Papers & Publications: Interdisciplinary Journal of Undergraduate Research

Volume 2 Article 14

2013

Implementation of Smart Grid Technology in the United States

Theresa Monypeny
Sewanee: University of the South

Recommended Citation

Monypeny, Theresa (2013) "Implementation of Smart Grid Technology in the United States," *Papers & Publications: Interdisciplinary Journal of Undergraduate Research*: Vol. 2 , Article 14.
Available at: http://digitalcommons.northgeorgia.edu/papersandpubs/vol2/iss1/14

Background

Both the past and present goal of the electric power industry has been to provide a reliable supply of electricity at a reasonable cost for consumers; however, the electric grid system, little changed since its creation well over a century ago, can no longer support the multifaceted and increasing demands of today's society (Blumsack and Fernandez 2012). The current operating system in the United States, referred to as 'the grid' within this paper, relies on a three link power supply chain fueled by fossil fuels (including oil, natural gas, and coal), renewable energy, or nuclear fission (Abel 2007). Within the first link of the electricity supply chain, power station transmission substations, often located long distances from consumers, produce and convert energy from medium voltage to high voltage alternating currents (Able 2007). High voltage currents produced by power stations then travel over a network of 300,000 miles of transmission wires to substations located near consumers, where a series of locally distributed transformers step down the voltage to less than 10 kV and distribute the electricity to consumers (Able 2007, Blumsack and Fernandez 2012). Due to the weaknesses within each link of this antiquated system, many critics question the ability of the system to adapt to changing modern conditions.

The global volatility surrounding oil and petroleum supplies, increasing scarcity of coal, and growing concerns over environmental degradation have exposed critical weaknesses in the first link of the U.S. grid system. In the past decade, fossil fuel prices have been steadily increasing, with natural gas prices increasing from \$2/GJ in 1990 to \$6.6/GJ in 2007, seam coal increasing from \$41/tonne in 2003 to \$67/tonne in 2005, and crude oil increasing from \$18/bbl in 1990 to \$80/bbl in 2007 (Rout et al. 2008). Increasing prices for fossil fuels, due to scarcity and exponentially increasing demands, coupled with concern over global warming, have forced the United States to promote the incorporation of alternative sources of energy into the current grid system. However, power stations comprising the first link of the chain have been unable to successfully incorporate renewable energy—such as wind, geothermal, and solar energy— into their energy portfolios because of the inherently intermittent supply of energy from these sources, with many renewable sources unable to supply power for longer than 1/3 of the day (Ferrey 2009). Traditional coal fired power plants are unable to accommodate the intermittent nature of these resources because of their use of nonaero-derivitive generators which take an extended period of time to warm up; this means that these generators burn fossil fuels before power can even be produced and continue to burn fossil fuels long after the generators have been shut down (Ferrey 2009). Consequently, traditional coal fired generators cannot be restarted quickly after being shut down to accommodate wind or solar energy supplies; such ineffective incorporation of renewable energy has resulted in the current emission of more than 1/3 of the carbon dioxide in the United States (Ferrey 2009).

Problems in energy supply are also present in both the second and third links of the energy supply chain. The second link of the chain consists of a 300,000 mile network of transmission lines across the United States, with many of the lines being at least half a century old; consequently, power plants lose approximately 10 % or more of the energy produced within the power stations along the lines from the power plant to the consumer (Parks 2009). The transmission lines are also ineffective in connecting areas with abundant supplies of renewable resources to areas with limited access to renewable resources (Ferrey 2009). In the final link of the grid system, once the power reaches the local substations, utility operators carefully monitor consumer use and dispatch energy to meet consumer demands (Blumsack and Fernandez 2012). As a result, consumers are unable to influence operational decisions or express personal preferences for levels of reliability or service quality (Blumsack and Fernandez 2012). The exclusion of consumers from the energy market effectively prevents consumer access to real time pricing of energy and discourages the implementation of energy conservation and efficiency measures (Rokach 2010). Growing populations and rising rates of consumption are placing increasing demands on all links of the grid; as a result, blackouts across North America are increasing in frequency (Hines et al. 2007).

