338-446 billion will be required over the next 20 years to bring the nation's power delivery system to the performance levels required for a smart grid. The spending would be directed at the infrastructure to provide full customer connectivity and to integrate distributed energy resources, but excludes the cost of developing generation, the cost of transmission expansion, and the customer costs for smart-grid ready appliances and devices. On an annual basis, investment between $17 and $24 billion from both private and government sources will be required over the next 20 years to achieve a national smart grid infrastructure. [24]

Although U.S. investment in smart grid has increased sharply since 2009, it remains far below the levels indicated in the EPRI report to create a national smart grid within the next 20 years. For example, Duke University's Center on Globalization, Governance & Competitiveness estimated the U.S.'s 2010 total smart grid investment at $7.0 billion.[25] Moreover, the Obama administration estimated in June 2011 that the federal government's $4.5 billion in stimulus funds directed at smart grid have been matched by $5.5 billion in private money.[26] These stimulus funds and matching private funds are investments extending over a five year period that fall well short of the annual $17 to $24 billion necessary to create a national smart grid over the next two decades.

Title XIII of the Energy Independence and Security Act of 2007 (EISA) established the federal government's role, through the U.S. DOE and other agencies, to initiate smart grid R&D activities and coordinate national grid modernization efforts. The Act initially provided $100 million per year over the period 2008-2012. ARRA increased the federal funding for smart grid initiatives to about $4.5 billion in multi-year funding to implement EISA.

Within the U.S. DOE, the Office of Electricity Delivery & Energy Reliability (OE) works with national stakeholders on smart grid research and development. The two largest initiatives under OE for testing and deployment are SGIG and the Smart Grid Demonstration Program (SGDP). Both SGIG and SGDP are currently five-year programs that received significant ARRA funds starting in 2009.

- SGIG focuses on deploying existing smart grid technologies, tools, and techniques to improve grid performance today. SGIG deployed $3.4 billion in ARRA funds for 99 projects.

- SGDP explores advanced smart grid and energy storage systems and evaluates performance for future applications. SGDP deployed $1.6 billion in ARRA funds to a total of 32 projects (16 regional demonstration projects and 16 energy storage projects).

At the local level, utilities and communities are providing models for investment in smart grid technology R&D. In Colorado, two utilities provide two very different models for conducting smart grid pilot deployment projects. In 2008, the investor owned utility Xcel Energy selected Boulder for its SmartGridCity™ project and began installing and testing a diverse set of smart grid technologies including: installing monitoring devices on 4,600 transformers and four substations; upgrading 24,000 electricity meters; and installing 200 miles of fiber-optic cable to allow the components of the grid to communicate with one another. The project came to a close in late 2011. Although SmartGridCity™ has faced criticism for its unexpected costs, Xcel states that the project will provide benefits to all its customers from the testing of technologies that improve service and the collection of valuable information for future implementation of smart grid technologies across the company's system.[27] To cover the costs of the project, Xcel has requested before the Colorado Public Utilities Commission a total of $44.5 million in ratepayer funds.[28]

The other smart grid pilot deployment project in Colorado is called FortZED and involves Fort Collins Utilities (a municipal utility) along with several other private and public organizations. The ZED stands for "zero energy district" and represents an area with over 10 percent of the city's distribution system, including the downtown business district and the campus of Colorado State University. The goal of the project is to demonstrate through the deployment of smart grid, energy efficiency, and distributed generation technologies how an existing community can be retrofitted to produce as much energy as it uses. The project began in 2007 with over $500,000 in funds raised from local foundations and private interests. These local funds made the project eligible for federal funds that were received in subsequent years totaling more than $9 million.[29] FortZED continues to be an active project that is supported by research at Colorado State University and several private partners engaged in the deployment of advanced smart grid technologies.

