November 1, 2010

Ms. Patricia Hoffman
Assistant Secretary for Electricity Delivery and Energy Reliability
United States Department of Energy
1000 Independence Avenue, SW, Room 8H033
Washington, DC 20585

RE: Smart Grid RFI: Addressing Policy and Logistical Challenges

Dear Secretary Hoffman,

Thank you for the opportunity to provide information to the Department of Energy Federal Register Doc. 2010-23251 filed September 16, 2010. The GridWise Alliance is a coalition of over 150 companies, organizations, and academic institutions advocating for a smart grid for a more sustainable future. We are consensus-driven and technology neutral and do not advocate for specific platforms or technologies, but, rather, for policies that will move the entire market forward to create jobs, provide clean energy solutions, and increase the reliability, flexibility, and efficiency of our electric grid. Our members and interests comprise the entire system of systems—from power plant to load center; from the electric grid to the transportation infrastructure to the built environment. We will thus address the RFI with a holistic approach focusing on policy rather than technology solutions.

Definition and Scope

Title XIII of the Energy Independence and Security Act (EISA) defines smart grid as simply a list of attributes and functions rather than concretely defining a system. GridWise Alliance defines smart grid as two-way communications and control from power plant bus bar to meter and load center which allows stakeholders on the grid to participate in and benefit from informed choices and control. We believe smart grid is the means to an end, not an end unto itself and that the dynamic end states should reflect the constantly-evolving goals and needs of such systems. Smart grid is defined by the goals it seeks to meet, not as a static set of technologies. As policies evolve, those goals will change as well and the grid will change accordingly. Smart grid is a set of technologies that will enable a more reliable, more flexible, more efficient, more secure, and cleaner electric grid.

GridWise Alliance firmly believes that while national and international standards of interoperability are absolutely critical; these standards should be "open" such that a variety of technologies can participate in the system. We do not support choosing one platform for development of smart grid. We also strongly believe that in order for manufacturers to succeed in the United States, we need consistent metrics and measurement and verification for installation of smart grid equipment. If we are able to have open standards and protocols with the same baseline and goal metrics, the market will truly be open for innovation and competition. We have developed a set of principles of interoperability that we have headlined here and have attached in complete form.

1. GridWise Alliance endorses the key principles of interoperability expressed by the GridWise Architecture Council's (GWAC) Interoperability Constitution White Paper.

2. GridWise Alliance believes that interoperability is critical to enabling interconnection and reliability of operation in smart grid, both now and in the future.

3. GridWise Alliance believes that interoperability-related standards need to be established to ensure consistent compliance and security review, such as those offered in the NIST smart grid framework.

4. GridWise Alliance believes that in order to fully enable smart grids, new equipment is needed to make the most effective use of increased information, communication, and control capabilities.

5. GridWise Alliance believes that smart grid stakeholders should make use of appropriate system and energy usage information in ways that enable coordinated grid response, reconfiguration and self-healing.

6. GridWise Alliance believes that open standards and protocols are critical to foster innovation.

RECOMMENDATION: Ensure that while EISA 2007 contains a definition, the Administration looks at smart grid applications holistically rather than simply by attributes. GridWise Alliance fully supports continued and increased funding for the NIST process, especially as it moves to international compliance and testing phases.

Interactions With and Implications for Consumers

Consumer benefits of smart grid technologies include: empowering consumer energy decision-making; increasing energy use information to all consumers; managing costs through a variety of rate structures and programs designed to complement individual customer needs; engaging consumers in technology applications; and providing environmental value. An IBM study in 2008 indicated that almost 70 percent of 5000 respondents expressed a willingness to experiment with how they interact with energy providers and would take advantage of partnerships different from traditional utility-customer relationship.[i] In 2009, Oracle found that only 20% of consumers said they would pay an upfront fee to view a detailed, real time energy consumption report and only 14% gave their utility an "A" grade on its "current ability to provide detailed, useful information on energy consumption". While 58% of utilities surveyed offer net metering programs – allowing homeowners to generate and sell back to the utility own renewable energy –only 11% say their customers are active in those programs. Only 6% of respondents had installed some type of renewable energy source in the last 12 months.[ii]

In March of 2010, a survey by GE showed that even with the increased deployment of smart grid technologies, 79% of the U.S. consumers polled were not familiar with the term "smart grid." A mere 4% said they have heard of a smart grid and have a good understanding of what it is and yet 80% who are familiar with smart grid wish they knew more about how it affects them.[iii] GE also found that 96% of those polled think smart grid offers benefits, 80% are excited about upgrading the electrical network so that our country can rely more on clean domestic energy sources, and 78% believe smart grid would help reduce the number of power outages and restore power more quickly. Three quarters of respondents who understand smart grid thought they would participate in a time-of-use rate if they could save money by shifting or reducing daytime energy usage and 66% say they would buy smart appliances and other in-home devices to maximize their control over energy once smart grid installed.

For example, a Baltimore Gas and Electric demand response pilot program demonstrated that customers responded emphatically to pricing signals, reducing consumption by one quarter to one third. The average customer savings was $115 over the summer months and more than 98% reduced their bills across all socio-demographic groups. Customer satisfaction was 92-99%.[iv]

In addition, a number of studies have been done during pilot roll-outs of smart meters. Data from demonstration projects confirm these poll results time and again and across socioeconomic lines. And yet, there is still a great deal of push-back from consumers and regulators. Despite these benefits, there remains concern among some regulators, customers, and other stakeholders that need to be addressed to help gain consensus and move forward with deployment of the smart grid.

An Implementation Example:

If we use the example of the value shift we have had in garbage disposal over the last several decades, we can take some lessons and perhaps implementation strategies for the smart grid. First, we need to determine our goals and then write the rules that can provide the underpinning to get us there. In the case of trash, the goal was to eliminate litter. Policymakers wrote laws prohibiting littering and fined people who broke the law. In the same way, we need to first determine our energy goals. The goal is not to build a smart grid but to use smart grid to achieve our other goals. Once we have determined those metrics, we can begin to strategize how smart grid can be the enabling platform. A start to looking at those benefits and metrics is attached in the Handbook for Assessing Smart Grid Projects developed by GridWise Alliance.