In response to the many challenges faced by the current grid, a new system—known as the Smart Grid—has emerged as the future of the energy industry. In general, the Smart Grid is an "electricity network that can intelligently integrate the behavior and actions of all users connected to it—generators, consumers and those that do both—in order to efficiently deliver sustainable, economic, and secure electricity supplies" (Clastres 2011). In practice, this requires a combination of management and reporting software constructed within an intelligent communications infrastructure (Miller 2009). Within the new grid system, improvements will reach from power plants to the consumer through the implementation of smart distribution systems, in-home information displays (IHD), and dynamic pricing (Hledik 2009).

The smart distribution component of the Smart Grid focuses on improving the current grid by installing new sensors, monitoring technology, and storage equipment while creating a more distributed, decentralized network of power stations (Blumsack and Fernandez 2012, Hledik 2009). Within the current system, a few centralized power stations located large distances from consumers produce the power in the grid, but the new distribution system seeks to distribute power among many, smaller power stations located near consumers (Hledik 2009). By reducing the distance between the power stations and consumers, transmission and distribution losses—common in the current system—will be minimized (Hledik 2009). Also, a larger, more interconnected system of distribution networks outfitted with new monitoring technology will increase reliability within the system by allowing plant operators to control energy flows across the grid with more precision and to quickly identify and respond to outages or to reroute electricity to areas that would otherwise experience the blackouts (Blumsack and Fernandez 2012, Hledik 2009).

Another important aspect of the smart distribution system is its ability to handle diverse energy inputs, including renewable energy from solar, wind, and geothermal systems; in order to accommodate the intermittency of renewable power, the Smart Grid will increase the deployment of electricity storing technologies which would increase the amount of energy supplied by renewable resources, reduce dependence on fossil fuels, and increase the flexibility of the grid system (Hledik 2009). Increased flexibility within the grid system will also benefit homes and businesses that utilize personal solar panels or wind turbines by allowing those consumers to sell excess electricity back to the grid (Hledik 2009). However, quick-start aero-derivative generators (capable of restarting in less than 10 min after being shut down) will need to accompany the deployment of increased electricity storage technology in order to accommodate the incorporation of intermittent renewable energy supplies (Ferrey 2009). Advanced storage technology coupled with the quick-start generators will facilitate greater use of renewable energy under the Smart Grid system and assist in reducing greenhouse gas emissions from the energy sector (Ferrey 2009).

Smart meters and in-home information displays are also fundamental components of the Smart Grid system. Within the current grid system, companies charge consumers the same rate for each unit of electricity used, and those utility companies record (using conventional meters) and manually collect that information; however, a new smart meter system would more accurately record electricity usage, use a dynamic pricing model to charge consumers for their electricity usage, and replace conventional meters within the Smart Grid to create two-way communication between consumers and the electricity providers (Depuru et al. 2011, Hledik 2009, Parks 2009). Instead of charging consumers a flat rate for each unit of electricity, regardless of the time of day, the dynamic pricing model would charge consumers higher rates for electricity units consumed during peak power usage periods while units consumed in nonpeak periods would be less expensive (Hledik 2009). The smart meter is a digital electric meter that measures real time energy consumption and stores electricity usage history of consumers; utility companies are then able to read the information stored in the smart meters remotely and automatically (Depuru et al. 2011, Hledik 2009). After gathering information about consumer energy usage, the utility company can send information on grid conditions or electricity prices to consumers through in-home information displays so that consumers can adjust their energy use accordingly (Blumsack and Fernandez 2002). As a result, consumers will be able to see how electricity prices fluctuate throughout the day and potentially allow consumers to shift electricity usage to times when prices are low or to reduce the amount of electricity being used (Blumsack and Fernandez 2002). Blumsack and Fernandez (2002) suggest that load shifting in response to price fluctuations could reduce carbon dioxide emissions by approximately 10 % annually. Also, by providing consumers with information of price dynamics, those users could collectively reduce peak power usage by approximately 15 % annually and save consumers an average of 10 % annually (Parks 2009). Therefore, within the smart meter system, consumers have an incentive to reduce electricity usage and implement conservation measures.

