An Overview of Smart Grid Technology

Teddy Harrison

Grant Smith

Citizens Action Coalition of Indiana

603 E. Washington St, Suite 502

Indianapolis, IN 46204

Main Office: (317) 205-3535 Fax: (317) 205-3599

Email: staff@citact.org

April 20, 2009

Table of Contents

Executive Summary

This research paper focuses on "smart grid" technology and related issues in an effort to gain a clear working understanding of the term and how it is being used by various stakeholders.

"Smart grid" is a term being used by many people and organizations, and yet an authoritative definition of a smart grid is something that has not yet been universally accepted. Several definitions have goals and characteristics in common, such as: digital technology, improved reliability, cyber-security, distributed resources and generation, "smart" technologies that are interactive in real time, advanced storage, customer controlled usage, and interoperability. Adding the goal of achieving zero carbon emissions would have a fundamental impact on how we conceive and implement a functional smart grid society.

The smart grid can work in the public interest by being a powerful tool in environmental stewardship. The development of the distributed grid is an essential step in reaching a vision of carbon-free and nuclear-free energy, and eventually making obsolete the polluting systems we currently use.

In looking at what is achievable now, the utility industry has made varied progress toward testing or implementing smart technologies, which indicates that we have not yet achieved a standardized progress toward a nation-wide smart grid reality. Real steps toward that standardized progress have recently been taken, as FERC's interim policy statement, circulated in April 2009, provides guidance on standards to the electric power industry.

In the meantime there are achievable steps that can be taken now to address the drivers for energy improvement. A stressed grid infrastructure can be eased by affordable end-use energy efficiency initiatives that address both policy-making and also change at the household level. End-use energy efficiency and renewables contribute to addressing global warming and

rising energy costs. Many of the involved technologies or techniques involved are also affordable to implement.

End-use efficiency can be achieved without a smart gird. The potential savings through efficiency now are enormous. Placing an emphasis on the ability of end-use energy efficiency to save hundreds of billions nationwide can be part of a strategy for how we frame the cost/benefits of smart grid development to customers.

Technologies involved in the development of a smart grid are internet-based and interactive in nature, such as smart meters. While the advanced or smart metering technology may be needed in the creation of the smart grid, the current uses of these meters can be abusive to customers. Also, recent predictions suggest the U.S. will make an investment of $300 billion dollars over the next decade, which ultimately will be funded by the taxpayer/ratepayer base. Therefore the technology and cost issues become, inevitably, a policy issue. There is also no single comprehensive timeline for implementation, although some timelines project as far as 2030.

We have to move beyond current conventional thinking to accept this new paradigm of transformative technology and take steps forward that protect the public interest. Given the detailed, expensive and exploratory nature of employing smart grid technology, individual state commissions should hold off approval for smart meter investments until a clear connection to FERC's immediate goals with respect to cost recovery can be proven.

There are two steps to a rational approach to the smart grid issue in Indiana The first, most critical and economical step is to establish an Energy Efficiency Resource Standard (EERS), as already have been implemented by 18 other states. The second step is to develop pilot projects that test smart grid technologies and strategies in order to make more informed policy decisions that will inevitably have sweeping consequences, keeping in close communication with FERC and present mandates.

Just as evidenced by the various local and regional pilot projects that have been undertaken, only incremental progress can be made by individual utilities and stakeholders. In order to fully realize a national transformation to smart grids along with all the attendant technologies needed to make them work, the visionary action must occur at the federal level. What also should occur at the federal level is the adoption of an EERS, as outlined by the ACEEE, which will substantially reduce stress on our current energy systems, create jobs, and produce significant savings not only financially but environmentally. Above all else, critical questions need to be answered, such as the allocation of costs and how the public interest will be protected, before definitive and very expensive action is taken in this swiftly evolving industry phenomenon.

An overview of smart grid technology

Introduction

This research paper focuses on "smart grid" technology and related issues in an effort to gain a clear working understanding of the term and how it is being used by various stakeholders. It is an updated and expanded version of the original paper which was completed and circulated on March 18, 2009. This updated version is based on a literature review of 70 resources, including trade publications, press releases, news articles, governmental publications and various websites, PowerPoint presentations and e-newsletters.

The paper will work to answer the question of what is a smart grid and how it can work in the public interest. It will touch on what is achievable now, and what telecom—and other—technologies are involved. It will explore cost issues along with what is projected as timelines for implementation. It will also discuss the public interest versus utility interests, and will attempt to lay out a rational approach by looking at a few privately funded pilot projects. Finally, the paper will make recommendations, including those found in the literature, and will provide points for further research.

This written piece is not meant to be definitive or to draw conclusions for the reader. Rather, it aims to be informative and provide a current overview of how a complex, extremely dynamic, constantly evolving aspect of the utility industry is being conceptualized by a wide sampling of the stakeholders involved. The paper is also closely tied to citations to provide opportunities for further reading. Along with this working understanding of the smart grid phenomenon is a list of various stakeholders who have been or are active in conceptualizing, piloting, researching or promoting smart grid technology in order to map out key participants that were identified in the research.

What is a smart grid?

"Smart grid" is a term being used by many people and organizations, and yet an authoritative definition of a smart grid is something that has not yet been universally accepted. There are several reasons for this. First, not everybody is on the same page regarding how to define the smart grid. Rather, there are several circulating definitions, each with its own emphasis according to the context in which it is used. Secondly, the ultimate concept of the smart grid involves so many interlocking technological parts that a simple definition may not be achievable. And last, the term appears to be used by several stakeholders as they work to further their agendas. One acknowledgement of this comes from Booth (2008) who stated, "too often, the terms 'smart grid' and 'smart metering' are used together or even interchangeably, as if they are two sides of the same investment coin" (p. 40).

The following is a series of working definitions for a smart grid. Each one is listed here because it either supports a common understanding of the smart grid, which lends to the development of a working definition, or it adds something to a greater explanation of the smart grid phenomenon.

As a first consideration to incorporate into our understanding of the smart grid, Masiello (2008) wrote that today's technological environment calls for us "to develop a different understanding of how we deliver power. We are destined to experience more volatile load on the grid, combined with drastically increased iterations with consumers" (p. 72). What is needed is a grid that will become:

> …a 'power plexus'…that is capable of moving power from any source to any destination and sensing the complex interactions between its 'nodes.' This has deep implications for the way the grid is designed, engineered and operated, and will require changes in the

> technologies and methods used for protection, control and operations. (Masiello, 2008, p. 72)

This would indicate the necessity of a transformative aspect to smart grid technology, from how we conceptualize and utilize power systems today.

As a second addition to the development of underlying concepts involved in a working definition, Van Welie (2008) wrote:

> This "smart grid" means far more than the use of technology. It means establishing "smart" policies that will bring new technology to all corners of the power system to optimize supply, transmission, and conservation. It also means being smart about resource choices in the long term, so that the region can diversify its fuel sources and lessen its reliance on natural gas and oil to produce electricity. (p. 12)

What is needed is a "strategic perspective on communication technology options that bridge the historical gap between the substation and the 'last mile' of primary and secondary distribution feeders delivering power to customers" (Booth, 2009, p. 40).

A few other definitions are comprehensive in concept but are perhaps too simplistic. They might, however, be good talking points to use in communicating with the general public. First, president of the Washington-based GridWise Alliance, Katherine Hamilton, told an OnPoint interviewer, "The smart grid is a wide range of technologies. It's anything that makes the electric grid communicate better, from the power station all the way through the distribution substation to the home" (as cited in Laurant, 2009, para. 3). Continuing in more simple language is the definition that the smart grid involves a transformation in the electric industry "from a centralized, producer-controlled network to a decentralized, user-interactive one" ("Identify the Changes," 2007, para 3).

The last offering on the available shorter definitions, Jesse Berst's company GlobalSmartEnergy (2006) has defined the "Smart Grid as the use of computers, electronics and advanced materials to optimize electric power delivery" (p. 54). This definition is elegantly compact, and yet one wonders if it is not, perhaps, also too simple to adequately convey the sheer complexity of the smart grid phenomenon to the average stakeholder or consumer.

A technological definition offered by Keen (2009), from the Indiana Office of Utility Consumer Counselor, lists five main components of a smart grid that would contain: 1) grid-wide integrated communications; 2) sensing, metering, measurement; 3) advanced control capabilities; 4) advanced grid components; and 5) decision support (slide 2). The following are the characteristics in a smart grid, which is: self-healing; empowering and incorporating the customer; tolerant of security attacks; with 21st Century power quality; accommodating a wide variety of generators; fully enabling electric markets; optimizing asset utilization; and minimizing operation and maintenance costs (Keen, 2009, slide 3).