Next, we had massive public information campaigns; “Don’t Mess With Texas” was one of the catchiest and longest lasting slogans. We then provided people with tools to change the way we view trash, providing citizens with recycle bins to change the way they dealt with waste. Most of these were conceived of and implemented on the local and state level, but perhaps the Federal government can help with a toolkit for communities. Since the electric grid is interstate in scope the potential and justification for federal action is great. In addition, perhaps challenges can be made to incentivize communities to become energy efficient or “energy smart”.

Our values and attitude toward garbage disposal have changed. People don’t throw trash out their car windows because their neighbors and kids would chide them. Most people have more in their recycle bins than their trash cans now.

Taking this concept to an even higher level, new companies like e-Bay and Amazon are exploiting reuse of items for profit by enterprising individuals. New businesses have been created that are run over the internet, avoiding the cost of importing new products and allowing small business to flourish. Our culture around energy also needs to change to reduce overall carbon emissions in any meaningful way. The Federal government can show leadership here, leading by example in the Federal sector and providing tools and resources to state and local governments to do the same.

One customer class that deserves special attention in the world of smart grid is the small and medium sized business. These consumers' revenue streams are often during electric peak demand times and, as a consequence, the consumers are not in a position to easily curtail their demand. In addition, these consumers likely do not have the financial means to purchase sophisticated energy management systems and are left without tools to complete energy efficiency projects.

RECOMMENDATION: GridWise Alliance recommends that a program be established to assist these "Main Street" business consumers in overcoming the barriers they face to smart grid participation. Their survival often determines how thriving our economy is; helping them save energy and reduce their costs will allow those businesses to invest more in their products and services and become more profitable. By leveraging existing state and local programs, we can build an effective education campaign and toolkit for small and medium business owners. In addition, residential consumers can be assisted through research and education in partnership with the Smart Grid Consumer Collaborative (www.smartgridcc.org); GridWise Alliance is a founding member of that organization that brings together utilities, vendors, consumer advocates, regulators, and environmentalists.

Interaction with Large Commercial and Industrial Consumers

GridWise Alliance has convened a Commercial and Industrial Subgroup for the very reason that these consumers are different from residential and small business. They have more resources and have been able to participate in a variety of innovative rates for decades. They are also often able to participate directly in energy markets. To date, this Alliance group has convened ELCON, BOMA Chicago, Wal-Mart, The Green Grid, and University of California San Diego to participate in webinars to inform our commercial and industrial policy efforts.

We need to develop policies that facilitate participation in smart grid deployment by these customers to the maximum extent possible. Such deployment will improve operation of the grid for all customers, including those who will primarily benefit nonetheless from the participation of others.

RECOMMENDATION: A program that should be leveraged is the Department of Commerce Manufacturing Efficiency Program (http://www.nist.gov/mep) which has centers deployed nationwide that can assist small and medium manufacturers to become more energy efficient. This program is well-positioned to help in efforts to deploy smart grid as enabling to distributed energy and demand response as well as energy efficiency.

Assessing and Allocating Costs and Benefits

The key to getting state regulators to approve smart grid projects lies in the ability to communicate tangible and quantifiable benefits. We will need to track project metrics and then share those in such a way that we keep learning from the development of each project and feeding that knowledge back into the cost-benefits model. GridWise Alliance has completed a metrics report as well as a gaps analysis to help us understand what we do not know yet about smart grid. Continuous learning by sharing will be critical. We are also undertaking a value streams project to try to quantify some of those benefits which will be complete in December 2010. Additionally, we have convened a team to look at integrated systems planning for utilities and regulators. That project is underway and should have first draft of the white paper by the end of 2010 so that we can begin testing the process.

RECOMMENDATION: Ensure that the websites www.smartgrid.gov and the Smart Grid Information Clearinghouse (www.sgiclearinghouse.gov) are kept current. The Smart Grid Maturity Model (http://www.sei.cmu.edu/library/abstracts/reports/10tr009.cfm), run by Carnegie Mellon's Software Engineering Institute, can give utilities a tool for measuring progress in smart grid. Rather than replicating them, these tools should receive the appropriate resources to remain current and relevant to the industry.

Utilities, Device Manufacturers and Energy Management Firms

While the Administration and Federal government can provide tools for state policymakers, GridWise Alliance believes that forcing state regulators into action is an inappropriate solution for smart grid deployment. The best use of Federal engagement will be to focus on ensuring that the Federal government provides resources, guidance, and certainly to the industry so that consumers on all levels can actively participate in the market. The FERC has the authority to set rules that encourage development of smart grid with respect to interstate commerce.

While decoupling or other lost revenue adjustment mechanisms have worked in some states, others have found that these cost recovery approaches more difficult to implement. GridWise Alliance does not advocate for national legislation on particular cost recovery options, but perhaps a study could be undertaken to better understand resistance to these concepts in states that have pursued other alternatives. In addition, utilities that are not decoupled have been able to develop and manage energy efficiency programs; it would be beneficial to learn from those utilities how those programs have found success in a fully integrated construct. In addition, the study could identify best rate structure practices that motivate or impair smart grid deployment so that we can learn from the lessons and successes of others.

RECOMMENDATION: The DOE should make clear its support for FERC rules designed to facilitate smart grid development in the markets and on FERC jurisdictional transmission systems. Another effort that should be provided appropriate resources is the National Action Plan for Demand Response; this coalition is trying to ensure that consumers can take advantage of demand response programs while enabling utilities and system operators to operate the utility grid more efficiently. This undertaking seeks to provide guidance in the area of demand response for consumers and utilities and warrants support from the Federal government in coordination with other policy activities.