Attempts to deploy smart meters into existing homes have met with many challenges, including limited funding, insufficient technological support, and privacy rights issues (Depuru et al. 2011). Some critics of the smart meter argue that data gathered may be used to infer activities that occur within a private dwelling; additionally, they claim that commercial entities will use the data gathered from consumers to increase their profits (McKenna et al. 2012). Others argue that information gathered by the smart meter strongly correlates with house occupancy; such information may be used by burglars intending to rob the targeted house (McKenna et al. 2012). However, proponents of the smart meter system are addressing the weaknesses in smart meter cyber security (McKenna et al. 2012). One must weigh these costs against the benefits of the Smart Grid system; benefits include potential reductions in greenhouse gases, increases in reliability, increased efficiency, and reduced electricity bills for consumers. For many, the benefits of the Smart Grid system outweigh the potential costs, with future improvements in technology addressing potential cyber security issues.

Policy Context

Electricity policies in the United States created in the twentieth century have been slow to adjust to the recent technological revolution; as a result, policies are usually biased toward using existing infrastructure and institutions (Blumsack and Fernandez 2002). Both the federal and state levels of government are given authority over different aspects of electricity usage and pricing. The first policy specifying the role of federal and state governments in the electricity industry is the *Federal Power Act*, passed in 1935 (Weeks 2010). The *Federal Power Act* (1935) relegates the regulation of wholesale market electricity to the newly created agency, the Federal Energy Regulatory Commission (FERC), while charging states with the regulation of electricity prices at the retail level (Weeks 2010). In the years following the *Federal Power Act* (1935), U.S. energy policy (such as the *National Energy Act* (1978) and the *Energy Policy Act* (1992)) continued to focus on creating short term plans to reduce reliance on petroleum and decrease domestic energy consumption (Stolte 2006). However, the passage of the *Energy Policy Act* in 2005 represented the first policy initiative urging state utilities to incorporate renewable energy and Smart Grid pricing components.

In response to unrest in the Middle East and rising oil and natural gas prices in the early 2000s, Congress passed the *Energy Policy Act* (2005). The *Energy Policy Act* (2005) was a significant victory for certain aspects of the smart grid system, including dynamic pricing, smart meters, and renewable energy initiatives. Under section 1252 of the *Energy Policy Act*, consumer participation is encouraged through the implementation of smart metering and dynamic pricing:

> Sec 1252(f): FEDERAL ENCOURAGEMENT OF DEMAND RESPONSE DEVICES.—It is the policy of the United States that time-based pricing and other forms of demand response, whereby electricity customers are provided with electricity price signals and the ability to benefit by responding to them, shall be encouraged, the deployment of such technology and devices that enable electricity customers to participate in such pricing and demand response systems shall be facilitated, and unnecessary barriers to demand response participation in energy, capacity and ancillary service markets shall be eliminated. (Public Law, 109th Congress)

The *Energy Policy Act* (2005) also incentivizes consumer installation and incorporation of renewable energy through the implementation of tax credits while promoting increased domestic energy production through renewable energy projects and energy conservation and efficiency measures (Smith 2005, Stone 2009). However, policymakers did not take steps toward the realization of the entire Smart Grid system until 2007 with the *Energy Independence and Security Act* (2007).

In 2007, Congress moved toward creating the Smart Grid with the passage of Title XIII of the *Energy Independence and Security Act* (2007) (Rokach 2010). Under the *Energy Independence and Security Act* (2007), "[I]t is the policy of the United States to support the modernization of the Nation's electricity transmission and distribution system to maintain a reliable and secure electricity infrastructure…characterize[d] by the Smart Grid" (110th Congress

2007). The *Energy Independence and Security Act* (2007) lays out the policy objectives that characterize the Smart Grid:

> (1) Increased use of digital information and controls technology to improve reliability, security, and efficiency of the electric grid. (2) Dynamic optimization of grid operations and resources, with full cyber-security. (3) Deployment and integration of distributed resources and generation, including renewable resources. (4) Development and incorporation of demand response, demand-side resources, and energy-efficiency resources. (5) Deployment of ''smart'' technologies…for metering, communications concerning grid operations and status, and distribution automation. (6) Integration of ''smart'' appliances and consumer devices. (7) Deployment and integration of advanced electricity storage and peak shaving technologies…(9) Development of standards for communication and interoperability of appliances and equipment connected to the electric grid. (110th Congress 2007)

The rest of the *Energy Independence and Security Act* (2007) then details the mechanisms for realizing the above policy objectives, including the formation of a Smart Grid Advisory Committee, which assists in creating standards for smart grid technology across states, and the Smart Grid Task Force, which coordinates future policies (Rokach 2010). However, state governments still retain their role as the primary regulators of the distribution and sale of electric power. As a result, the FERC is unable to require states to implement retail level electricity programs or policies, but the FERC does have the authority to ensure that the products used at the retail level conform to a national standard (Richman 2010). Unfortunately, the overlap in federal and state authority has inevitably created tension between states and the FERC (Richman 2010).