One of the most detailed descriptions found in the literature is provided by Neville (2008), who stated:

> The general definition of a smart grid, according to a recent white paper by power generation analysts at Xcel Energy, is an intelligent, auto-balancing, self-monitoring power grid that takes a variety of fuel sources (coal, sun, and wind, for example) and transforms them into electricity for consumers' end use (heat, light, and warm water) with minimal human intervention. They assert that it is a system that will allow society to optimize the use of renewable energy sources and minimize our collective environmental footprint. A smart grid has the ability to sense when a part of its system is overloaded and reroute electrons to reduce that overload and prevent a potential outage.

> Additionally, it is a grid that enables real-time communication between the consumer and the utility, allowing the utility to optimize a consumer's energy usage based on that person's environmental and/or price preferences. (para. 5)

This self-healing concept is present in many of the sources as a fundamental benefit.

The Electric Power Research Institute (EPRI, 2008) offers one of the more detailed definitions:

> The term Smart Grid may best be understood as the overlaying of a unified communications and control system on the existing power delivery infrastructure to provide the right information to the right entity (e.g. end-use devices, transmission and distribution—T&D— system controls, customers, etc.) at the right time to take the right action. It is a system that optimizes power supply and delivery, minimizes losses, is self-healing, and enables next-generation energy efficiency and demand response applications. (p. 2-1)

What is missing in this EPRI definition is the intent of more saturation of renewables.

In final consideration as to how we choose to define the smart grid, it is essential to incorporate the definition that has been published by the federal government. A DOE publication (2008) provides a definition which also happens to be one of the most detailed:

> For the purposes of this report, the Electricity Advisory Committee (EAC) is referencing two U.S. Department of Energy (DOE) publications to better illustrate a Smart Grid. *The Smart Grid: An Introduction* explains that a Smart Grid uses "digital technology to improve reliability, security, and efficiency of the electric system: from large generation, through the delivery systems to electricity consumers and a growing number of distributed-generation and storage resources." In the soon-to-be-published *Smart Grid*

> *System Report*, DOE further explains that "the information networks that are transforming our economy in other areas are also being applied to applications for dynamic optimization of electric system operations, maintenance, and planning. Resources and services that were separately managed are now being integrated and rebundled as we address traditional problems in new ways, adapt the system to tackle new challenges, and discover new benefits that have transformational potential. (p. 3)

By all accounts, including DOE's definition, the smart grid is revolutionary in concept, scope and deployment.

It is also essential to note that recently the Federal Energy Regulatory Commission (FERC) released an interim policy statement that provides a list of goals and characteristics for the smart grid, as follows:

> (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 (real-time, automated, interactive technologies that optimize the physical operation of appliances and consumer devices) 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, including plug-in electric and hybrid electric vehicles, and thermal storage air conditioning. (8) Provision to consumers of timely information and control options. (9) Development of

> standards for communication and interoperability of appliances and equipment connected to the electric grid, including the infrastructure serving the grid. (10) Identification and lowering of unreasonable or unnecessary barriers to adoption of smart grid technologies, practices, and services. (FERC, 2009, p. 5-6)

Each point listed has its own immense complexities and complications, but the list is useful for providing an overall view of the smart grid phenomena according to FERC.

As a concluding point, we can, like other stakeholders, consider defining the smart grid in terms of furthering our own agenda. Makhijani (2008) described a goal of developing a more efficient energy economy "that is set in the technical context of zero-CO2 emissions in the supply sector. The social goal is that this transition should be accomplished with justice for the affected workers and communities" (p. 12). The goal of achieving zero carbon emissions would have a fundamental impact on how we conceive and implement a functional smart grid society.

How can it work in the public interest?

The smart grid can be a powerful tool in environmental stewardship. Makhijani (2008) has argued that a reshaping of our current energy supply must take place:

> ….a large and fundamental transformation of the energy supply system will have to occur in the coming decades in order to transition to an economy with zero-CO2 emissions without nuclear power. The division of investment resources between supply, storage, conversion (to electricity and/or hydrogen), and efficiency in utilization of energy will vary with policy and prices. (p. 28).

This shift to a distributed grid from a centralized grid will allow—or even necessitate—generating plants of all types that contribute to energy generation, rather than continuing with such a high degree of consumer dependence on station power plants (Makhijani, 2008, p. 28).

The development of the distributed grid is an essential step in reaching a vision of carbon-free and nuclear-free energy, and eventually making obsolete the polluting systems we currently use.

Wind energy, solar energy in the form of solar photovoltaics and solar thermal power plants, solar energy in the form of biomass, and direct hydrogen production from solar energy all, according to Makhijani (2008), "have the theoretical potential to supply the entire U.S. energy requirement. However, each faces certain constraints, such as intermittency with wind and solar, and land-area considerations with biofuels" (p. 30). The intermittency issue can be alleviated with storage technologies, such as "combining solar thermal power plants with heat storage" which can be used to offset diurnal and seasonal variations (Makhijani, 2008, p. 44).

According to FERC's smart grid policy statement (2009), several states have been working on "aggressive regional carbon control measures, and one regional effort has already begun operation in the form of the Regional Greenhouse Gas Initiative" (FERC, 2009, p. 13). The FERC document then stated, "Federal legislation addressing carbon control and other environmental and climate related matters may follow" (FERC, 2009, p. 13). Additional transmission capability is needed in order to manage the mix of fuels and new resources, and FERC recognized the need to "reliably integrate variable generation into the electric grid" (FERC, 2009, p. 13). Variable energy generation can be handled with "Smart Grid-enabled demand response capabilities [which] could add important new tools to deal with both resource adequacy and resource management" (FERC, 2009, p14-16).

Another public benefit, the economic boost to consumers, is addressed by the DOE's Energy Advisory Committee (EAC, 2008), who underscored the need for a smart grid infrastructure:

> While much of the technical and policy discussion about how to ensure a sustainable energy future focuses on energy efficiency, renewable energy sources, storage, and plug-in electric cars, it is often forgotten or underemphasized that these solutions all depend on a smarter grid to achieve scale and cost effectiveness. A Smart Grid is therefore foundational for a sustainable energy future; and if there is a growing consensus within the United States that clean energy is a platform for rebuilding the American economy, then it follows that the realization of a Smart Grid is also critical to economic growth. (p. 1)

It's possible, however, that EAC estimates on the economic boost may be optimistic, considering how much money needs to be invested in order to create this fundamental change. According to the Galvin Electricity Initiative, "Widespread deployment of technology that allows consumers to easily control their power consumption could add $5 billion to $7 billion per year back into the U.S. economy by 2015, and $15 billion to $20 billion per year by 2020" (as cited in DOE, 2008, p 5). The DOE then stated, "Assuming a 10% penetration, distributed generation technologies and smart, interactive storage capacity for residential and small commercial applications could add another $10 billion per year by 2020. (DOE, 2008, p. 5)

In addition to economic benefits is the consideration of reliability. The Galvin Electricity Initiative (2008) considered that the current U.S. electric power system is:

> …designed and operated to meet a '3 nines' reliability standard. This means that electric grid power is 99.97% reliable. While this sounds good in theory, in practice it translates to interruptions in the electricity supply that cost American consumers an estimated $150 billion a year. (as cited in DOE, 2008, p. 7)

The smart grid is conceived to be a more reliable option.

In conceptualizing the reliability of the smart grid, along with its possible effects to consumers, the DOE (2008) provided:

> Through proactive grid management and automated response, the frequency and duration of power outages can be reduced, which will result in fewer anxious calls to utility call centers and improved consumer satisfaction. Remote monitoring and control devices throughout the system can create a "self-healing" grid, which can restore and prevent outages and extend the life of substation equipment and distribution assets. Through such automation, rising consumer expectations for power quality and reliability can be met in the face of growing electricity demand and an aging infrastructure and workforce. (p.7)

Other theoretical benefits include: deferred capital spending for generation, transmission and distribution investments; reduced operations and maintenance costs; integration of renewable energy and distributed resources; improved system security; consumption management; cost savings from peak load reduction; convenience of distributed generation; and cost savings through energy efficiency (DOE, 2008).

What is achievable now?

In looking at what is achievable now, we should first briefly consider what the utility industry, and state and federal entities are currently achieving. Several pilot smart grid projects are being conducted throughout the U.S., which are mentioned in more detail later on in the paper. Regarding the overall state of the utility industry as a whole, the utilities in Indiana, which include Duke Energy, Indiana & Michigan Power, Indianapolis Power & Light, NIPSCO, Vectren, and a variety of member-owned electric cooperative distribution utilities (REMC's), might be seen as a cross sampling.

According to the Indiana Utility Regulatory Commission (IURC) smart grid technical workshop held on February 19, 2009, representatives reported a wide variety of progress made in implementing and testing new technologies, from some reporting working with targeted test populations to one utility that had not begun implementation or testing of new technologies yet (Utility Group, 2009). If the rest of the utility industry resembles the cross sampling in Indiana, the industry is a patchwork of those who are in more advanced stages of testing and implementation at the local or regional level to those who have not yet, for whatever reason, begun incorporating smart grid technologies into their infrastructure. This would indicate that we have not yet achieved a standardized progress toward a nation-wide smart grid reality.