With ARRA funding for smart grid R&D coming to a close, it is critical that new sustainable funding sources be identified to ensure a continued focus on smart grid building technologies that provide energy-savings benefits to residential, commercial, and industrial customers. Potential new, emerging funding streams may include:

- State and local government support for research and demonstration projects
- Utility programs for customers and direct investment in new smart buildings and smart grid technologies
- Public-private partnerships to propel research

ASERTTI Member Smart Grid Research

The California Energy Commission recently awarded $1.5 million for two research projects addressing smart grid. Funding for both projects comes from the Commission's Public Interest Energy Research (PIER) program. In 2010, the New York State Energy Research and Development Authority (NYSERDA) awarded $11.3 million to 25 next generation renewable energy and energy storage projects.

Private corporations, especially those in the communications technologies industry, are increasingly collaborating and teaming on research projects for the smart grid. These projects are often coordinated through national associations and networks. For example, the EPRI has created a large industry collaborative for smart grid demonstration initiatives. EPRI's smart grid demonstration project initiative has been established to conduct several regional demonstrations and support research focusing on smart grid activities related to the integration of distributed energy resources.

In addition, EPRI has created an initiative called IntelliGrid to create a vision of the future electric delivery system. The IntelliGrid Consortium is a public-private partnership that integrates global research efforts, funds technology R&D, works to integrate technologies, and disseminates technical information. Through IntelliGrid, a forum has been created to establish a methodology, tools, and recommendations for standards and technologies for utility use in planning, specifying, and procuring IT-based systems, such as advanced metering, distribution automation, and demand response. The initiative also provides a living laboratory for evaluating smart grid devices, systems, and technologies.

Private Investment to Spur Smart Grid Innovation

Another collaborative effort involving private industry and support from DOE is the GridWise® Alliance. It is a consortium of public and private electricity sector stakeholders, providing a forum for idea exchanges, cooperative efforts, and meetings with policy makers at federal and state levels. The effort is focused on developing information technology to modernize the U.S. electrical grid. The program seeks to find opportunities for investment in communications architecture and standards; simulation and analysis tools; smart technologies; test beds and demonstration projects; and new regulatory, institutional, and market frameworks.

2. Energy Efficiency & Smart Grid Policies and Regulation

Policies and regulations that promote energy efficiency for consumers and buildings will be important to drive both customers and utilities to invest in smart grid technologies. Under the traditional utility revenue model, profits are tied exclusively to energy sales. Within this model, encouraging customers to use energy more efficiently has the effect of reducing a utility's profits (less of the product sold equates to less revenue). Although utilities will derive benefits from the smart grid that do not impact energy sales, such as improved system reliability, additional polices and regulations may need to be put in place to offer other avenues of revenue generation for investor-owned utilities (IOUs), before they may be willing to make investments in the pursuit of energy efficiency for the smart grid.

Smart grid investments come with a price for either the customer or the utility. For example, the installation of a smart meter can cost between $200 and $500 per customer which includes the hardware, software, and other support systems.[30] IOUs will want to be assured of cost recovery before committing to smart grid outlays. State-level policies and regulations that have served to reorient utility cost-benefit analyses in favor of smart energy buildings include:

Energy Efficiency Resource Standards (EERS) establish annual energy efficiency targets to be met over a set period of time. An EERS policy can be structured in three ways: 1) Statewide targets applied to all utilities in a state; 2) inclusion of energy efficiency as an eligible resource in a state's renewable portfolio standard (RPS); or, 3) Long-term energy savings targets set by a utility commission, tailored differently to each regulated utility in the state. Twenty-four states have currently enacted energy efficiency targets, requiring utilities to meet an energy savings goal through energy efficiency measures.[31]

Alternative Utility Revenue Recovery Models create new mechanisms for rewarding energy efficiency by altering the traditional utility business model in which revenue is determined only by the amount of energy delivered to customers. These new models include such mechanisms as program cost recovery, lost margin recovery, and performance incentives. Program cost recovery mechanisms allow utilities to recover the direct costs of implementing an energy efficiency program through rates or a "systems benefits charge" included in customer energy bills. Lost margin recovery mechanisms mitigate the impact of lost sales from customers joining an energy efficiency program by employing rate adjustments based on program results. Performance incentives aim to encourage utilities to invest in energy efficiency programs by providing them with a financial reward if savings targets are met. As of April 2010, 43 states had adopted one of these forms of alternative utility revenue recovery.[32]