While both the *Energy Policy Act* (2005) and the *Energy Independence and Security Act* (2007) include provisions directing states (who play a significant role in deploying Smart Grid technology) to expand efforts in creating a smarter grid system, neither act provides sufficient monetary support for technological updates or education for locals on how to incorporate these new systems into the local grid (DRSG 2008). As a result, only select states, including California, New York, and the Mid-Atlantic states, with the expertise and funding for Smart Grid systems have begun to deploy smart meters, with installations levels reaching 4.7 % in 2007 (Miller 2009). Policies for the Smart Grid are still in the early stages, but more policies and funding will be necessary for continued progress.

Regulatory Barriers to the Smart Grid

Regulatory agencies in the electricity industry are responsible for ensuring reliability as well as evaluating risks associated with investing in Smart Grid technology in order to protect consumers from bearing the costs of the transition to the Smart Grid (Brown and Salter 2010). At the federal level, the FERC has jurisdiction over the sale of power at the wholesale level and authority to standardize the deployment of smart grid technology (Rokach 2010, Weeks 2010). Over the past 30 years, federal policies and the FERC have promoted competition within the electricity industry; as a result, market forces have become increasingly important in regulating wholesale prices of electricity (Brown and Salter 2010). However, consumers are only able to reap the benefits of these dynamic pricing initiatives if states, which regulate generation, distribution, and retail pricing, also use dynamic pricing at the retail level (Rochak 2010). Consequently, future deployment of the Smart Grid system relies on increased communication and regulatory coordination between both the state and federal levels.

State Utility Commissions are the main regulating agencies at the state level, but the diversity in electricity industry structure has posed regulatory challenges for State Utility Commissions. Historically, the entire electric industry was monopolistic and relied heavily on State Utility Commissions as regulators, but recent movement toward alternative energy use and technological advancement has pushed many states to adopt policies facilitating electric industry 'deregulation' (Brown and Salter 2010).

Under the monopoly model of the electricity industry, still used in 26 states, utility companies receive exclusive rights to service certain areas if the company agrees to regulations imposed by State Utility Commissions (Brown and Salter 2010). For example, retail level prices are set by regulators; regulators identify the revenue requirements of the utility and set a price that is likely to yield that revenue (Brown and Salter 2010). Regulated pricing coupled with profit caps create a risk adverse environment which stymies innovation; as a result, monopoly utilities are unlikely to invest in Smart Grid technology because of the risks associated with implementation and the reduced potential returns due to profit capping by regulators (Brown and Salter 2010). The socialization and use of average-cost pricing by regulators also presents another barrier to the adoption of Smart Grid technology and policy (Brown and Salter 2010). The foundation of the Smart Grid relies on the use of smart meters to provide consumers with accurate information of how prices change with the time of day; the utilization of average-cost pricing by monopolistic utilities obscures these pricing signals and eliminates any benefit of investing Smart Grid technology (Brown and Salter 2010). Therefore, policymakers need to address issues in pricing and regulation in order for the transition to Smart Grid technology to occur.

The lack of innovation and progress in monopolistic utilities toward a smarter grid has pushed some states to 'deregulate' the industry by opening up the market to competition (Brown and Salter 2010). A total of 24 states in the U.S. have been progressing toward deregulated markets, shifting regulation from State Utility Commissions to market forces (Bettelheim 2000). The lack of regulation on profits for deregulated utilities incentivizes the adoption of Smart Grid technology because of the increased profit potentials (Brown and Salter 2010). Also, consumers have the power to choose their electricity supplier in a market that allows competition and the entry of new utility providers, including those that utilize 'green' power, as well as access to dynamic pricing options (Bettelheim 2000). Benefits for consumers in deregulated markets include lower electric bills, power to pick renewable energy sources, and ability to control their service quality (Bettelheim 2000). Although there are many benefits in a deregulated market which support the progression toward the Smart Grid, the transition to deregulation is often fraught with regulatory costs that prevent consumers from reaping the benefits of a deregulated market (Bettelheim 2000). Currently, debates over deregulation focus on increasing the role of regulation standards at the federal level to protect consumers from costs that are associated with the process of deregulation (Bettelheim 2000). Continued governmental funding support for monopoly industries has caused concern amongst environmentalists who claim that green energy cannot compete with the still powerful monopoly industry (Bettelheim 2000). However, it is clear that deregulation, which emphasizes innovation and dynamic pricing, is necessary for the national adoption of the Smart Grid.