As mentioned previously, however, real steps toward that standardized progress have recently been taken, as FERC's interim policy statement provides guidance on standards to the electric power industry. The four points covered in the policy statement are:

- Cyber security;
- Communications among regional market operators, utilities, service providers and consumers;
- Ensuring that the bulk power system operators have "wide-area situational awareness" with equipment that allows them to monitor and operate their systems; and
- Coordinating operation of the bulk power system with new and emerging technologies for renewable resources, demand resources, electricity storage and electric transportation systems. (DOE, 2009, pp. 1-2)

This policy statement was issued after FERC solicited and incorporated public comments.

The importance of FERC's policy statement, circulated in March, 2009, lies in how it will:

> …prioritize the development of key interoperability standards, provide guidance to the electric industry regarding the need for full cybersecurity for Smart Grid projects, and provide an interim rate policy under which jurisdictional public utilities may seek to recover the costs of Smart Grid deployments before relevant standards are adopted through a Commission ruling. (FERC, 2009, p. 3)

With this interim policy in effect, the platform has been created for the development of an overarching set of federal regulations for "final interoperability standards" for the industry. (FERC, 2009, p. 4).

In the meantime this interim policy statement proposes that FERC will hear single rate case filings by public utilities who seek to recover the "costs of Smart Grid deployments involving jurisdictional facilities provided that certain showings are made," which include devices and equipment used in either a pilot program or demonstration project that can be shown to be "used and useful for purposes of cost recovery" (FERC, 2009, p. 4). [See Appendix I for a breakdown of rate recovery requirements.] Interoperability is expected to be an essential aspect in smart grid equipment (FERC, 2009, p. 7).

Wherever the various individual utilities are in their infrastructure developments, according to Scott (2008), there are "five converging trends" that utilities face. "These trends—a stressed grid infrastructure, global warming, energy costs, customer expectations and technology—form what some describe as a 'perfect storm'" and are the drivers for the kind of positive change a smart grid can provide (Scott, 2008, p. 18). The Litos Strategic Communication publication (2008), prepared for the DOE, argued, "We don't have much time" due to our current grid's limitations, power system security and climate change (p. 2).

However, adequately dealing with these difficulties is not an either/or argument. The development and implementation of a smart grid is not the only way to alleviate a stressed grid infrastructure. While there has been a huge collective dialogue among stakeholders on what everybody in the industry can see as a transformative vision, the amount of effort, technological expertise, consensus and monetary investment in this transformation are all challenges that have yet to be met.

This being the case, there are achievable steps that can be taken now to address the five trends or drivers for energy improvement. A stressed grid infrastructure can be eased by affordable end-use energy efficiency initiatives that address both policy-making and also change at the household level. End-use energy efficiency and renewables contribute to addressing global warming and rising energy costs. Many of the involved technologies or techniques involved are also affordable to implement.

End-use efficiency can be achieved without a smart gird. The potential savings through efficiency now are enormous. Placing an emphasis on the ability of end-use energy efficiency to save hundreds of billions nationwide can be part of a strategy for how we frame the cost/benefits of smart grid development to customers.

According to the American Council for an Energy-Efficient Economy (ACEEE), “Energy efficiency is the cheapest, fastest, and cleanest source of energy” (ACEEE, 2009, p. iii). Their 2009 report highlighted “the importance of energy efficiency and the various market barriers that have limited the use of energy efficiency, discuss[ed] current state actions, and explain[ed] how an EERS [Energy Efficiency Resource Standard] works to achieve large energy savings” (ACEEE, 2009, p. iii).

The amount of energy that can be saved through a federal EERS is enormously significant, not only monetarily but environmentally. The ACEEE stated:

> …the proposed federal EERS could power almost 48 million households in 2020, accounting for about 36% of the households in the United States. Moreover, this level of energy savings will save Americans almost $170 billion, create over 220,000 jobs and reduce greenhouse gas pollution by 262 million metric tons while eliminating the need to build 390 power plants. (ACEEE, 2009, p. iii)

These cost and savings projections are founded in real case studies, as six states have forged ahead on "enacting, implementing, and achieving significant energy savings with an Energy Efficiency Resource Standard" (ACEEE, 2009, p. 1). Just a few of the findings from these states are:

- After establishing an EERS in 1999 with measureable success, a report commissioned by Public Utility Commission of Texas (PUCT) found that a goal to 50% of load growth is feasible
- Efficiency Vermont (EV), established in 2000, met over 7% of Vermont's electricity requirements by the end of 2007
- California set energy savings goals in 2004, which were exceeded in 2007 by measures installed that met 1/5% of the state's electricity needs
- Since 2004, Hawaii's Renewable Portfolio Standard (RPS) requirements qualifies as an eligible resource, and the state has been achieving between 0.4%--0.6% yearly through energy efficiency
- In 2001, Nevada enacted RPS legislation, and in 2005 it was expanded from 15% to 20% of electricity sales by 2015. (ACEEE, 2009, p. 1)

Any federal EERS would not preclude the efficacy of a state-level efficiency utility, and any federal EERS standards that may be adopted should be considered a minimum requirement. Given the successes already demonstrated, we can alleviate the stress on our current grid, boost the economy by creating jobs, and take significant strides forward in reducing pollution relatively quickly and easily, especially in comparison to the enormous challenges and costs involved in creating a national smart grid. [See Appendix II for ACEEE's proposed EERS along with a list of supporting companies and organizations.]

What telecom technologies are involved?

Much of the telecom technologies involved in the development of a smart grid are internet-based. "The Internet's success is largely due to its networking capabilities. In a similar way, the smart grid will use broadband capabilities and high-speed computing to revolutionize the transmission and distribution to end users" (Neville, 2009, para. 2)

Technologies being tested for future use are: neural networks, smart sub-stations, smart distribution assets, smart outage management, consumer web portals and wind power storage (Neville, 2009, para. 8). Xcel Energy's pilot Smart Grid City project features a number of infrastructure upgrades and customer offerings, such as:

- A communications network that provides real-time, high-speed, two-way communication (via broadband over power lines)
- Conversion of substations to those capable of remote monitoring, near-real-time data collection and communication and optimized performance
- Installation, at the customer's invitation, of programmable in-home control devices and systems to fully automate home energy use

- Integration of infrastructure to support easily dispatched distributed generation technologies (such as plug-in hybrid vehicles with vehicle-to-grid technology, battery systems, wind turbines and solar panels) (Neville, 2009, para. 14)

There is also the need "for communications schemes that can integrate the public Internet and third-party smart devices controller, and which can flexibly reach beyond the meter to distributed energy resources" (Masiello, 2008, p. 72).

Going forward, this technological evolution will call for a "rare breed of engineer, one who combines knowledge of both information and operations technology, as power technology and digital communication and control functions continue to fuse under smart grid programs" (Booth, 2008, p. 41). As an example of this rare engineer, in a February 9th news release, the Smart Grid News e-publication ran the following news release article: "Google is announcing Google PowerMeter, which will ultimately become an open platform for home energy information. The initiative is led by Ed Lu, a former astronaut with a background in electrical engineering and astrophysics" (Berst, 2009, para. 3).

It is also generally accepted in the literature that advanced metering "is a fundamental enabling technology for the smart grid," but the trade publication *Transmission & Distribution World* warned that "utilities should pause and pay careful attention to the hard-earned, pragmatic wisdom of their distribution operations engineers" in order to use the technology effectively (Booth, 2008, p. 40).

To further complicate things, the terms advanced metering, or "smart" meters, are frequently confused with "smart grid" (Booth, 2008). While the advanced or smart metering technology may be needed in the creation of the smart grid, the current uses of these meters can be abusive to customers.

One way these abuses manifest is in rate impacts to customers. These rate impacts include:

- A sharp increase in value of the "rate base," as the meters can be a substitute investment for companies that do not, or cannot, invest in power plants as they used to
- Replacing old (and depreciated) meters with new (and undepreciated) meters, while customers can still be forced to pay for the remaining depreciation on old meters
- The smart meters become rapidly obsolete with a quick 7-year depreciation as opposed to a 30-year depreciation, which is akin to telecommunications equipment and thus more costs, again, are passed on to customers (Colton, 2008, p. 4)

What are the cost issues?

There is no single comprehensive estimate in the researched literature for the cost of a nation-wide or continent-wide transformation to smart grid technology. However, a 2007 publication by the GridWise Architecture Council (GWAC) did state, "Recent predictions suggest that the U.S. electric industry will invest $300 billion in new [transmission and distribution] facilities (including advanced meters) over the next decade, and $400 billion in new power plants over the next 25 years" (p. 3).