Financial Incentives for Investments in Smart Grid-Enabled Building Technologies should be offered through the federal government, state government agencies, utilities, and others. Many incentives already exist to encourage energy efficiency infrastructure upgrades to residential and commercial buildings. In addition to existing funding opportunities, the availability of financial incentives should be expanded to assist more consumers with the purchase of smart grid devices, software, and other enabling technologies.[33] Such incentives would help to grow the market for consumer smart grid applications by raising awareness and making investments in new products more affordable. Incentives could take many forms including rebates on qualified equipment and appliances; grants or loans for upgrades to facility energy management systems; or tax deductions. Specific incentives should be made available to different customer classes (residential, commercial and industrial).

DOE leveraged $3.4 billion in ARRA funds in 2009 to begin modernizing the nation's electricity grid. The two largest programs that were created through this funding were the Smart Grid Investment Grant (SGIG) program and the Smart Grid Demonstration program. Under these programs, Honeywell International, Inc. was awarded $11.4 million, which was augmented by additional funding from Southern California Edison and Pacific Gas and Electric, to implement automated demand response (ADR) technology at customer facilities in California, at no charge.[34] The initiative is providing automated peak pricing response for almost 700 commercial and industrial customers by integrating smart grid communication capabilities into their buildings' existing energy management systems.[35]

Smart Grid Technology policies and regulations are important to establish standards and parameters for the deployment of AMI technologies across an entire state or region and determine the limits of authority among stakeholders. These policies include legislation addressing smart meter deployment, allowing state regulatory commissions to authorize smart metering programs, and permitting large utilities to implement smart metering programs. [36] According to the National Conference of State Legislatures, 25 states and territories have enacted smart metering policies and regulations that provide utilities with guidance to deploy a smart meter infrastructure. These policies have addressed incentives, customer savings and protection, cyber security, and grid creation and reliability. [37] As smart grid projects and initiatives advance across the country, it will be essential for state policy makers and regulators to continue to provide guidance and support the deployment of AMI and associated technologies.

3. Electricity Rate Designs to Encourage Smart Grid Innovation

Dynamic pricing will be necessary to reap the full benefits of the smart grid. As research has shown, the combination of enabling technologies and dynamic electricity pricing provide consumers with both the ability and incentive to successfully reduce energy consumption. As AMI technologies continue to be installed at homes and businesses across the country, the transition to dynamic electricity pricing models will need to be considered by state regulatory commissions. As of March 2012, less than one percent of residential and small commercial and industrial customers in the U.S. were on any kind of time-varying electricity rate.[38] While many states have energy efficiency policies in place, efforts to adopt dynamic pricing models are only beginning. Moreover, the implementation of dynamic pricing will certainly drive the market for enabling technologies, such as automated demand response appliances.

4. Establishing the Market for Energy Information Technologies

Effective, enabling technologies for smart energy buildings will emerge from an open, competitive, and dynamic market, in which a wide variety of products are created and offered by utilities and third-party providers. Such a market will be essential for innovation and the development of successful information products and services for residential, commercial, and industrial consumers. Several key elements will be necessary to enable the development of an open market for smart energy building information tools, technologies, and services including:

- Smart meter installation on all customer facilities
- Consumer access to smart meter data
- Third-party service provider access to customer data with permission
- Consumer awareness of energy efficiency opportunities

Data access is essential for building consumer awareness about energy use and providing consumers with the tools to change energy use behavior. One data access strategy that some utilities are employing is to provide customers with a dedicated, password-protected web portal that allows them to view their energy use data.[39] While this approach provides value to customers, additional benefits can be achieved when that data is made available – with consumer permission – to a wide variety of enabling technologies developed by third parties. Under this scenario, consumers can have access to numerous devices, apps, and other technologies that will turn energy use data into valuable information (see discussion on *Green Button* below). When consumer data can be made available and understood by third-party providers, consumers will have a larger market of energy information, analysis, and management tools to choose from.