Institutional Involvement

Currently, over 3,200 electric utilities and an increasing number of alternative suppliers provide electricity services in the United States; however, ownership of these utilities and alternative supplies is complex, with 250 of these utilities being investor owned, 2,000 municipally owned, 1,000 owned by rural cooperatives, and 10 owned by the state or federal agencies (Stevenson and Penn 1995). Such complexities in ownership and the growing number of alternative suppliers entering deregulated markets have resulted in an intricate network of interacting institutions at both federal and state governmental levels.

At the federal level, many institutions manage and plan for the modernization of the current grid system. Funding for states attempting to deploy smart grid technology, as well as grants for pilot micro-smart grid programs, has primarily been the responsibility of the Department of Energy (Weeks 2010). However, the regulation of these programs is the responsibility of the FERC under the *Federal Power Act* (1935) (Brown and Salter 2010). The FERC, according to the *Energy Independence and Security Act* (2007), is responsible for the transmission and sale of power at the wholesale level and the deployment of standardized smart grid sensor technology (Rochak 2010). The *Energy Independence and Security Act* (2007) also created three other agencies responsible for planning the Smart Grid transition: the National Institute of Standards and Technology, the Smart Grid Advisory Committee, and the Smart Grid Task Force (Brown and Salter 2010). The primary responsibility of the National Institute of Standards and Technology is to ensure that smart grid technologies are standardized to make certain state systems can interact with each other (Brown and Salter 2010). The *Energy Independence and Security Act* (2007) also formulated a Smart Grid Advisory Committee, which is responsible for "advise[ing]…federal officials concerning the development of smart grid technologies…[and] the progress of national transition", as well as the Smart Grid Task Force to "ensure awareness, coordination and integration of activities…related to smart-grid technologies and practices" (*Energy Independence and Security Act,* 2007). All of the aforementioned agencies derive their jurisdiction over the Smart Grid transition from the *Energy Policy Act* (2005) and the *Energy Independence and Security Act* (2007).

At the state level, many actors are involved in the Smart Grid transition, including rural cooperatives, investors, stakeholders, and independent systems operators (Stevenson and Penn 1995, Weeks 2010). State public utility commissions under the *Federal Power Act* (1935) have authority over the generation and distribution of power as well as pricing at the retail level (Rochak 2010). Public utility commissions are also the primary regulatory agency of utilities; deployment of smart grid technologies and the transition to a Smart Grid deregulated market depend on utility commissions' regulations to protect consumers from market forces (Rochak 2010). Independent systems operators will also play an important role in the transition to the Smart Grid due to their role as managers of the grid (Weeks 2010). Independent systems operators communicate the balance of power in and out of the system within each state;

consequently, many of the Smart Grid technologies will be operated by independent systems operators. Because of all of the institutions involved in the progression toward the Smart Grid, its success will require the cooperation, communication, and interaction of all the previously mentioned entities (Weeks 2010).

Policy Solutions and Recommendations

Progress toward the realization of the Smart Grid in the United States has been slow, as policies and regulations struggle to keep pace with technological innovation. The *Energy Independence and Security Act* (2007) and the *Energy Policy Act* (2005) have succeeded in defining the goals of the Smart Grid and creating agencies responsible for formulating plans for modernization, but the energy sector needs more policies to accelerate the transition and promote renewable resource use. Both the *Energy Independence and Security Act* (2007) and *Energy Policy Act* (2005) only suggest that states should consider deploying Smart Grid technologies; because neither policy requires states to use the new technologies, monopolistic utilities have been slow to invest in system upgrades (Brown and Salter 2010). Utilities have also been slow to adjust to new technologies because of the traditional regulatory policy which links profits with sales; in short, the more electricity the industry sells, the more it will profit (Brown and Salter 2010). Consequently, the industry has no incentive to adopt smart grid technologies that would aid in conserving energy (Brown and Salter 2010). Although deregulation solves this problem by decoupling profits from sales, few policies have addressed the role of regulatory agencies in these new markets (Bettelheim 2000). As of now, few policies exist in deregulated markets which would prohibit abuses of market power. Future policies will need to address the role of state utilities and the FERC in an evolving electricity industry.