Long Term Issue: Managing a Grid with High Penetration of New Technologies

GridWise Alliance members understand the need to run a reliable, safe, cost-effective electric grid. We also believe that technology innovation to enhance those goals and to evolve the grid to a cleaner, more flexible and balanced system is critical. Disruptive technologies like dynamic renewable resources and plug-in electric vehicles will be deployed incrementally, giving time for energy storage and load management solutions to be developed. The Administration can assist by ensuring that those solutions—storage, forecasting, distribution automation, data collection and analysis—are given appropriate resources from the Federal R&D level such that solutions can keep pace with deployment. The loan guarantee program should be made whole again and ARPA-E fully funded. Appropriate incentives for financing renewable energy and other clean tech development should be put into place to free up capital for innovation investment. Tax incentives should be codified and made permanent so that manufacturers can afford to build these solutions in a predictable, long-term setting. Again, setting the goals and then putting policies in place to reach them will be critical. If we really want to move to a more electrified future, we need to put a great deal of thought and resources into planning for plug-in electric vehicle infrastructure, for transmission build out that will effectively tap renewable and energy storage resources, and for distributed power and microgrids to have a real seat at those tables as well. Some degree of success will be realized when our Nation's utility planners build these technologies and applications into their normal design standards, which in turn becomes "business as usual" in the future.

Reliability and Cyber Security

GridWise Alliance Interoperability and Cyber Security Work Group has developed a list of principles that we think should be foundational when assessing cyber security and smart grid policy. The key principle headings are below; the complete document is attached for reference.

1. GridWise Alliance believes that dialog and coordination among all stakeholders is essential to developing a secure and interoperable smart grid.
2. GridWise Alliance believes in a risk management approach that focuses on protecting the functions of the electric power system.
3. GridWise Alliance believes that smart grid component manufacturers (hardware and software) should apply sound security processes in design and development to minimize the risk and severity of vulnerabilities in their products and services.
4. GridWise Alliance believes that smart grid service providers (including utilities) have an important role to implement operational security procedures across their environment.
5. GridWise Alliance believes that existing facility, hardware, and software features and practices should be leveraged and built upon as part of the approach to securing a smart grid.
6. GridWise Alliance believes that the concept of "defense in depth" should be employed in any approach to securing a smart grid.
7. GridWise Alliance believes that measures intended to assure customer privacy, access to energy usage information, and cybersecurity access to data information must be balanced against operational and planning needs of the power system, in order to assure that the reliability, performance and integrity of the entire grid is preserved.

Managing Transitions and Overall Questions

One thing to keep in mind is that we don't have to solve everything right here and now. What we do have to do is get the metrics and policies right and the market signals consistent and open to innovators while maintaining the integrity of our grid. This will take the work of not only policymakers at all jurisdictional levels but all of those who work on, manufacture for, and participate on the grid. We need to engage our communities and state and local governments. Smart grid will not look the same for everyone—nor should it. The systems around the grid—electric, built environment, transportation, natural gas, and water—will evolve differently based on consumer and regional needs, as well as the operational and regulatory construct of the utility.

RECOMMENDATION: The Administration can lead by example and provide information and tools to assist those who will be making deployment and investment decisions on how to deploy smart grid. The Administration needs to make sure that the smart grid stimulus investment grants and demonstration projects are successful—creating jobs but also spreading lessons learned from those implementations. The Administration can also take a real stand on a vision for our energy future—what are our goals as a country on economic competitiveness, climate mitigation, and increased energy security? We can then begin to write rules to meet those goals.

Thank you for your consideration of these recommendations. The GridWise Alliance appreciates the opportunity to have input into the policy challenges faced by developing a smarter grid; we look forward to continuing to work actively with the Department of Energy. Feel free to call me should you have any further questions.

Best Regards,

Katherine Hamilton
GridWise Alliance, President

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[i] Source: Lighting the Way: Understanding the Smart Energy Consumer; 2008 Global Utility Consumer Survey

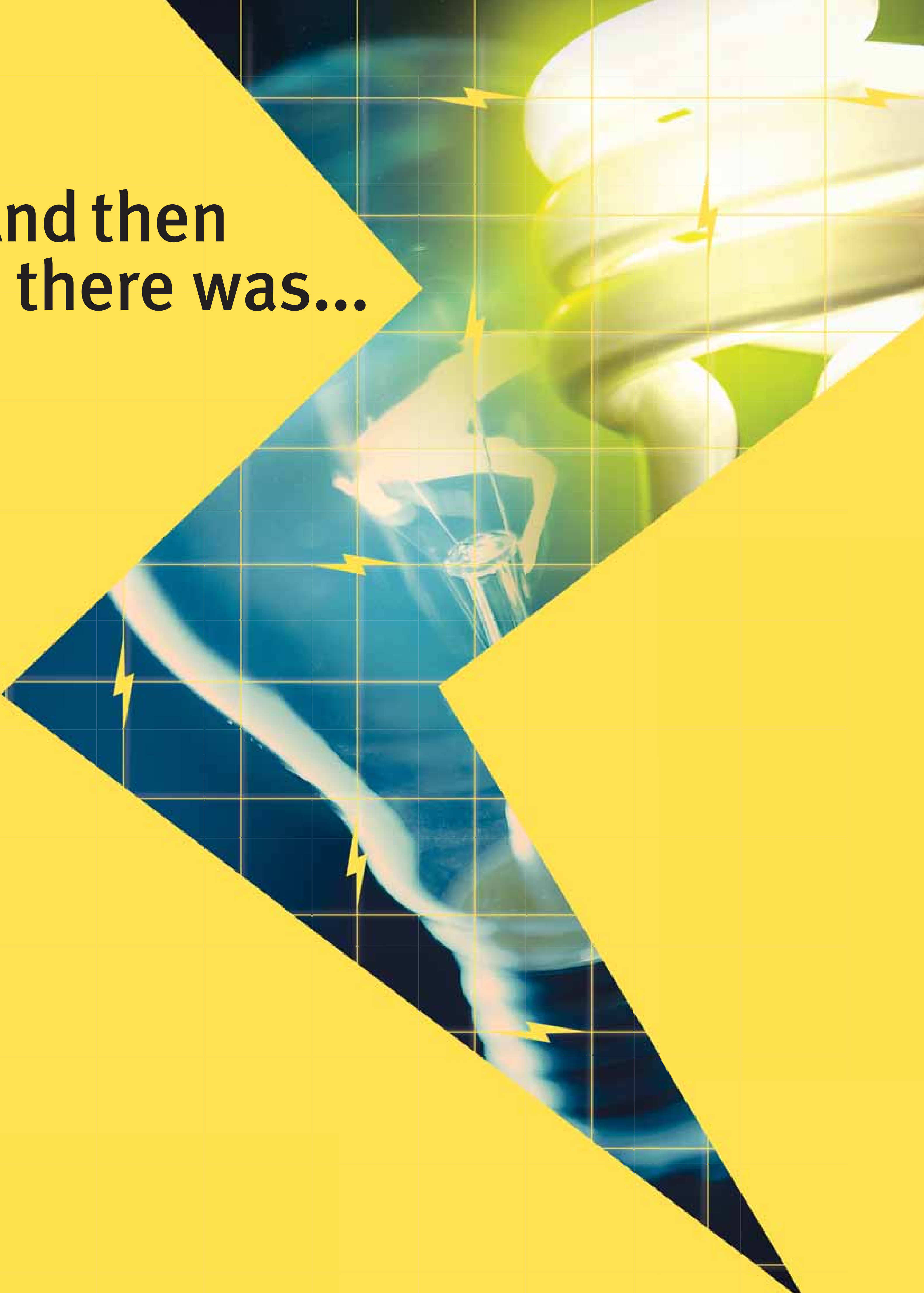
[ii] Source: Oracle, Turning Information Into Power Moving Toward the Smart Grid, 2009