Green Button

Green Button is a recent initiative that aims to further both consumer access to data, as well as a market for enabling technologies.[40] Green Button is an industry-led effort that responds to a White House challenge to provide customers access to their energy usage information electronically.[41] Green Button is designed around an open data standard that is available to all. By agreeing to share information in this format, utilities and developers can work together to provide consumers with valuable information.

Utilities participating in the program include a "Green Button" on their website. By clicking the button, customers can download their energy use data in a user-friendly, computer-friendly format. Moreover, consumers can voluntarily make this data available to a growing number of applications that are compatible with the Green Button format. As of June 2012, five large utilities had made the Green Button feature available to customers, and 14 more had committed to adopt it in the near future. This would provide 27 million customers with access to their energy data. As for consumer tools, many companies are already developing applications and services for residential and business customers that use Green Button data. To date, 11 companies have released related products, and another 15 have designs in progress.[42]

By clicking the button, customers can download their energy use data in a user-friendly, computer-friendly format.

To build awareness around the Green Button program, DOE held a competition in the spring of 2012, the "Apps for Energy Challenge." The contest challenged software developers and designers to create new apps for computers, smart phones, and tablets that help customers make the most use of their Green Button data.[43] Creators of the winning apps, as determined by a panel of judges selected from government, the energy industry, and the tech community, were awarded $100,000 in cash prizes. Entries ranged from apps that help users evaluate solar panel investments, to those that allow users to compete against Facebook friends to save energy.

Green Button may not be the only or the best approach for consumer access to smart meter data. But it is an important strategy to establish a precedent and forum for data sharing, and it's already demonstrating its potential to spur innovation around smart grid tools and apps. By agreeing to utilize an open data standard, utilities and developers provide greater value to consumers, who, as a result, are able to access not only energy use data, but useful analyses and assessments of that data, via software applications.

Barriers to Data Access

It is important to recognize that, at this point, energy data tools such as Green Button only provide value for customers of participating utilities that join the initiative and voluntarily make data accessible. The issue of data access is more complex than simply agreeing upon a standard energy format. Data access touches on larger issues of information ownership and control. Utilities are being asked to share data that has historically remained under their purview. Similar to the creation of energy efficiency programs, a new business model with revenue opportunities will need to be presented to utilities before they are convinced of the value of participating in data sharing initiatives allowing third-party access.

Most utilities are just beginning to fully evaluate the issue of data sharing. In an age when consumers want more information and more control over their energy use, utilities are being challenged to redefine their role in a new smart energy building and smart grid marketplace. These challenges involve far reaching, complicated issues, the answers to which will likely emerge through upcoming years of market development, guided by regulatory and policy action. In the face of these questions, 19 major utilities representing 27 million customers are already engaged in the Green Button program. These utilities have determined that open data access can provide benefits to them, as well as their customers.

Customer Awareness

Consumer awareness about the smart energy building technologies that connect to the grid is an essential component for building the smart market. Without consumers to test, use, and purchase smart grid devices and applications, there will be no market. The market for smart grid tools will be driven by consumer demand for enabling technologies that turn data into actionable information and empower individuals and businesses to make informed decisions about energy use. However, consumers are not likely to demand, or even inquire about, such technologies if the benefits of the smart grid are not made clear.

Just like utilities, consumers must be presented with a compelling value proposition before they will participate and adopt smart grid technologies.[44] States and utilities already committed to deploying the smart grid and its associated technologies should direct resources toward consumer education strategies. In addition, greater coordination between the federal government, utilities, state energy offices, and tech developers will be needed to seize the opportunity to shape a national conversation about the smart grid and build support for technology implementation among end-users. An example of this national effort to build awareness is the Smart Grid Consumer Collaborative (SGCC). Founded in 2010 as a nonprofit organization representing major smart grid stakeholders, SGCC's mission is to bring together key stakeholders to "work toward a common goal of accelerating the adoption of a smart grid that is consumer-friendly, consumer-safe, and consumer approved."[45] To further its mission, the SGCC conducts primary research to understand consumer priorities with regard to the smart grid; maintains a knowledge base of best practices, which are shared among all stakeholders; and educates consumers via outreach, events, and messaging toolkits for member use.[46]

Conclusion

The smart grid holds the potential to drastically change the U.S. electric grid. Benefits from the implementation of smart grid technologies include improving grid reliability and operation; making it easier to integrate distributed generation; and achieving efficiencies throughout the grid's transmission and distribution system. In addition, smart grid and enabling technologies present opportunities to improve the energy efficiency of U.S. buildings through several channels.