Cyber security issues and consumer concerns over privacy have also hindered the mass deployment of smart metering technology. According to Depuru et al. (2011), groups that may be interested in the energy consumption data collected by smart meters include vengeful ex-spouses, extortionists, terrorists, thieves, and civil litigants. Although the *Energy Independence and Security Act* (2007) explicitly states the importance of increasing cyber security, neither states nor the federal government have put in place policies or regulations to protect such data. However, privacy advocates have proposed several solutions to address the current cyber security issues; these solutions include limiting the amount of data collected by utilities, creating an agency responsible for monitoring privacy issues, limiting the amount of time data can be retained, and increasing encryptions on all smart grid devices (Weeks 2010). In a nation where privacy is of the utmost importance, regulations and policies will need to keep pace with the deployment of smart meters for the Smart Grid to be successful.

Success of the Smart Grid not only relies on regulatory and policy support but also on consumers; a lack of consumer participation will eliminate the benefits associated with the transition to the Smart Grid. Fortunately, studies have indicated consumer support for the new grid technologies (Mah et al. 2012). Consumers are reaping the benefits provided by smart technologies through reduced energy bills and increased control over their energy use; many also view modernization as a solution to climate change and volatile fossil fuel prices (Mah et al. 2012). One of the only barriers in western nations preventing full consumer support of Smart Grid technologies is concern that data collected by these technologies will lead to a breach in privacy. Rising fossil fuel prices, worsening environmental degradation, and increasing influence of technology on all aspects of modern life have created a receptive and supportive cultural environment for Smart Grid deployment (note that although many support the transition, some still resist progress toward the Smart Grid and renewable energy initiatives; for further information on the gap between supporters and critics of the new system, see Sovacool 2009).

The benefits associated with the transition from the current antiquated grid system to a Smart Grid outweigh any potential costs as long as consumers participate in the new system. Among the most important benefits is the role Smart Grid technology will play in climate change mitigation. Studies have shown the implementation of Smart Grid technologies will reduce carbon dioxide emissions by approximately 5-16 % annually by 2030 (Hledik 2009). Not only will the U.S. significantly cut carbon dioxide emissions by increasing inputs from renewable energy sources and assisting consumers in conserving energy, but it will also provide a net gain of green jobs, increase reliability of the current grid, and increase energy independence (Hledik 2009, DSRG 2008). Investments in the Smart Grid system also have the potential to accelerate economic recovery while creating a more sustainable electricity industry for future generations. The private sector can also contribute to the success of the Smart Grid by investing in new technologies that would increase the efficiency and compatibility of the components used within the system (Cavoukian et al. 2010). However, current policies are inadequate to facilitate the transition to the Smart Grid within the next 15 to 20 years (Weeks 2010).

In order to accelerate Smart Grid technological deployment, policymakers need to create tax incentives that reduce investment costs or reduce the cost of renewable energy for consumers (DSRG 2008). Another critical component for Smart Grid deployment is increased allocation of funds to states for Smart Grid pilot projects and electricity infrastructure updates; at the state level, governments need to use funding to update transmission networks, modernize management software, and facilitate the transition from socialized pricing to dynamic pricing models (DSRG 2008). However, many states lack the expertise required to effectively implement and update the many components associated with the Smart Grid system; therefore, states will need to receive federal funding for the expressed purpose of gaining expertise in this new area. In order to ensure the cooperation between all states within this transition period, the federal government needs to set renewable standards that apply to all states. These renewable standards should require states to increase their renewable energy use as well as energy efficiency measures to meet a nationally set standard. Such regulations would require states to reduce carbon dioxide emissions and move toward the full realization of the Smart Grid. New regulations also need to address the role of the FERC in newly deregulated markets; newly deregulated markets require heavier regulations at both the state and federal levels in order to protect consumers from possible abuses of market powers. The recent technological revolution has rendered the current grid system obsolete, making the transition to a smarter grid system inevitable. However, the only way to fully realize the Smart Grid is to increase funding for technology and pilot programs, increase regulations in deregulated markets, and pass new policy initiatives to plan for and manage the Smart Grid system.