Even when considered and implemented at the local or regional level, the costs in this innovative transformation are enormous. Xcel Energy's Boulder smart grid pilot project alone—which is a localized initiative—could end up costing $100 million, although they do not intend to pay for the entirety of the project, but anticipate input from other sources, including government grants (Neville, 2008, para. 11).

The following are other examples of the high cost involved in the research and implementation of smart grid-affiliated technologies, along with a few statements concerning potential cost benefits. As with the Xcel Energy project, the DOE has often been a funding partner.

The first example is in a 2006 study conducted in southern California which claimed a massive return on investment:

> The Energy Policy Initiative Center in San Diego outlines a scenario of smart grid implementation on the San Diego electric grid. The study shows that an initial $490 million investment would generate $1.4 billion in utility system benefits and nearly $1.4 billion in societal benefits over 20 years. (Moore & McDonnell, 2007, p. 21)

The societal benefits, however, were not defined.

Secondly, a specific utility, San Diego Gas & Electric (SDG&E), was given the go-ahead by the California Public Utility Commission (PUC) to “start work on a half-billion-dollar smart meter project that the utility says ‘will revolutionize how it delivers services to customers and how customers manage their energy usage.” SDG&E planned to start replacing “around 1.4 million electric meters with smart meters and retrofitting approximately 900,000 gas meters throughout their service territory, beginning in 2008” (Brown, 2007, p. 6).

Also, Southern California Edison (SCE) has invested over a dozen years on research and development. The SCE has invested $5 billion from 2002 to 2007 in infrastructure expansion, and plans another $9 billion from 2007 to 2012. The DOE provided almost $1 million in research and development funds in support of SCE’s smart grid technology project called the “Circuit of the Future” (Smith, 2007, para. 3).

All of these examples involve huge sums of money. Regarding the immensity of the cost figures involved, Bruce (2003) has stated:

> As attractive as a 'smart grid' sounds, it's the cost that brings one up short. The existing transmission and distribution infrastructure already needs investment, with estimates ranging from $56 billion just to maintain the system, to $63 billion for distribution and $25 billion for transmission over the next five years…..Today the question is, who pays [for the development of the smart grid]? Transmission owners don't want to invest in technology they aren't sure they'll get a return on. (Bruce, 2003, p. 37)

These cost estimates are just to maintain the existing infrastructure, not to transform our infrastructure to the smart grid paradigm. Therefore who pays and who benefits is a key unresolved issue in the smart grid discussion.

There are further costs involved in the questions: who takes this jump and how do we make it happen? These questions remain unresolved while the industry and our federal and state governments grapple with the complexities of a term that has no simple definition or singular solution. As Maize (2007) stated:

> …the grid of today, not the grid of the future, isn't getting built. The results are higher electric prices (or costs not passed on to consumers) in congested areas and more risk of grid failure. While the industry ponders the wonders of a smart grid, consumers face the immediate problems of not enough grid. (Maize, 2007, para. 10)

Therefore the cost issue becomes, inevitably, a policy issue. Maize (2007) also asked:

> Where are the boundaries between state and federal regulation of allegedly smart grid technologies? Are these transmission-oriented costs, or distribution costs? It's not an

> easy question, but the answer will determine the outcome of the debate: who will pay—ratepayers or federal taxpayers. (Maize, 2007, para. 15)

The irony in this is, of course, that ratepayers and taxpayers are the same people. The difference lies in the policies that underlie the technology, and whether the cost to the ratepayer/taxpayer is equitable with the benefits and protections received. For the creation of customer-protections in the form of good policies, a close analysis of the cost and benefit issues to customers is needed.

FERC addressed this issue in their interim policy statement. Not only should recoverable costs be used and useful, as mentioned earlier, but "Smart Grid policies should encourage utilities to deploy systems in the near term that advance efficiency, security, and interoperability" (FERC, 2009, p. 32), and FERC provides a list of showings that an applicant must make in individual rate cases, which include promoting system security, and minimizing the possibility of stranded investment (FERC, 2009, p. 34).

The Pacific Northwest Gridwise Testbed claimed that "a smarter grid through information technology could save the United States $80 billion over 20 years by partially offsetting the need to build new electric transmission lines and generation required to meet projected load growth" (*Utility Automation*, 2005, p. 16). However this claim does not address the investment needed to achieve the benefit.

In one final note, the EPRI's cost analysis projections included maximum versus realistic potential:

> The projected implementation cost for energy efficiency and demand response efforts to realize the maximum achievable potential ranges from a low of $3 billion and a high of $7 billion in 2010. By 2020, those costs are projected to increase to a low of $16 billion

> and a high of nearly $41 billion. By 2030, the cost grows further to a low of $25 billion and a high of over $63 billion. (EPRI, 2009, p. 6-3)

It must be noted that these costs are not necessarily specific to creating a smart grid, but instead are related to maximizing energy efficiency.

What are the timelines for implementation?

Just as there is no one authoritative definition of the smart grid and no single comprehensive cost estimate for a total transformation to a smart grid paradigm, there is also no single comprehensive timeline for implementation. What follows are a series of projected timelines.

First there is an estimate for a timeline based on need. Current challenges in implementing smart grid technology include the North America's electric grid infrastructure. "Approximately 60 percent of the electric power grid's current assets will need replacement within the next 10 years" or by 2017 (Tichelman, 2007, p. 56).

Department of Energy publications, while dated, provide drafts of timelines that, for lack of anything else found in the current literature review, show at least what governmental projections are. The first listed DOE timeline is:

By 2010:

- Customer "gateway" for the next generation "smart meter," enabling two-way communications and a "transactive" customer-utility interface
- Intelligent homes and appliances linked to the grid
- Programs for customer participation in power markets through demand-side management and distributed generation
- Advanced composite conductors for greater transmission capacity

- Regional plans for grid expansion and modernization

By 2020:

- Customer "total energy" systems for power, heating, cooling, and humidity control with "plug & play" abilities, leasable through mortgages
- "Perfect" power quality through automatic corrections for voltage, frequency, and power factor issues
- HTS (high-temperature superconductivity) generators, transformers, and cables will make a significant difference
- Long distance superconducting transmission cables

By 2030:

- Highly reliable, secure, digital-grade power for any customer who wants it
- Access to affordable pollution-free, low-carbon electricity generation produced anywhere in the country
- Affordable energy storage devices available to anyone
- Completion of a national (or continental) superconducting backbone (DOE, 2003, p. 23)

The second DOE timeline on the following page is more sophisticated, including projections for design, testing, acceptance, manufacturing and implementation:

Figure 1

	Phase I **Design and Testing** **2010**	**Phase II** **Technology Development and Market Acceptance** **2020**	**Phase III** **Manufacturing and Scale-up** **2030**
Design "Grid 2030" Architecture	Conceptual design Prototyping Field testing	Expanded field testing and Demonstrations Local and regional deployment	Expanded local and regional Deployment National Grid
Develop Critical Technologies	Advanced conductors and HTS Storage Real-time monitoring Power electronics	Expanded field testing and demonstrations (including distributed energy) Local and regional deployment	Expanded national and international applications
Accelerate Technology Acceptance	Technology transfer Education and outreach	Introduction of advanced manufacturing and scale-up techniques Enhanced distribution channels and O&M infrastructure	Established manufacturing infrastructure Established distribution and servicing infrastructure
Strengthen Market Operations	Systems and market analysis Address siting and permitting Regulatory reforms	Jurisdiction issues clarified Regional planning processes in place Market power prevention mechanisms in place	Regulations and markets in equilibrium and functioning properly
Build Partnerships	Federal coordination Federal-state-regions Industry coordination International cooperation	Public-private partnerships highly effective, running smoothly, and achieving a high level of leverage and cost sharing	Public-private partnerships efficient, effective, and have global reach

(DOE, 2004, p. ix)

The final DOE timeline listed is a summary of Research, Development & Demonstration needs that are to be completed by 2010:

Backbone

- Evaluate and select architectural design
- Accelerate RD&D for “critical” technologies
- Develop a manufacturing infrastructure for next generation technologies
- Develop techniques for overlaying next generation technologies onto the existing grid
- Address security threats to eliminate outages and downtime
- Demonstrate use of new technologies on the grid to validate performance and reliability
- Develop suitable cryo-cooling technology (high Carnot efficiency, large size, ultra-high reliability, affordable)

Regional Interconnection

- Develop tools and techniques for fast network evaluation planning, operation, stability and reliability
- Develop standard distribution system models for urban, suburban and rural locations
- Determine conceptual design for the use of self correcting architecture
- Determine root cause analysis of power control systems break ups
- Update existing infrastructure
- Make critical technologies commercially available
- Lower cost and improve reliability of power electronics including converters/inverters, solid state current limiters, static voltage regulators and solid state transformers
- Develop new protection scheme for two-way power flow

- Develop high speed, high accuracy and control algorithms for distributed control and protection systems
- Explore alternative distribution system concepts such as DC grids, high voltage and multi frequency

Local Distribution

- Develop "ride-through" capabilities for end-use appliances and equipment
- Update existing infrastructure
- Develop standard distribution system models for urban, suburban and rural locations
- Develop "ride-through" capabilities for end-use appliances and equipment
- Make critical technologies commercially available
- Integrate lower cost distributed energy resources into the distribution grid
- Develop new protection scheme for two-way power flow
- Depend on distributed energy for backup to distribution system for reliability services
- Explore alternative distribution system concepts such as DC grids, high voltage and multi frequency (DOE, 2004, p. 47)

What is in the public interest versus the utility business plan?