Enabling technologies, designed to display information about customer energy use, can provide real-time feedback about energy used in homes and businesses. Experience has demonstrated that access to this type of information will lead to more energy efficient behavior. Smart grid, implemented in combination with dynamic electricity pricing, will allow utilities to implement demand response programs. While designed to reduce peak loads, these programs have also proven to be effective at inducing overall reductions in energy use at customer facilities. Continuous commissioning, enabled by advanced communication and smart grid technologies will enable commercial energy users to constantly maintain equipment at optimal efficiency levels. And improved EM&V capabilities will allow more accurate assessment of the energy savings impacts of efficiency programs and the expansion of those programs that are proven to be effective.

While the smart grid holds great promise for advancing the pursuit of energy efficient buildings, supportive policies and programs will be necessary to guarantee that results are realized. Policies and regulations that support energy efficiency, smart grid deployment, and dynamic electricity pricing models will be essential. Access to smart meter data by consumers and designated third-party service providers will be necessary to ensure a dynamic, open, competitive market for smart grid-enabled technologies. Additionally, support for research, development, and deployment activities related to smart grid and enabling technologies is critical to ensure the engagement of residential, commercial, and industrial customers in smart grid programs and applications.

ASERTTI

The Association of State Energy Research and Technology Transfer Institutions (ASERTTI) promotes energy efficiency and clean energy applied research and commercialization through state, federal, and private collaboration on emerging and breakthrough energy technologies. ASERTTI members include state energy agencies, university energy centers, national laboratories, non-profit organizations, utilities, and others.

ASERTTI's mission is to increase the effectiveness of energy research efforts in contribution to economic growth, environmental quality, and energy security. ASERTTI accomplishes this by:

- Collaborating on research projects with state, federal, and private partners
- Sharing technical and operational information among members and associates

ASERTTI Buildings Committee

The ASERTTI Buildings Committee works with public, private and nonprofit stakeholders to support the development and application of low-impact, energy efficient building technologies. Committee activities are driven by member interests and expertise.

To learn more about ASERTTI, including membership opportunities, visit www.asertti.org.

Appendix A: ASERTTI Members Engaged in Smart Energy Building Activities

Advanced Energy's Applied Buildings Science team provides training, consultation, applied research, and program development to help the building industry produce better products. Advanced Energy offers a wide variety of training products and services designed to translate technical building science knowledge into practical solutions that can be implemented in the field. In addition, Advanced Energy provides assistance with the development and deployment of building science programs, both regionally and nationally. A library of building science information is available through the organization's website, http://www.advancedenergy.org/.

Brookhaven National Lab (BNL) researchers are working to improve the efficiency of building systems, which includes developing the next generation of heating, ventilation, and air conditioning equipment. In addition, BNL is collaborating with utilities to model the smarter electric grid and conduct cost-benefit analyses. The lab has received funding to develop the Smarter Grid Research, Innovation, Development, Demonstration, Deployment ($SGRID^3$) Center in partnership with Stony Brook University. $SGRID^3$ is designed to foster the development of new smart grid technologies by providing an infrastructure for research and testing. BNL is also a member of the New York State Smart Grid Consortium (http://nyssmartgrid.com/) and the Smart Grid Consumer Collaborative (http://smartgridcc.org/). Visit BNL's website to learn more: http://www.bnl.gov/world/.