Bibliography

Able, A. (2007, December 20). *Smart Grid Provisions in H.R. 6, 110th Congress*. (Congressional Report No. RL34288). Washington DC: Congressional Research Service.

Bettelheim, A. 2000. Utility Deregulation: Can the power industry be opened to competition?. *CQ Researcher*, **10**: 1-16.

Blumsack, S. and A. Fernandez. 2012. Ready or not, here comes the smart grid. Energy, **37(1)**: 61-68.

Brown, A, and R Salter. “Smart Grid Issues in State Law and Regulation.” Galvin Electricity Initiative, 17 Sept. 2010. Web. 19 Oct. 2012

Cavoukian, A., J. Polonetsky, and C. Wolf. 2010. SmartPrivacy for the Smart Grid: embedding privacy into the design of electricity conservation. *IDIS*, **3**: 275-294.

Clastres, C. 2011. Smart grids: Another step towards competition, energy security and climate change objectives. *Energy Policy*, **39(9)**: 5399-5408.

Demand Response and Smart Grid Coalition (DRSG). *Accelerating the use of demand response and smart grid technologies is an essential part of the solution to Americas energy, economic and environmental problems*. Washington: Policy recommendation (111th Congress), 2008.

Depuru, S., L. Wang and V. Devabhaktuni. 2011. Smart meters for power grid: Challenges, issues, advantages, and status. *Renewable and Sustainable Energy Reviews*, **15(6)**: 2736-2742.

Energy Independence and Security Act. “Energy Independence and Security Act of 2007.” Public Law 110-140, 121 Stat. 1492, December 19, 2007.

Ferrey, S. 2009. Restructuring a green grid: legal challenges to accommodate new renewable energy infrastructure. Environmental Law, **38**: 986-987.

H.R. 6--109th Congress: Energy Policy Act of 2005.” GovTrack.us (database of federal legislation). 2005. October 19, 2012

Hines, P., J. Apt, and S. Talukdar. 2009. Large blackouts in North America: Historical trends and policy implications. *Energy Policy*, **37**: 5249-5259.

Hledik, R. 2009. How green is the smart grid. *The Electricity Journal*, **22(3)**: 29-41.

Mah, D.N., J. M. van der Vleuten, P. Hills, J. Tao. 2012. Consumer perceptions of smart grid development: Results of a Hong Kong survey and policy implications. *Energy Policy*, **49**: 204-216.

McKenna, E., I. Richardson, and M. Thomson. 2012. Smart meter data: Balancing consumer privacy concerns with legitimate applications. *Energy Policy,* **41**: 807-814.

Miller, E. 2009. Renewables and the smart grid. *Renewable Energy Focus*, **10(2)**: 67-69.

Parks, N. 2009. Energy efficiency and the smart grid: new energy policy goals for the U.S. promise diverse benefits, including reductions of carbon emissions. Environmental Science and Technology, **43(9)**: 2999-3000.

Richman, G. 2010. "Smart Grid: The devil is in the details." New America Foundation, 23 Feb. Web. 19 Oct. 2012.

Rokach, J. Z. 2010. Unlocking the smart grid. The Electricity Journal, **23(8)**: 63-71.

Rout, K.U., K. Akimoto, F. Sano, J. Oda, T. Homma and T. Tomoda. 2008. Impact assessment of the increase in fossil fuel prices on the global energy system, with and without CO_2 concentration stabilization. Energy Policy, **36(9)**: 3477-3484.

Smith, D. 2005. RE Gains?: The US Energy Policy Act 2005. *Refocus*, **6(5)**: 45-47.

Sovacool, B.J. 2009. Rejecting renewable: the socio-technical impediments to renewable electricity in the United States. *Energy Policy*, **37(11)**: 4500-4513.

Stevenson, R.E. and D.W. Penn. 1995. Discretionary Evolution: Restructuring the Electric Utility Industry. *Land Economics*, **71(3)**: 354-367.

Stolte, J. 2006. The Energy Policy Act of 2005: The Path to Autonomy? *Journal of Legislation,* **33:** 119-143.

Stone, T. 2009. The impact of the Energy Policy Act. *World Pumps,* **2009(511)**: 30-33.

Weeks, J. 2010. Modernizing the Grid: Is the electric power system at risk?. *CQResearcher*, **20(7)**: 145-168.