Maseillo's new paradigm of the 'power plexus' faces a "technology risk" by the "new generation of widgets on the horizon" (Masiello, 2008, p. 72). He argued that we have to move beyond current conventional thinking to accept this new paradigm. There is an inherent tension between the public interest and the utilities that the new widgets can cause, in the form of the advanced metering abuses previously mentioned.

Better energy management, by both utilities and customers, appears to be an accepted benefit that is achievable with some effort. Booth (2008) stated that:

> Utilities working on advanced metering programs and rate cases should consider, and work to fund, communications networks/capabilities to address more than just advanced metering connectivity. Smart grid communications planning should consider opportunities across the entire service delivery value chain—from supply source all the way into the consumer's home—to help all market participants manage energy better. (Booth, 2008, p. 40)

He also wrote that "…utilities consistently cite improved customer service, enhanced reliability, and lower outage management times as some of the top benefits discussed within advanced metering reviews at their respective companies" (Booth, 2008, p. 40).

What utilities claim can be at times disingenuous, and they are not necessarily forthcoming with their real agendas. The public interest must be protected from stakeholders who are rushing to cash in on new technologies that may indeed be necessary for the development of the smart grid, but are also profit-making avenues at the expense of captive customers. As Keen stated, we need "a Smart Grid using 'smart' technology coupled with 'smart' rates" (Keen, 2009, slide 4).

A clear example of this type of proprietary action is in the usage of smart meters in Indiana. According to Colton (2008), the "real time pricing" of smart meters assumes the viability of "price signals" (Colton, 2008, p. 3) Further, Colton stated that "demand response" strategies assume the capacity of the customer to respond to those price signals (Colton, 2008, p 3), which is very often not the case in low-income areas where customers are too often on the wrong side of the modern informational digital divide.

The AARP Public Policy Institute's 2008 report on the potential impact of advanced metering on residential customers provided an argument that is in agreement with Colton's main points. The AARP report stated, “There is particular concern that high-income and high-use customers might benefit from the use of AMI, while low-income and lower used customers would not. As a result, AMI systems might achieve their overall goal of reducing peak demand, but at the expense of some customers” (AARP Public Policy Institute, 2008, p. 2). The report provided a list of potential concerns about AMI, which follows:

- Bills not lowered for all customers
- Vulnerable populations less likely to benefit
- Negative health impact as some customers reduce use of electricity during times of extreme weather
- Cost of implementing AMI will be paid by consumers
- Not the lowest cost means of reducing demand (AARP, 2008, p. 4)

With all of these considerations, any use of the AMI system should, according to the report, be approached with caution (AARP, 2008, p. 6).

FERC did address metering in its interim policy document, as it stated that “specifications for customer meters are within the jurisdiction of the States” (FERC, 2009, p. 28). FERC also stated, “achieving… demand response capabilities will require additional standardization of the interface between systems on the customer premises and utility systems” (FERC, 2009, p. 28). Given these statements along with the necessity for individual rate cases to provide showings such as the used and useful clause in smart grid investment, some usage of smart meter technology is not necessarily the kind of smart grid development that will meet FERC approval. This would necessitate state commissions to hold off approval for smart meter investments unless a clear connection to FERC’s immediate goals with respect to cost recovery can be proven.

What is the rational approach to the smart grid issue?

There are two steps to a rational approach to the smart grid issue in Indiana The first, most critical and economical step is to establish an Energy Efficiency Resource Standard (EERS) that has set goals and target dates for the achievement of end-use efficiency percentages, with savings "documented in accordance with evaluation rules established by regulators" (ACEEE, 2009, slide 10).

As ACEEE argued, not only can an EERS produce substantial energy and emissions savings, but it can be performance based, emphasizing saving and not spending. This can be easier to legislate than spending amounts, and the programs can be started quickly, without many years of study (ACEEE, 2009, slide 11). With 18 states already that have Energy Efficiency Resource Standards and 3 more with pending EERS's, including Michigan, Illinois and Ohio, there are plenty of resources from which to draw upon in implementing our own EERS (ACEEE, 2009, slide 12). Also, an EERS doesn't require a massive restructuring of our current grid system, nor does it require designing, or redesigning, equipment and technologies that meet interoperability standards.

The second step is to develop pilot projects that test smart grid technologies and strategies in order to make more informed policy decisions that will inevitably have sweeping consequences, keeping in close communication with FERC and present mandates. Faruqui (2008) recommended planning for an experiment that last for about a year (slide 5).

One example of a pilot experiment, as previously mentioned in the cost issues section, began in 2008 when Xcel Energy introduced intelligent grid technologies that the company envisioned would make Boulder, Colo., the first Smart Grid City (Neville, 2008).

The $100 million experiment was “the first full-fledged test of a high-tech ‘smart grid’ in the U.S.,” which was timely when considering that President Obama and Congress “declared it a priority to modernize the electrical system, and they've put smart grids at the center of those efforts” (Simon, 2009, para. 4). One draft of the stimulus package included $30 billion for developing smart grids and expanding the use of renewable resources (Simon, 2009).

Initial results from the Xcel “Smart Grid City” project have been full of surprises (Simon, 2009). They include confusing technologies and differing priorities for consumers; how usage of Web portals and customer options have been time-consuming and boring for them to manage effective results; how utilities don’t make money off of energy efficiencies; how there was a consumer outcry on utilities getting remote control of their utility usage; how there is the potential for boosting rates for customers who don’t have the sophistication or time to manage their electric usage via the Web; the challenge of developing a myriad of appliances that all speak the same language; and finally, the current technology is too expensive to be used widely (Simon, 2009). The sheer expense of the technology seems to be an argument for having the public own the transmission and distribution system, since it appears financially and logistically impossible for the private sector to support this.

Another issue discovered in the pilot project is the “Orwellian” aspect, or the lack of privacy involved in the utilities’ ability to monitor in detail customer usage of electric power (Simon, 2009, para. 7). This privacy infringement can lead to, among other things, data mining such as now occurs on the Internet.

Innovation in pilot projects which involve collaborative effort might provide strong benefits. Google has paired with Pacific Gas & Electric (PG&E), as outlined in the utility’s press release that stated:

> Pacific Gas and Electric Company (PG&E) today announced it has teamed with Google (NASDAQ: GOOG) to demonstrate Vehicle-to-Grid (V2G) technology at the search leader's Mountain View campus as part of the company's philanthropic initiative to reduce greenhouse gas emissions that contribute to global warming through Google.org. The two companies also celebrated the completion of Google's 1.6 megawatt (MW) photovoltaic system at the campus, for which PG&E will award the company approximately $4.5 million in incentives – one of the largest commercial solar rebates ever for the utility. (PG&E News Department, 2007, para. 1)

Through these forward-looking initiatives, we can get a clearer picture of technological considerations, financial challenges, and consumer issues and protections that need to be addressed. The projects will ultimately help us prepare and define how we need to step into the future of energy generation in a way that will be environmentally and economically fair and sound.

What are recommendations based on the research?

This section contains two sets of recommendations. One set is a list of recommendations from the research made by industry professionals. The second set of recommendations or points to consider is for us to consider in our approach to the issue of smart grid technologies. These two sets are not separate lists but are entwined with each other in a holistic discussion.

First, in consideration of grid security, Booth (2008) wrote: “From a resource planning perspective, utility executives in larger investor-owned utilities should work today to dedicate in-house, full-time staff resources to security functions in smart grid strategy, resource, and rate recovery planning” (p. 40).

Secondly, Berst (2007) pointed out: “If utility automation is to get what it needs—the budget it needs from utility executives, the acceptance it needs from the public, the rate support it needs from regulators—it must become a more compelling story” (p. 56). Berst’s point about the smart grid becoming a ‘more compelling story’ might be a good recommendation to adopt in working to maintain consumer protections as events progress.

Also, Borlass (2008) recommended various groups within the utility come together to discuss and agree upon a cost benefit analysis. This suggests there is good reason to consider bringing a variety of Indiana stakeholders together in a task force in order to assess costs and benefits, and to create a realistic implementation plan for creating smart grid pilot projects within the state. Among options considered when looking at policy, utility and consumer issues, the task force could explore federal funding options and work to locate potential areas for a pilot project to be located. Several regional projects, from Southern California Edison to Xcel in Boulder, and others, have received significant funding from the DOE for pilot projects. These funding opportunities should be explored for projects in Indiana.