[iii] Source: GE Smart Grid Survey, March 2010

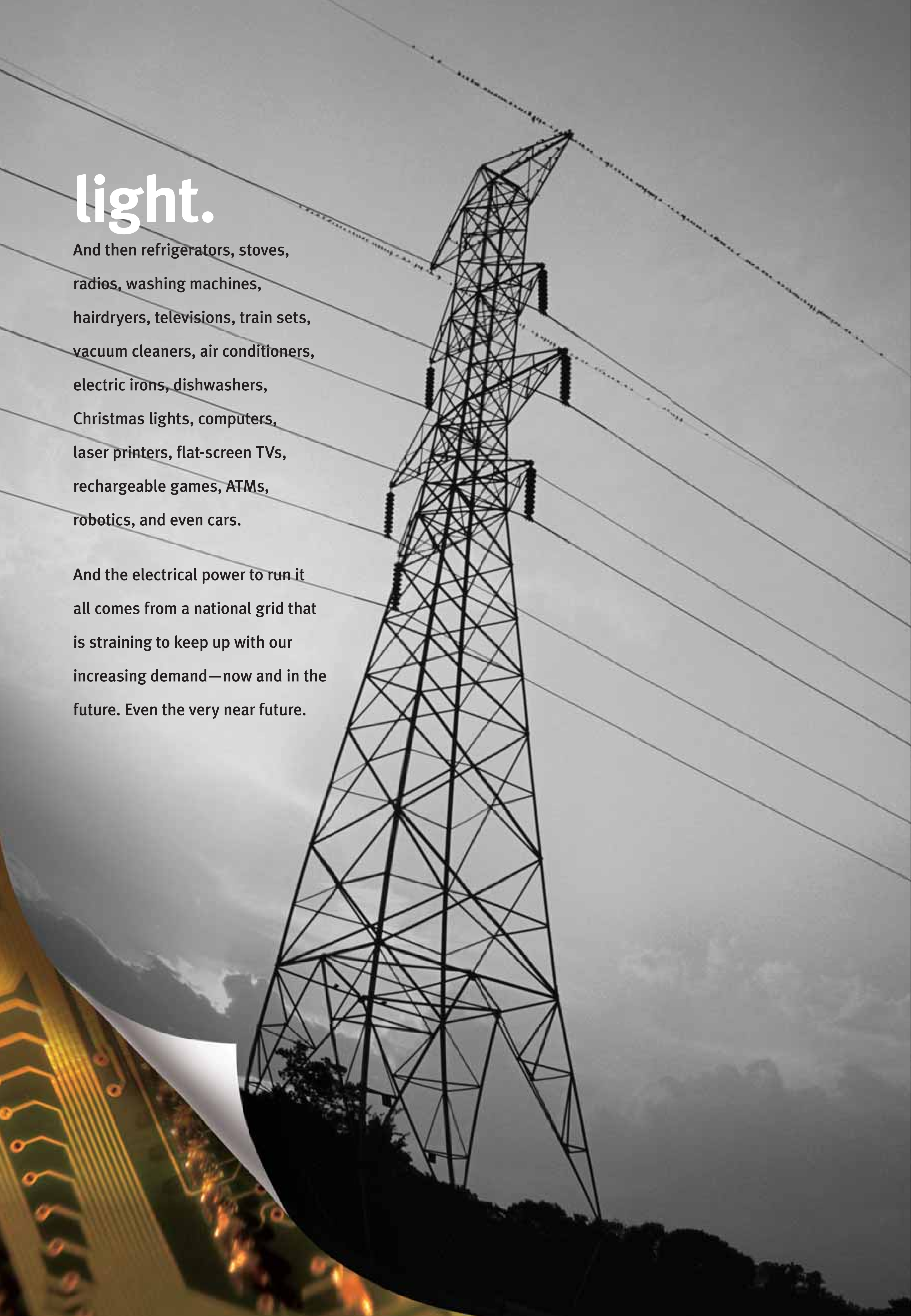
[iv] Source: Baltimore Gas and Electric PEAKRewards Program, 2009