California Energy Commission (CEC) promotes building energy efficiency and conservation by setting California's appliance and building efficiency standards. The CEC also supports energy research, development, and deployment through its Public Interest Energy Research (PIER) program. PIER conducts and funds research in several areas, including buildings and smart grid. PIER's buildings research explores new and emerging energy efficiency technologies suitable for residential and commercial building applications. PIER's smart grid research focuses on four topic areas: demand response, energy storage, transmission and distribution, and security. Learn more about the PIER program at http://www.energy.ca.gov/research/.

Desert Research Institute (DRI) researchers are examining the integration of intermittent renewable generation with the smart grid, by matching the output of these generators with electricity demand. The research aims to provide feasibility data for the expansion of wind and photovoltaic energy production to meet residential, commercial and industrial loads throughout the country. DRI also operates a Renewable Energy Experimental Facility (REEF), consisting of a demonstration net-zero energy home and workshop facility. Details are available here: http://www.dri.edu/.

Energy Center of Wisconsin (ECW) provides a wide range of services to help architects, designers, owners, builders, manufacturers, and utilities improve building performance. Services include: early design assistance; building systems assessment, modeling, and research; energy management for existing buildings. ECW was selected by ComEd of Chicago to design and administer its new construction design service, which aims to improve standard building practices to make commercial and industrial buildings more energy efficient. Further information is available on the ECW website, http://www.ecw.org.

Energy Resources Center (ERC), University of Illinois at Chicago: The ERC's Engineering Solutions group is focused on solving energy problems in industrial, commercial, institutional, and residential markets. Through energy audits, computer modeling, and on-site consultation and assessments, the ERC team identifies opportunities for improved efficiency and reduced utility bills. ERC works with city, state, and national organizations to deliver efficient and cost-effective solutions. Learn more here on the ERC website, http://www.erc.uic.edu.

Electric Power Research Institute (EPRI) conducts research and development relating to the generation, delivery and use of electricity for the benefit of the public. One focus of EPRI's work is the development of building envelope materials and end-use technologies that offer increased efficiency and improved demand-response capabilities, for use in residential and commercial buildings. In addition, EPRI is engaged in extensive research addressing smart grid technologies and deployment. EPRI's Smart Grid Resource Center (http://www.smartgrid.epri.com), which includes an online research library; information about EPRI's smart grid demonstration project initiative, which includes several regional demonstrations and supporting research exploring the integration of distributed energy resources with the smart grid; and details about EPRI's IntelliGrid Program, focused on the development of smart grid standards and the promotion of interoperable systems. EPRI is also an advisory member of the Smart Grid Information Clearinghouse (http://www.sgiclearinghouse.org/).

Gas Technology Institute (GTI) promotes energy efficiency through the development of products and programs for the residential, commercial, and industrial sectors. In the residential sector, GTI offers expertise in space conditioning and water heating, with programs and projects that cover traditional equipment such as furnaces, boilers and HVAC systems; water heaters (advanced tank and tankless products); cooking equipment; hearth and outdoor products; and building systems issues for multi-family dwellings (e.g., venting and code issues). GTI has played a role in the development of advanced high efficiency, low-emission gas-fired equipment for the commercial sector, with a special emphasis on commercial food service equipment, water heating, steam generation and space conditioning. Learn more here: http://www.gastechnology.org.

Iowa Energy Center (IEC) is engaged in a variety of energy efficiency research, demonstration, and education projects. The National Building Controls Information Program was established to address energy efficiency problems associated with building controls. IEC's Energy Resource Station allows for the simultaneous testing and demonstration of multiple, full-scale commercial building heating, ventilation, and air conditioning systems. In addition, IEC provides performance information on energy-efficient lighting through the Lighting Research Center. Visit the IEC website for details: http://www.iowaenergycenter.org/.

Long Island Power Authority (LIPA) was awarded $12.5 million from the U.S. DOE for the Smart Energy Corridor project, a collaboration between LIPA, Stony Brook University, and Farmingdale State College to create the first smart grid on Long Island. The project plans include integration of smart grid technologies, smart meters, distribution automation, distributed energy resources, and electric vehicle charging stations. In the spring of 2012, LIPA began installing approximately 2,000 smart meters in homes and businesses located along the Route 110 corridor. LIPA also provides financial incentives to support the design and construction of commercial buildings that are as energy efficient as current technology and design allows. Learn more on the LIPA website, http://www.lipower.org/.