Federal funding is a bumpy road, and not an entirely friendly one to the perspective that is opposed to nuclear and other technologies that have environmental consequences. As Tankersley pointed out:

> [Energy Secretary-designate] Chu told Republicans that he would help fast-track a resurgence of domestic nuclear power and accept oil and gas drilling as part of a broad energy package. He told Democrats that he would champion solar plants and a “smart grid” that could help bring more wind power to market. (Tankersly, 2009, para. 3)

The recommendation to meet this challenge is to increase efforts to avoid this type of policy decision-making.

Further reinforcing the need to strengthen efforts to protect the public interest, in a later-dated *Chicago Tribune* article, Tankersly (2009) stated:

> Barack Obama portrays his stimulus package as a quick jolt for the ailing economy and a 'down payment' on his priorities as president. But those goals appear to be colliding in at least one key area: energy independence.
>
> The stimulus plan appears increasingly unlikely to include major investments in so-called "green infrastructure" – the wires and rails that could deliver renewable energy to American's homes and help them kick their gasoline addictions-according to energy advocates…. (para. 1-2).

This potential lack of major investment in green infrastructures would mean that we are not working to alleviate that 'perfect storm' of needs that is driving the utility industry to consider smart grid investments when low-cost alternatives can ease the strain on our current electrical system.

Despite these public policy issues, significant and aggressive research projects are underway by a variety of stakeholders (Carlson & Asgeirsson, 2008). Now that the stimulus package is actually approved and finalized, it is important to track the ways in which energy issues are addressed and if any of those discussions can be used to channel in positive ways on this subject.

One of the biggest issues is there are so many different stakeholders and technologies involved. Many if not all of the various stakeholders are working to influence policy in ways that benefit them. Therefore smart policies should reflect the intent of the smart grid, which should be to:

- Reduce substantially the reliance of base-load power to the extent that base-load power becomes completely renewable, i.e. hot rock geothermal, bio-fuel fired turbines, solar thermal (mainly in the southwest)
- Advocate for government control of the transmission and distribution system with proper safeguards in place for the protection of consumers, since it appears that only the ratepayer/taxpayer resources are significant enough to support a comprehensive continent-wide system
- Decentralize the grid with distributed power, including mass deployment of renewables (in particular solar technology)
- Deploy storage technology to allow for saturating the grid with renewables (plug-in hybrids, electric cars, stationary battery storage)
- Work for aggressive and comprehensive utilization of end-use energy efficiency to allow the smart grid to function properly

As part of the creation of these smart policies, it is important to make sure that the differing technologies and options aren't lumped together in umbrella legislation that does not attend to the unique strengths and needs of each. Belechak (2007) wrote, "We need to be careful to understand the differences in…technologies and their purposes, or we will add to the confusion and make it difficult to promote consistent, clear legislation and regulation" (p.64). Included in the clear and consistent legislation and regulation are the interoperability principles and standards mentioned in FERC's interim policy statement, for if we do not include those princples, "more resources will be wasted, more assets stranded, and reliability threatened by our failure to move ahead with grid modernization" (The GridWise Architecture Council, 2007, p.

3). Accordingly, Congress has charged the National Institute of Standards and Technology to coordinate the development of interoperability standards (FERC, 2009, p. 8).

Just as evidenced by the various local and regional pilot projects that have been undertaken, only incremental progress can be made by individual utilities and stakeholders. In order to fully realize a national transformation to smart grids along with all the attendant technologies needed to make them work, the visionary action must occur at the federal level. According to Hendricks (2009), state and federal policymakers have the need and responsibility to weigh national issues at stake, and then to "strike a balance and maintain this new energy grid (p. 49). Therefore, becoming an active participant in the policy process should include not only actions at the state level but collaborating with other stakeholders with similar views across the U.S. to advocate at the federal level. What also should occur at the federal level is the adoption of an EERS, as outlined by the ACEEE, which will substantially reduce stress on our current energy systems, create jobs, and produce significant savings not only financially but environmentally.

Several recommendations for "smart regulation" include: effective regulatory structures and policies; how to support an effective R & D model that protects consumers against "nonaccountable R & D expenditures;" financial models that effectively support innovation that benefits both industry and customers; shifting investment dollars in a timely manner from steel and physical infrastructure to technology and software, and "regulatory models" that "incent participation in effective utilization and demand-response programs. Rate structures need to reflect the costs and benefits of responsible consumption and pass those benefits and responsibilities on to consumers" (Carlson, 2008, para. 12). The FERC policy statement addressed this issue by providing the interim standards for smart grid developments and rate recovery, so therefore state regulatory commissions should hold off on approval of various investments such as smart meters unless there is a clear connection to FERC's immediate goals with respect to cost recovery.

The following are just a few of the questions that need to be addressed, but for which no immediate answers are available:

- Can a "smart" grid make distinctions between a federal wholesale transmission system and a state retail distribution system?
- Does "smart" end when the retail distribution system begins, beyond which "stupid" prevails?
- How can regulators at the federal and state level allocate the costs of smart and stupid grids? (Maize, 2007, para. 19)

As a final recommendation, continuing research needs to be conducted in order to keep abreast of a swiftly evolving industry phenomenon. By maintaining an informed perspective on current developments and how they impact the public interest, we can set our own agenda effectively and act in the consumers' best interests.

Appendix I

The following is a breakdown of FERC's interim rate policy for smart grid-related filings by jurisdictional entities:

- Utilities should deploy systems in the near term that advance efficiency, security, and interoperability in order to address potential challenges to the bulk-power system.
- All rates for the transmission or sale of electric energy subject to the Commission's jurisdiction must be just and reasonable.
- Facilities must be "used and useful."
- Compliance with these standards may be a mandatory condition for rate recovery

An applicant must show:

- The reliability and security of the bulk-power system will not be adversely affected by the deployment at issue.
- The applicant has minimized the possibility of stranded investment
- Smart Grid deployments should provide feedback useful to the interoperability standards development process
- The applicant must address the security concerns discussed in the key standards.
- An applicant must show compliance with Commission-approved reliability standards, during and after the installation and activation of Smart Grid technologies
- An applicant must also address:
    1. the integrity of data communicated (whether the data is correct)
    2. the authentication of the communications (whether the communication is between the intended Smart Grid device and an authorized device or person)

3. the prevention of unauthorized modifications to Smart Grid devices and the logging of all modifications made
4. the physical protection of Smart Grid devices; and
5. the potential impact of unauthorized use of these Smart Grid devices on the bulkpower system.

- The applicants must make good faith efforts to adhere to the vision of a Smart Grid, including optimizing asset utilization and operating efficiency.
- Applicants should attempt to adhere to the principles of the Gridwise Architecture Council Decision-Maker’s Interoperability Checklist. The most weight will be placed on the following principles:
    1. reliance to the greatest extent practical on existing, widely adopted and open interoperability standards; and
    2. where feasible, reliance on systems and firmware that can be securely upgraded readily and quickly.
- The following information should be shared with the Department of Energy Smart Grid Clearinghouse:
    1. any internal or third party evaluations, ratings, and/or reviews including all primary source material used in the evaluation;
    2. detailed data and documentation explaining any improvement in the accurate measurement of demand response resources;
    3. detailed data and documentation explaining the expansion of the quantity of demand response resources that resulted from the project and the resulting economic effects;

4. detailed data and documentation for any improvements in the ability to integrate variable renewable generation resources;
5. detailed data and documentation that shows any achievement of greater system efficiency through a reduction of transmission congestion and loop flow;
6. detailed data and documentation showing how the information infrastructure supports DER such as plug-in electric vehicles; and
7. detailed data and documentation that shows how the project resulted in enhanced utilization of energy storage. Additional criteria required by the DOE for grant purposes for Smart Grid demonstration and pilot projects should also be shared.