- 3TIER
- ABB
- Accenture
- ADICA
- Alcatel-Lucent
- Alliander N.V.
- Altman Vilandrie & Company
- Ambient Corporation
- American Electric Power
- Arcadian Networks
- AREVA T & D
- Arizona Public Service Company
- AT&T
- Austin Energy
- Autodesk Inc.
- BAE Systems
- Battelle
- BC Hydro
- Beacon Power Corporation
- Belden, Inc.
- Bellevue University
- Better Place
- Black & Veatch
- The Boeing Company
- BPL Global, Ltd.
- Bridge Energy Group, Inc.
- Bridge Strategy Group
- British Columbia Institute of Technology
- Carnegie Mellon University
- Case Western Reserve University
- Center for Study of Science, Technology, and Policy (CSTEP)
- Center for the Commercialization of Electric Technologies
- CenterPoint Energy Inc.
- Cisco Systems Inc.
- CMEA Capital
- Columbia Technology Ventures
- Con Edison of New York, Inc.
- Consert, Inc.
- Cooper Power Systems
- CURRENT Group
- Dominion Resources Services, Inc.
- Duke Energy
- ECOtality/eTec
- Electricite de France
- Elia System Operator
- Elster Integrated Solutions
- EMC Corporation
- Energy Insights
- Energy Providers Coalition for Education
- The EnergySolve Companies
- Enel Distribuzione SPA
- EnerNex Corporation
- Ernst & Young
- ESPY Energy Solutions, LLC
- ESRI
- Florida Power & Light Company
- Florida State University, Center for Advanced Power Systems
- GE
- General MicroGrids, Inc.
- George Mason University – Center for Infrastructure Protection
- Georgia Institute of Technology
- Google
- GridPoint, Inc.
- Grid Net
- HCL America Inc.
- Hewlett-Packard
- Honeywell International, Inc.
- IBM
- Illinois Institute of Technology
- Indian Hills Community College
- Institute of Electrical Power Engineering, TU Clausthal
- Intel Corporation
- Itochu Corporation
- Itron Inc.
- Ivy Tech Community College of Indiana
- Johnson Controls Inc.
- Johnson County Community College
- Juniper Networks, Inc.
- KEMA, Inc
- Landis+Gyr
- Litos Strategic Communication, Inc.
- Lockheed Martin
- Management Development Institute
- Mercury Cable & Energy
- Microsoft Corporation
- Midwest ISO
- Milsoft Utility Solutions
- National Energy Center of Excellence – Bismarck State College
- National Grid
- National Institute for the Commercialization of Clean Energy
- National Instruments
- New York ISO
- Nexans
- Northern New Mexico College
- NSF FREEDM Systems Center
- Oncor Electric Delivery
- Open Systems International, Inc.
- OPOWER
- ORACLE
- OTN Systems
- Penn State University, Grtr. Allegheny Campus
- Pepco Holdings, Inc.
- PJM Interconnection
- Portland State University
- Power Systems Consultants, Inc.
- PPL Electric Utilities
- Progress Energy, Inc.
- Purdue University
- Qualcomm
- Quanta Technology
- R.W. Beck
- RockPort Capital Partners
- RuggedCom Inc.
- SAMSUNG Electronics
- SAP
- Schweitzer Engineering Laboratories, Inc.
- Science Times
- Sempra Energy: San Diego Gas & Electric
- Sensus
- Sharp Laboratories of America, Inc.
- Shore ENERGY at Salisbury University
- Siemens Energy, Inc.
- Silver Spring Networks
- Site Controls
- SmartSynch
- Southern California Edison
- Telvent
- Tendril Networks, Inc.
- Tennessee Valley Authority
- Teridian Semiconductor Corporation
- Tollgrade Communications Inc.
- Toyota Motor Engineering and Manufacturing North America, Inc.
- Trilliant Inc.
- Universal Powerline Association
- University at Buffalo, Department of Electrical Engineering
- The University of Texas at Austin – Office of Sponsored Projects
- UtiliPoint International, Inc.
- Utilities Telecom Council
- Van Denburgh Consulting Group
- Ventyx, Inc.
- Verizon
- Vermont Electric Power Company
- Vertex Business Services
- Virginia Tech - Advanced Research Institute
- Viridity Energy, Inc.
- Washington State University
- Western Dakota Technical Institute
- ZIV USA, Inc.

And then there was...



GRIDWISE ALLIANCE



light.

And then refrigerators, stoves, radios, washing machines, hairdryers, televisions, train sets, vacuum cleaners, air conditioners, electric irons, dishwashers, Christmas lights, computers, laser printers, flat-screen TVs, rechargeable games, ATMs, robotics, and even cars.

And the electrical power to run it all comes from a national grid that is straining to keep up with our increasing demand—now and in the future. Even the very near future.

Transforming the Power Grid Is Imperative

The electric power grid, hailed as "the most significant engineering achievement of the 20th Century," has been the primary driver of the economy for more than a century. It contributes incalculably to the comfort, security, and safety that we associate with everyday life.

But this massive infrastructure, this marvel of engineering, is aging rapidly. And our growing demand for more electricity is outpacing what our current grid can deliver.

Given our irreversible dependence on electricity and our growing concerns about the increasing demands of the digital age, the cost of energy, protecting the environment, reliability and security, it is critical that we now rethink how we transmit and distribute this essential "public good."

Fortunately, hundreds of organizations, both private and public, are building consensus on a wholly different approach to fulfilling this public trust: a Smart Grid.

Thomas Edison started it all when he patented the improved incandescent lamp on January 27, 1880.

Why Now?

Traditional power plants, transmission lines, and distribution networks cannot keep up with demand. Our economy, security, and quality of life are at risk if we continue to rely on the existing electrical power grid. The inability to store excess capacity limits effective asset management.

- **We can't afford a business model** that rarely utilizes maximum capacity. Today's grid lacks the advanced sensors, integrated communication systems, and supercomputers that would optimize the production, distribution, and use of our electric power assets.
- **We can't afford blackouts.** There have been five massive blackouts in the past 40 years; three of them occurred in the last 9 years. Smaller blackouts and power interruptions cost nearly $100 billion annually.

> " Since 1998, the frequency and magnitude of blackouts has increased at an alarming rate . . . If present trends continue, a blackout enveloping half the continent is not out of the question." [1]

- **With surging demand for**—and the rising cost of—energy of all kinds, we can't afford the inefficiencies of the current system. Storing excess capacity far from areas that need to offset maximum capacity demand results in poor asset management.
- **With growing awareness of,** and concern for global warming, we must enable the integration of other forms of energy—especially renewables.
- **To best protect our communities from** natural disasters and terrorist threats, we can't afford a grid that doesn't integrate all types and sizes of electrical generation and storage systems, or is unable to identify and isolate a problem.