New York State Energy Research and Development Authority's (NYSERDA's) Buildings RR&D program is to advance the development and application of energy efficient building-related technologies. Over the past decade, the Buildings R&D group has helped small businesses to introduce 40 new products, create 334 jobs, increase New York product sales by $238 million, and achieve energy savings of about $161 million. Through the Electric Power Transmission and Distribution (EPTD) Smart Grid Program, NYSERDA is supporting research and engineering studies, product development, and demonstration projects that promote the implementation of a smart grid and improve the performance of New York State's electric power and delivery system. NYSERDA is a member of the New York State Smart Grid Consortium (http://nyssmartgrid.com/), a public-private partnership to promote broad statewide implementation of the smart grid. Further information can be found on NYSERDA's website: http://www.nyserda.ny.gov/.

North Carolina Solar Center (NCSC): NCSC's High Performance Building program provides technical assistance, education, and support to the building industry in constructing resource-efficient commercial, institutional, and residential buildings. Information available here: http://ncsc.ncsu.edu/.

Northeast Energy Efficiency Partnerships (NEEP): Since 1996, NEEP has been facilitating regional partnerships to advance the efficient use of energy in homes, buildings, and industry in the Northeast and Mid-Atlantic States. NEEP's Commercial Buildings and Technologies Initiative is aimed at improving energy efficiency in commercial and industrial buildings through the integration of technologies and best practices in building systems. The goal of NEEP's High Efficiency Home Performance Initiative is to maximize energy savings in existing homes by coordinating the work of various regional market actors promoting widespread adoption of whole house energy efficiency programs. NEEP also works to promote energy-efficient lighting through its Solid State Lighting and High Efficiency Residential Lighting initiatives. Learn more on the NEEP website: http://neep.org/.

Oregon Department of Energy (ODE) works with state agencies to improve the energy efficiency of the state's public buildings. Oregon's State Energy Efficiency Design (SEED) program directs state agencies to work with ODE to ensure that cost-effective energy conservation measures are included in new and renovated public buildings. Since 2001, all new state facilities are required to exceed the energy conservation provisions of the Oregon State building code by at least 20 percent. Program details are available here: http://www.oregon.gov/energy/cons/seed/.

Sacramento Municipal Utility District (SMUD) received a $127 million Smart Grid Infrastructure Investment Grant from the U.S. DOE in 2009. The funding is supporting the installation of an automated metering infrastructure network to read more than 600,000 smart meters across the utility's service territory. In coordination, SMUD is providing customers with access to a powerful new online tool to view their hourly, daily and monthly electricity use. An advanced operating system will be deployed as part of this smart grid initiative. After completion of the project in 2013, the estimated benefits will be an approximate 10.4 MW reduction of peak summer load and 36,520 MWh of annual energy savings. Details can be found on SMUD's website: https://www.smud.org.

Washington State University (WSU) Energy Program assists the construction industry, code officials, facility managers, homeowners, and others to improve the efficiency of buildings. WSU offers training on a number of building topics, including code compliance, duct testing, certifications, and more. WSU manages the Northwest ENERGY STAR Homes regional initiative to promote the construction of energy efficient homes. The program also operates a Natural Exposure Test Facility for wall system moisture and thermal-performance testing. As part of the U.S. DOE's Building America Industrialized Housing Partnership and the Building Industry Research Alliance, WSU experts evaluate energy-efficient homes constructed in the Pacific Northwest. In addition, program staff members develop two to four peer-reviewed research papers each year on emerging energy efficiency strategies for residential buildings. Learn more about the WSU Energy Program's work at http://www.energy.wsu.edu.

Wisconsin Energy Research Consortium conducts research on smart grid technologies. Program details are available at http://www.energywercs.org.

ASERTTI is also a member of the **Zero Energy Commercial Buildings Consortium**'s Steering Committee**.** Information available here: http://zeroenergycbc.org/.