- Finally, applicants are permitted to file for recovery of the otherwise stranded costs of legacy systems that are to be replaced by smart grid equipment.
- Any filing for the recovery of stranded legacy system costs must demonstrate that a plan to minimize the stranding of unamortized costs of legacy systems has been developed.
- An applicant may recover abandoned plant costs if the project is abandoned for reasons outside the control of the public utility specifically tied to Smart Grid deployments. Requests for such rate treatments for Smart Grid deployments will need to address all of the concerns discussed above for rate recovery and make the same showings.
- Applying rate treatments may occur to the portion of a smart grid pilot or demonstration project's cost that is not already paid for by Department of Energy funds
- Abandonment authority will apply to any Smart Grid investments that, despite reasonable efforts, could not be made upgradeable and must ultimately be replaced. (FERC, 2009, p.32-38)

Appendix II

The ACEEE supports a proposed Energy Efficiency Resource Standard (EERS) that would:

1. Achieve significant savings of both electricity and natural gas and significant reductions of greenhouse gas emissions;
2. Set energy-saving targets that are to be achieved by utilities by 2020;
3. Help energy consumers achieve significant savings of energy at their point of use;
4. Encourage combined heat and power (CHP) and recycled energy as eligible energy-saving choices;
5. Allow energy efficiency improvements within utility distribution systems to be credited toward compliance with the standard;
6. Ensure credible and workable measurement and verification of energy savings;
7. Encourage transparency in energy efficiency procurement;
8. Provide for bilateral contracts to permit covered utilities to procure some efficiency savings from other utilities or third-party efficiency providers. (ACEEE, 2009, p. 1)

The following is a list of supporting entities for the EERS, as of January, 2009:

- ACEEE
- Allianz of America, Inc.
- Alliance to Save Energy
- Ceres
- Clean Water Action
- Conservation Law Foundation
- Digital Energy Solutions Campaign

- Energy Future Coalition
- Environment Northeast
- Environmental Advocates of New York
- Environmental Law & Policy Center
- Federal Performance Contracting Coalition
- Johnson Controls, Inc.
- Intel
- Midwest Energy Efficiency Alliance
- National Association of Energy Service Companies (NAESCO)
- North American Insulation Manufacturers Association (NAIMA)
- Northeast Energy Efficiency Partnership
- NRDC
- Physicians for Social Responsibility
- Sierra Club
- Southern Alliance for Clean Energy
- Sun Microsystems
- The Dow Chemical Company
- The Mosaic Company
- The Real Estate Roundtable
- Whirlpool Corporation (ACEEE, 2009, p. 1)

Appendix III

Who are identified stakeholders, and events?

The following is a list of conferences, projects and various stakeholders identified through the course of research of the literature:

- CenterPoint Energy has built a technology center that puts all of the parts of the smart grid together and shows how they work for the utility and the customer, from the substation to the customer's home."
- DistribuTECH is a yearly professional conference, which in 2008 had the theme "Building Tomorrow's Smart Grid Today."
- Intelligrid (http://intelligrid.epri.com) is the EPRI-created consortium.
- Netl's Modern Grid Initiative (www.netl.doe.gov/moderngrid), by the DOE's National Energy Technology Laboratory.
- The GridWise Architecture Council (www.gridwiseac.org), another stakeholder group.
- The GridWise Alliance, a self-purported "consortium of public and private stakeholders."
- The Pacific Northwest GridWise Testbed is a group of several Northwest utilities and a DOE national laboratory that has a collective purpose of testing and adopting "new smart grid technology."
- San Diego Gas & Electric (SDG&E) has a half billion dollar investment in a smart meter project.
- Southern California Edison announced in 2007 that its "Circuit of the Future" was a success. This project began delivering power to 1,420 residential and business customers in the Inland Empire.

- The Modern Grid Initiative, at www.themoderngrid.org, who had, in 2005, Steve Pullins as its team leader.
- Sydney-based Energy Australia launched that country's first smart grid in mid-2007.
- GlobalSmartEnergy research consultancy, which also published SmarGridNews.com.
- The Galvin Electricity Initiative is, according to GlobalSmartEnergy's Berst, one of the most important efforts in smart grid initiative.
- Berst also mentions the Power Systems Engineering Research Center (PSERC) university research consortium.
- Another one Berst mentions is the California Public Interest Energy Research (PIER) Program.
- Utilimetrics is an "Alliance for Advanced Metering & Data Management Solutions."
- "Smartgrids (www.smartgrids.eu) bills itself as a 'European technology platform for the electricity networks of the future."
- The Electric Advisory Committee at: http://www.oe.energy.gov/eac.thm.
- Austin Energy developed a Smart Grid initiative.

References

AARP Public Policy Institute. (2008). *Can advanced metering help reduce electricity costs for residential customers?* Washington, D.C.: Walters, N.

The American Council for Energy-Efficient Economy. (2009). *Energy efficiency resource standards.* [PowerPoint slides] Washington, D.C.: Nadel, S. Retrieved April 3, 2009 from http://www.aceee.org/energy/national/EERS_Hill_0309.pdf

The American Council for Energy-Efficient Economy. (2009). *Energy efficiency resource standard (EERS) retail electricity and natural gas distributors.* Retrieved April 3, 2009 from http://www.aceee.org/energy/national/FederalEERSfactsheet_Mar09.pdf

The American Council for Energy-Efficient Economy. (2009). *Laying the foundation for implementing a federal energy efficiency resource standard.* Washington, D.C.: Laitner, J., Furrey, L., & Nadel, S. Retrieved April 3, 2009 from http://www.aceee.org/pubs/E091.pdf

The American Council for Energy-Efficient Economy. (2009). *The national energy efficiency resource as an energy productivity tool.* Washington, D.C.: Laitner, J., Furrey, L., & Nadel, S. Retrieved April 3, 2009 from http://www.aceee.org/energy/national/EERS_article09.pdf

The American Council for Energy-Efficient Economy. (2009). *Position statement.* Retrieved April 3, 2009 from http://www.aceee.org/energy/national/EERSpstatement09.pdf

The American Council for Energy-Efficient Economy. (2009). *Please co-sponsor H.R. 889: The save American energy act.* Retrieved April 3, 2009 from http://www.aceee.org/energy/national/EERScs889.pdf

The American Council for Energy-Efficient Economy. (2009). *Success with energy efficiency* *resource standards.* Retrieved April 3, 2009 from http://www.aceee.org/energy/state/EERS_statesuccess0109.pdf

The American Council for Energy-Efficient Economy. (2009). *Talking points for the energy efficiency resource standard (EERS)*. Retrieved April 3, 2009 from http://www.aceee.org/energy/national/EERStp09.pdf

Assessment of achievable potential from energy efficiency and demand response programs in the U.S. (2010-2030). (2009, January) *Electric Power Research Institute.*

Belechak, J. (2007, August). Creating a Smart Grid. *Transmission & Distribution World*, pp. 64, 64. Retrieved January 21, 2009, from Corporate ResourceNet database.

Berst, J. (2006, May). What Is a Smart Grid?. *Utility Automation & Engineering T&D*, *11*(4), 54 54. Retrieved January 21, 2009, from Business Source Premier database.

Berst, J. (2006, June). Smart Grid Tipping Point. *Utility Automation & Engineering T&D*, *11*(5), 58-58. Retrieved January 21, 2009, from Business Source Premier database.

Berst, J. (2007, February). Why (and How) to Make the Smart Grid More Appealing. *Utility Automation & Engineering T&D*, pp. 56, 56. Retrieved January 21, 2009, from Business Source Premier database.

Berst, J. (2009, February). Google jumps into smart grid. *SmartNews.com.* Retrieved February 10, 2009, from http://www.smartgridnews.com/artman/publish/companies/Google_Jumps_Into_Smart_rid_printer.html

Booth, D. (2008, January). A Smart Smart Grid Strategy. *Electric Light & Power*, *86*(1), 40-41. Retrieved January 21, 2009, from MasterFILE Premier database.

Borlase, S. (2008, September). Smart Grids: Moving Beyond the AMI Pilots. *Utility Automation & Engineering T&D*, *13*(9), 12-18. Retrieved January 21, 2009, from Business Source Premier database.

The Brattle Group. (2008). Experimental design considerations in evaluating the smart grid. Boston, Massachusetts: Sergici, S. & Faruqui, A.

Brown, S. (2007, May). Smart Grid Becoming a Reality. *Utility Automation & Engineering T&D*, pp. 6, 6. Retrieved January 21, 2009, from Business Source Premier database.

Brown, S. (2008, March). Let's Define the 'Smart Grid'. *Utility Automation & Engineering T&D*, pp. 4, 4. Retrieved January 21, 2009, from Business Source Premier database.

Bruce, J. (2003, November). The Smart Grid. *Electric Perspectives*, *28*(6), 37-37. Retrieved January 21, 2009, from MasterFILE Premier database.

Calwell, C. & Moorefield, L. (2008). Efficiency in a climate-constrained world: Are we aiming high enough? *American Council for an Energy Efficient Economy*.

Carlson, M. (2008, May). Smart Grid requires clearing mental gridlock. *Power*, pp. 64, 1. Retrieved January 21, 2009, from Academic Search Premier database.

Carlson, N., & Asgeirsson, H. (2008, June). A Smart Recloser for the Smart Grid. *Transmission & Distribution World*, *60*(6), 48-51. Retrieved January 21, 2009, from Corporate ResourceNet database.

Center for American Progress. (2009). *Wired for progress: Building a national clean-energy smart grid.* Washington, D.C.: Hendricks, B.

Colton, R. (2008, October). *"Smart meters"/pre-payment meters: An unwise choice for low income.* [PowerPoint slides]. Belmont, MA: Fisher, Sheehan & Colton.

Duke Energy. (2009). *Smart grid: What energy can be.* [PowerPoint slides]. Indiana: Arnold, T.