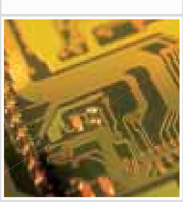
Fortunately, we *can* afford to shift our thinking, our business models, and our resources toward the creation of a smarter grid.

"It is evolutionary in its development and will ultimately be controlled by a combination of supply-and-demand market forces, regulatory stimulation, and environmental consciousness."[2]

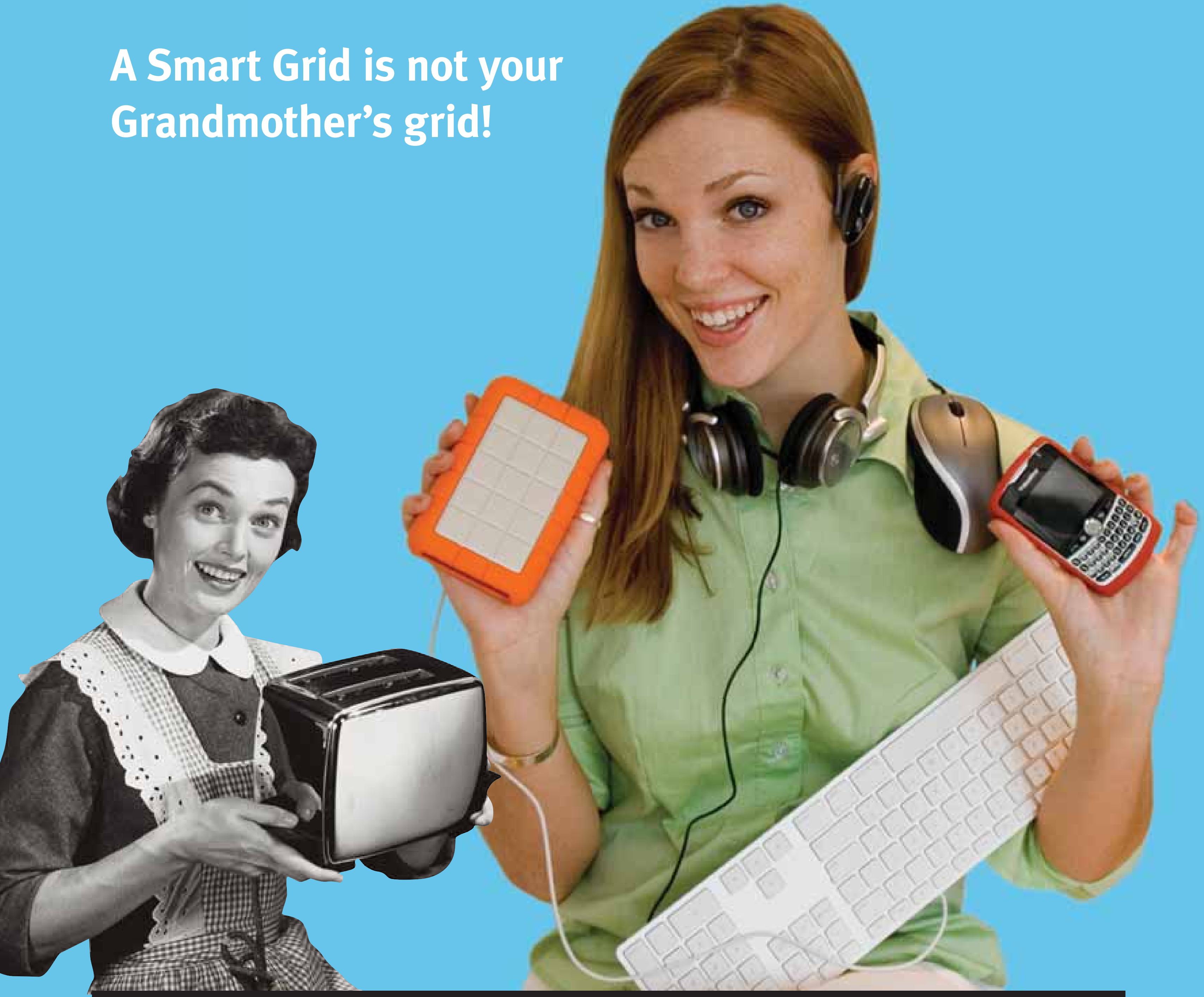
What is a Smart Grid?

The Smart Grid envisions an entirely transformed electrical infrastructure. It will embody a network of devices as vast, interconnected, automated, and interactive as the Internet.

- **A Smart Grid will integrate** the utility electrical system with telecommunications systems and innovative new technologies. Consumers will be able to reduce the cost of the electricity they use; utility companies will reduce their cost to deliver it.
- **A Smart Grid will deploy** new systems to integrate clean sources of energy such as wind power, solar power, fuel cells, and batteries to store the vast amounts of excess electricity that can be produced when sun and wind conditions are optimal.
- **A Smart Grid will employ** new tools and techniques to more efficiently and securely balance power between rising and falling demand.
- **A Smart Grid will be managed** with rapid response digital controls, automated problem analysis, and automated devices, much like the Internet is managed today.
- **A Smart Grid will deliver** new and essential business intelligence, be self-correcting, and allow networks of connected "assets" to communicate with each other.
- **A Smart Grid will allow** utilities and consumers together, to use information-rich dashboards and decision tools to manage the grid in real time.
- **A Smart Grid will be a flexible** and adaptable system that will transmit and distribute the power required for economic growth for the next 20 years and beyond. Transforming today's grid to a Smart Grid is possible, prudent, and necessary.



A Smart Grid is not your Grandmother's grid!