Appendix B: Smart Grid and Smart Energy Building Resources

Federal Government

U.S. Department of Energy, SmartGrid.Gov is the gateway to information on federal initiatives that support the development of the technologies, policies and projects transforming the electric power industry. You can view this resource at http://www.smartgrid.gov/

U.S. Department of Energy, Office of Electricity Delivery & Energy Reliability provides a wide array of information on smart grid at the federal level. http://energy.gov/oe/technology-development/smart-grid

Title XIII of the Energy Independence and Security Act of 2007 which sets forth the policy of the U.S for smart grid initiatives and programs.
http://energy.gov/sites/prod/files/oeprod/DocumentsandMedia/EISA_Title_XIII_Smart_Grid.pdf

Federal Smart Grid Task Force works to ensure awareness, coordination and integration of the diverse activities of the federal government related to smart grid technologies, practices, and services.
http://energy.gov/oe/technology-development/smart-grid/federal-smart-grid-task-force

American Recovery and Reinvestment Act (ARRA) Smart Grid Investment Grants and Smart Grid Demonstration Projects

- http://energy.gov/oe/technology-development/smart-grid/recovery-act-smart-grid-investment-grants
- http://energy.gov/oe/technology-development/smart-grid/recovery-act-sgdp

National Organizations and Networks

American Council for an Energy-Efficient Economy is a nonprofit organization that acts as a catalyst to advance energy efficiency policies, programs, technologies, investments, and behaviors.
http://www.aceee.org/topics/smart-grid

Green Button is an industry-led effort that responds to a White House call-to-action to provide electricity customers with easy access to their energy usage data in a consumer-friendly and computer-friendly format via a "Green Button" on electric utilities' website. http://www.greenbuttondata.org/

Institute for Electric Efficiency (IEE) focuses on accelerating the electric power industry's energy-efficiency efforts and increasing the industry's associated investments. IEE works with the electric utility industry, regulators, policymakers, and other stakeholders to advance customer-side solutions for energy management including energy efficiency, demand response, distributed power, and customer-focused technologies. http://www.edisonfoundation.net/iee/Pages/IEEHome.aspx

Edison Electric Institute (EEI) is the association of U.S. shareholder-owned electric companies. EEI's members serve 95 percent of the ultimate customers in the shareholder-owned segment of the industry, and represent approximately 70 percent of the U.S. electric power industry. http://smartgrid.eei.org

GridWise® Alliance is an organization that represents a broad range of the energy supply chain from utilities to large tech companies to academia to venture capitalists to emerging tech companies. The entities involved create a smart grid forum for sharing new ideas and concepts. http://www.gridwise.org

National Association of Regulatory Utility Commissioners (NARUC) is a non-profit organization dedicated to representing the State public service commissions who regulate the utilities that provide essential services such as energy, telecommunications, water, and transportation. NARUC has developed smart grid policies that can be viewed at http://www.naruc.org/SmartGrid/.

Institute for Building Efficiency is a new initiative of Johnson Controls providing information and analysis of technologies, policies, and practices for efficient, high performance buildings and smart energy systems around the world. http://www.institutebe.com/smart-grid-smart-building.aspx

Electric Power Research Institute (EPRI) – Smart Grid Resource Center. EPRI is an independent, non-profit company performing research, development and demonstration in the electricity sector for the benefit of the public. EPRI's Smart Grid Resource Center provides information on current research and demonstration projects. http://smartgrid.epri.com

Smart Grid Information Clearinghouse (SGIC) is administered by the Virginia Tech Advanced Research Institute and receives input from many organizations within 12 stakeholder groups. http://www.sgiclearinghouse.org/

Smart Grid Consumer Collaborative (SGCC) is a nonprofit organization that works to learn the wants and needs of energy consumers in the United States, encourage the collaborative sharing of best practices in consumer engagement among industry stakeholders, and educate the public about the benefits of the smart grid. http://smartgridcc.org

Smart Grid News and Updates

Smart Grid News provides news and analysis for the modernization and automation of electric power. http://www.smartgridnews.com

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