EC to allow small generators a smart route to Grids. (2006, May). *European Power News*, Retrieved January 21, 2009, from Corporate ResourceNet database.

The green grid: energy savings and carbon emissions reductions enabled by a smart grid. (2008, June). *Electric Power Research Institute.*

GridWise Architecture Council. (2007). Introduction to interoperability and decision-maker's interoperability checklist. (version 1.0) Retrieved April 2, 2009 from http://www.gridwiseac.org/pdfs/gwac_decisionmakerchecklist.pdf

Identify the changes that the smart grid will bring about so that industry participants can be prepared to face them. (2007, September 7). *M2PressWIRE*, Retrieved January 21, 2009, from Newspaper Source database.

The Indiana Office of Utility Consumer Counselor. (2009). *Smart grid: A process in evolution. I.U.R.C. smart grid workshop.* [PowerPoint slides]. Indianapolis, Indiana: Keen, R.

Kamen, D., President, P., & Development, D. (n.d.). Smart electric grid. *FDCH Congressional Testimony*, Retrieved January 21, 2009, from Middle Search Plus database.

Laitner, J., Furrey, L., & Nadel, S. (2009). *The national energy efficiency resource as an energy productivity tool.* The American Council for Energy-Efficient Economy.

Laurant, D. (2009, January 15). The News & Advance, Lynchburg, Va., Darrell Laurant column: Trying to plug in the stimulus. *News & Advance, The (Lynchburg, VA)*, Retrieved January 21, 2009, from Newspaper Source database.

Maize, K. (2007, June). Smart Grid Still Just a Vision Thing. *Power, 151*(6), 68-16. Retrieved January 21, 2009, from Academic Search Premier database.

Masiello, R. (2008, February). A new look at smart grid. *Transmission & Distribution World*, Retrieved January 21, 2009, from Corporate ResourceNet database.

Makhijani, A. (2008, March). Carbon-Free and Nuclear-Free: A Roadmap for U.S. Energy Policy. *Institute for Energy and Environmental Research. Retrieved January 21, 2009* from http://www.ieer.org/carbonfree/CarbonFreeNuclearFree.pdf

Moore, D., & McDonnell, D. (2007, March). Smart Grid Vision Meets Distribution Utility Reality. *Electric Light & Power*, *85*(2), 21-21. Retrieved January 21, 2009, from Corporate ResourceNet database.

Nahigian, K. R. (2008, June). The smart alternative: Securing and strengthening our nation's vulnerable electric grid. *The Reform Institute.*

Neville, A. (2008, May). Boulder to be first Smart Grid City. *Power*, *152*(5), 42-1. Retrieved January 21, 2009, from Academic Search Premier database.

New report analyzes concept of smart grid taking a dispassionate look at what the impact of this revolutionizing technology is having on the U.S. power transmission industry. (2007, November 6). *M2PressWIRE*, Retrieved January 21, 2009, from Newspaper Source database.

PG&E teams with Google to demonstrate vehicle-to-grid technology at the company's mountain view campus. (2007, June 19). *PG&E News Department.* Retrieved January 13, 2009, from http://www.pge.com/about/news/mediarelations/newsreleases/q2_2007/070619.shtml

Pacific Northwest to Test Smart Grid Energy Technologies. (2005, July). *Utility Automation & Engineering T&D*, Retrieved January 21, 2009, from Business Source Premier database.

SAIC Smart Grid Team. (2006, October). San Diego smart grid study final report. *The Energy Policy Initiatives Center, University of San Diego School of Law.*

Santos, A., & Valocchi, M. (2007, June). The View from Europe: Smart Grid Efforts Share Common Goal with U.S. *Utility Automation & Engineering T&D*, pp. 56, 56. Retrieved January 21, 2009, from Business Source Premier database.

Scott, D. (2008, May). The Smart Grid and Your Utility. *Transmission & Distribution World*, *60*(5), 18-18. Retrieved January 21, 2009, from Corporate ResourceNet database.

Seal, R. (2007, September). AMR to Smart Grid: Today's Technology is the Cornerstone for Tomorrow's Grid. (cover story). *Utility Automation & Engineering T&D*, *12*(9), 10-13. Retrieved January 21, 2009, from Business Source Premier database.

Simon, S. (2009, February). The more you know: A groundbreaking 'smart grid' test in Boulder, Colo., is delivering some surprises for both consumers and utilities. *The Wall Street Journal.* Retrieved February 10, 2009, from http://online.wsj.com/article/SB123378462447149239.html#printMode

Smith, K. (2007, October 16). 'Smart grid' project called success. *San Gabriel Valley Tribune (West Covina, CA)*, Retrieved January 21, 2009, from Newspaper Source database.

Spring, N. (2008, March). It's tough to describe the smart grid in words. It's made up of lots. *Electric Light & Power*, *86*(2), 8-8. Retrieved January 21, 2009, from MasterFILE Premier database.

Sydney-Based Energy Australia Launched the Country’s First Smart Grid in Mid-2007. (2007, July 16). *M2PressWIRE*, Retrieved January 21, 2009, from Newspaper Source database.

Tankersley, J. (2009, January 13). Senators praise Chu, who signals support for a variety of energy alternatives. *Chicago Tribune (IL)*, Retrieved January 21, 2009, from Newspaper Source database.

Tankersley, J. (2009, January 14). Stimulus spending on ‘green infrastructure' runs into hurdles. *Chicago Tribune (IL)*, Retrieved January 21, 2009, from Newspaper Source database.

Tichelman, B. (2007, October). Using a Smart Grid to Address Our Aging Infrastructure. *Utility Automation & Engineering T&D, 12*(10), 56-56. Retrieved January 21, 2009, from Business Source Premier database.

United States. Department of Energy. The Electricity Advisory Committee. (2008). *Bottling electricity: Storage as a strategic tool for managing variability and capacity concerns in the modern grid*. Retrieved February 10, 2009, from http://www.oe.energy.gov/DocumentsandMedia/final-energy-storage_12-16-08.pdf

United States. Department of Energy. The Electricity Advisory Committee. (2008). *Smart grid: Enabler of the new energy economy.* Retrieved February 10, 2009, from http://www.oe.energy.gov/DocumentsandMedia/final-smart-grid-report.pdf

United States. Department of Energy. The Electricity Advisory Committee. (2009). *Keeping the lights on in a new world.* Retrieved March 9,2009 from http://www.oe.energy.gov/DocumentsandMedia/adequacy_report_01-09-09.pdf

United States. Department of Energy. Federal Energy Regulatory Commission. (2009). *FERC accelerates smart grid development with proposed policy, action plan.* Washington, D.C.: U.S. Printing Office. (Docket No. PL09-4-000)

United States. Department of Energy. Federal Energy Regulatory Commission. (2009). *Proposed smart grid policy statement and action plan*. Washington, D.C.: U.S. Printing Office. (Docket No. PL09-4-000)

United States. Department of Energy. Federal Energy Regulatory Commission. (2009). *Smart grid policy*. Washington, D.C.: U.S. Printing Office. (Docket No. PL09-4-000)

United States. Department of Energy. Federal Energy Regulatory Commission. (2009). *State, regulators offer criteria for DOE smart grid stimulus funding.* Washington, D.C.: U.S. Printing Office.

United States. Department of Energy. Office of Electricity Delivery and Energy Reliability. (2008). *Smart grid: An introduction* by Litos Strategic Communication. Washington D.C.: Department of Energy. (No. DE-AC26-04NT41817)

United States. Department of Energy. Office of Electricity Delivery and Energy Reliability. (2009). *Smart grid project criteria collaborative letter.* Washington, D.C.: NARUC/FERC SmartGrid Collaborative.

United States. Department of Energy. Office of Electricity Delivery and Energy Reliability. (2009). *Proposed funding criteria for the ARRA smart grid matching grant program and the ARRA smart grid demonstration projects.* Washington, D.C.: NARUC/FERC Smart Grid Collaborative.

United States. Department of Energy. Office of Electric Transmission and Distribution. (2003). *"Grid 2030" A national vision for electricity's second 100 years.* Retrieved March 9, 2009 from http://www.ferc.gov/eventcalendar/files/20050608125055-grid-2030.pdf

United States. Department of Energy. Office of Electric Transmission and Distribution. (2004). *National electric delivery technologies roadmap: Transforming the grid to revolutionize electric power in North America.* Retrieved March 9, 2009 from http://www.oe.energy.gov/DocumentsandMedia/ER_2-9-4.pdf

Utility Group. (2009). *Utility group presentation: I.U.R.C. smart grid workshop*. [PowerPoint slides].

Van Welie, G. (2008, October 27). Fostering the Development of a 'Smart Grid'. *Business West*, pp. 12, 12. Retrieved January 21, 2009, from MasterFILE Premier database.

Who's shaping the smart grid? (2008, May). *Power*, Retrieved January 21, 2009, from Academic Search Premier database.