THE GRID TODAY	THE GRID TOMORROW
Electromechanical analog	Digital
MInimal communications (if any)	Ubiquitous two-way communication
Centralized generation	Distributed generation
Radial topology	Network topology
Few sensors	Ubiquitous monitors and sensors
"Blind"	Self-monitoring
Manual restoration	Semi-automated restoration; eventually, self-healing
Failures and blackouts	Adaptive protection and "islanding"
Manual equipment checking	Remote equipment checking
Emergency decisions made by committee/phone	Decision support systems, predictive reliability
Limited control over power flows	Pervasive control systems
Limited price information	Full price information
No consumer influence/involvement	Consumer influence/involvement

What REA Service Means to Our Farm Home (1940's)

The first benefit we received from the REA service was lights, and aren't lights grand? My little boy expressed my sentiments when he said, "Mother, I didn't realize how dark our house was until we got electric lights." . . . We changed our washing machine from a machine driven by gasoline to one driven by the electric current as our next improvement. The machine was all right with gasoline, but, my, the noise it made! It is such a blessed relief to do the laundry in peace and quiet . . . I always said that I wanted a vacuum cleaner. . . I have an old-fashioned Brussells carpet on my living-room floor, and when I swept it I raised as much dust as if I had been sweeping the dusty pike. When I finished I was choking with the dust, the carpet was not clean, and I was in a bad humor. Now with the vacuum cleaner, I can even dust the furniture before I clean the carpet, the carpet gets clean, and I stay in a good humor. So you see I am thoroughly enjoying the many things that electricity has made possible, and I am enjoying life more because I have more time to spend visiting my friends, studying and reading, and doing the things that make life richer and fuller.

—By Rose Dudley Scearce Rural Electric Cooperative

Today's Consumer—Taking Control

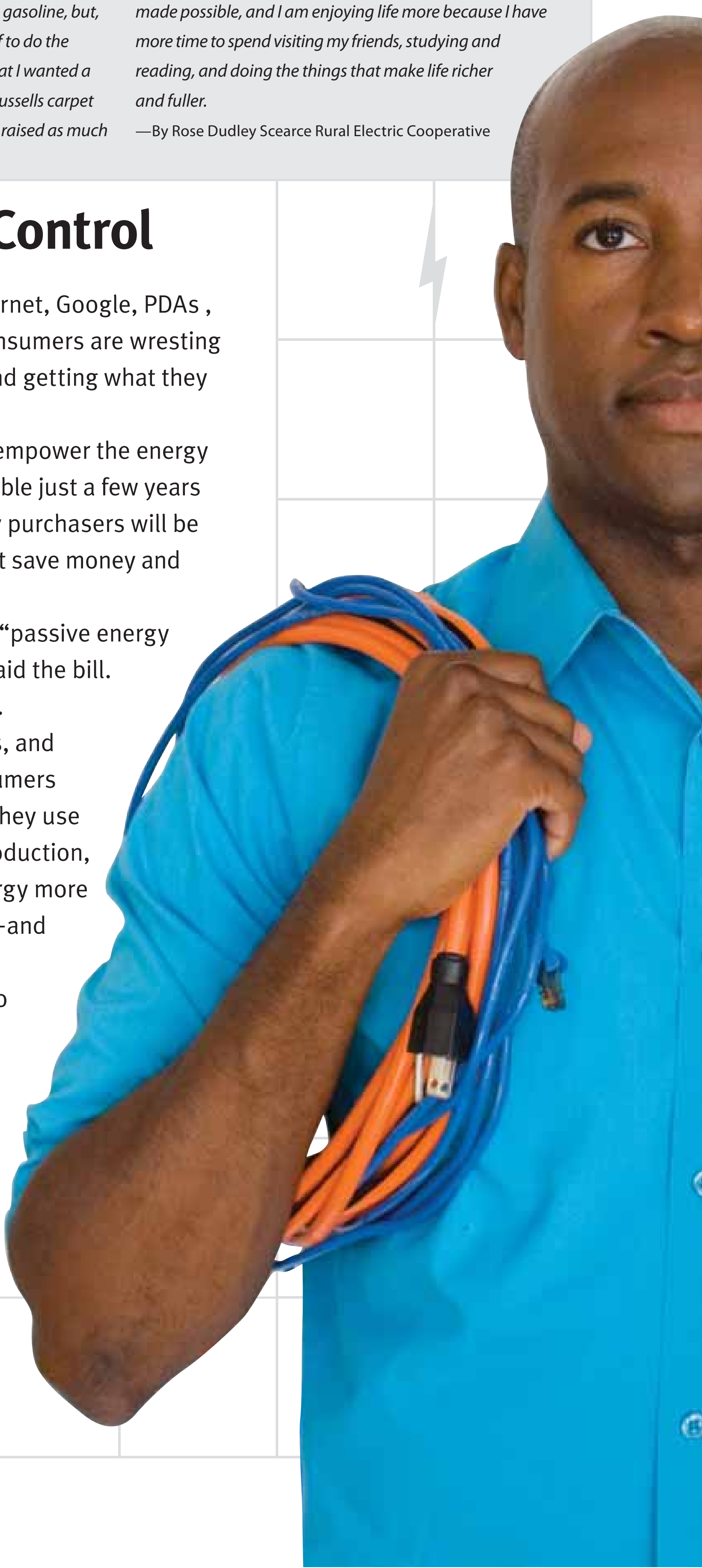
With the coming of the Digital Age and its offspring—the Internet, Google, PDAs , and the burgeoning world of RSS feeds, wikis and blogs—consumers are wresting control from traditional producers, suppliers, and retailers and getting what they want, when they want it.

So it will go with the Smart Grid. This smarter grid will empower the energy consumer—residential or commercial—to a degree unimaginable just a few years ago. Given new awareness, understanding, and tools, energy purchasers will be able to use the electricity they need while making choices that save money and help the environment.

Until recently, most consumers were content to remain "passive energy purchasers." You turned the lights on. Six weeks later, you paid the bill. Was there a relationship between the two? It was hard to tell.

With rising energy costs, our growing carbon footprints, and heightened awareness of the threat of global warming, consumers today demand more involvement in deciding how and when they use energy. Many are actively investing in their own means of production, using solar, wind, and geothermal. But options for using energy more wisely (and being rewarded for it by paying less) are limited—and expensive.

A Smart Grid will change that. Consumers can choose to use power at off-peak times and be rewarded for that choice with a lower per kilowatt hour rate. They will be able to find out hour by hour the units of power they've used, what they cost, and how to use less without compromising their quality of life. A Smart Grid will give energy users control, choices, and power. And the result—more informed energy choices—will benefit everyone.



Imagine a Complete Transformation of our Electric Power System

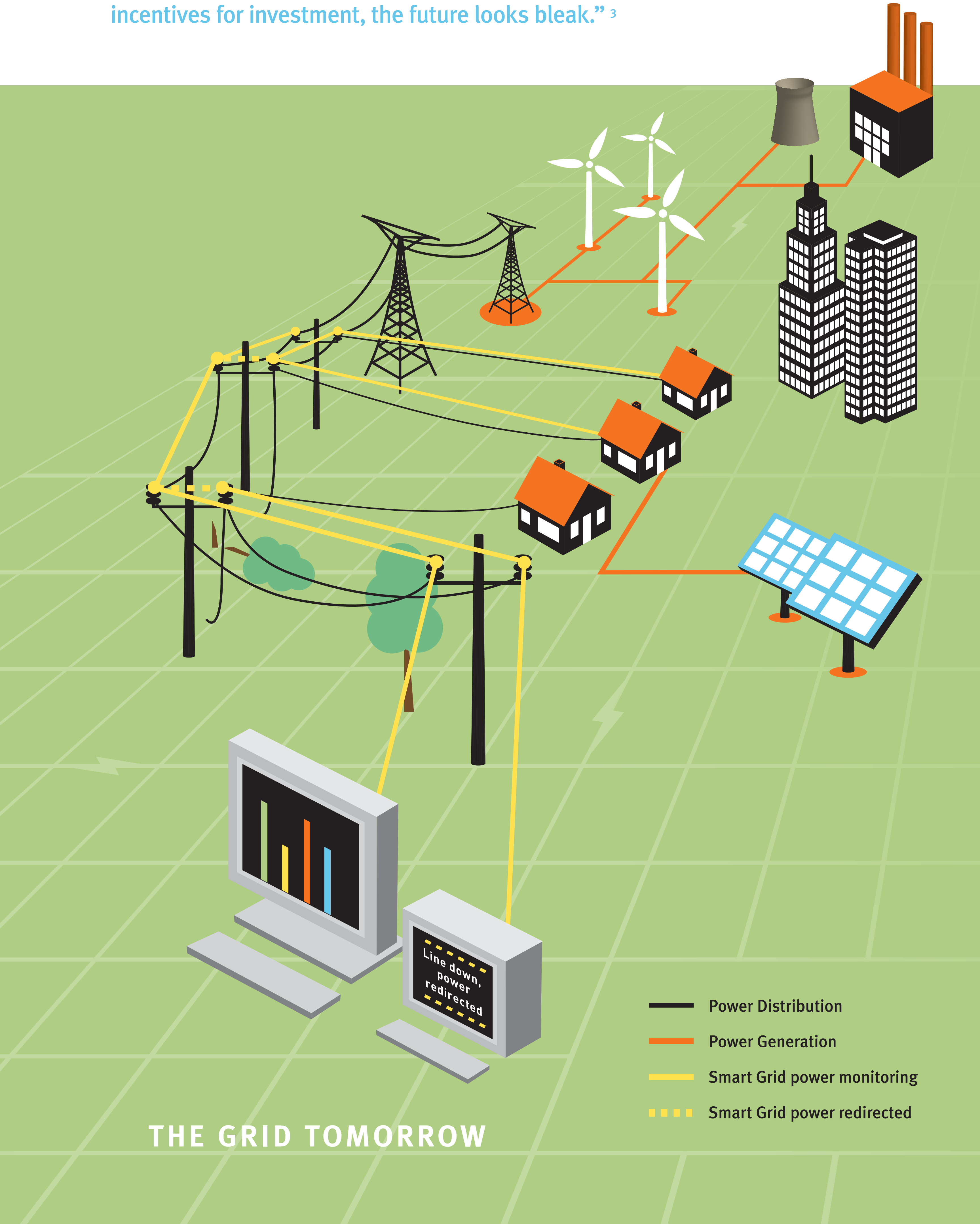
Imagine a power grid beginning with decentralized power generation to customer appliances and equipment. Think of a collaborative network filled with information and a myriad of market-based opportunities as revolutionary to power distribution as the Internet was to information exchange.

A Smart Grid will be powered by the most innovative technologies the energy and information industries can design. It will be supported by a new utility industry infrastructure—including businesses, regulatory agencies, and private-public partnerships—that offers incentives for investment in the best new products and services.

- A Smart Grid will support two-way communication between electricity producers and consumers.
- A Smart Grid's ability to send excess power to parts of the grid experiencing peak demand will reduce blackouts and power surges.
- Command, control, and communications technologies will detect, collect, analyze, and interpret operational data across the entire Smart Grid. This will allow for more reliable and efficient generation, distribution, and load balancing of electrical power as well as real-time threat detection.
- Producers of alternate forms of energy—wind, solar, geothermal—will be able to connect to the grid to sell power they don't need or to purchase power they do.
- Smarter devices in homes and businesses will give customers power—for the first time—the ability to lower their utility costs based on how much electricity they consume or conserve.

THE GRID TODAY

" The technology exists to enable a radical overhaul of the way in which energy is generated, distributed and consumed—an overhaul whose impact on the energy industry could match the Internet's impact on communications. But unless regulators restore the economic incentives for investment, the future looks bleak." [3]



GridWise® Alliance: Joining Forces to Realize a Smart Grid Future

A Smart Grid is already much more than a concept. Hundreds of enterprises, large and small, are pushing, adapting, and improving existing technologies to find solutions to the complex generation, storage, communication, networking, and delivery challenges that lie ahead.

It is essential that we capture the synergy created by this explosion of innovation. We need to relay new discoveries from one arena to the next; to engage local, state, and federal governments to create the policies and regulations that will support these efforts; and to ensure that we move collectively and confidently to a common endpoint.

The Gridwise Alliance is the forum for these new ideas and concepts. It is a vehicle for expanding the sphere of stakeholders, and engaging leaders of industry, government, and our communities. In this forum, all stakeholders can work cooperatively to move our industrial-age electrical grid into the information age.

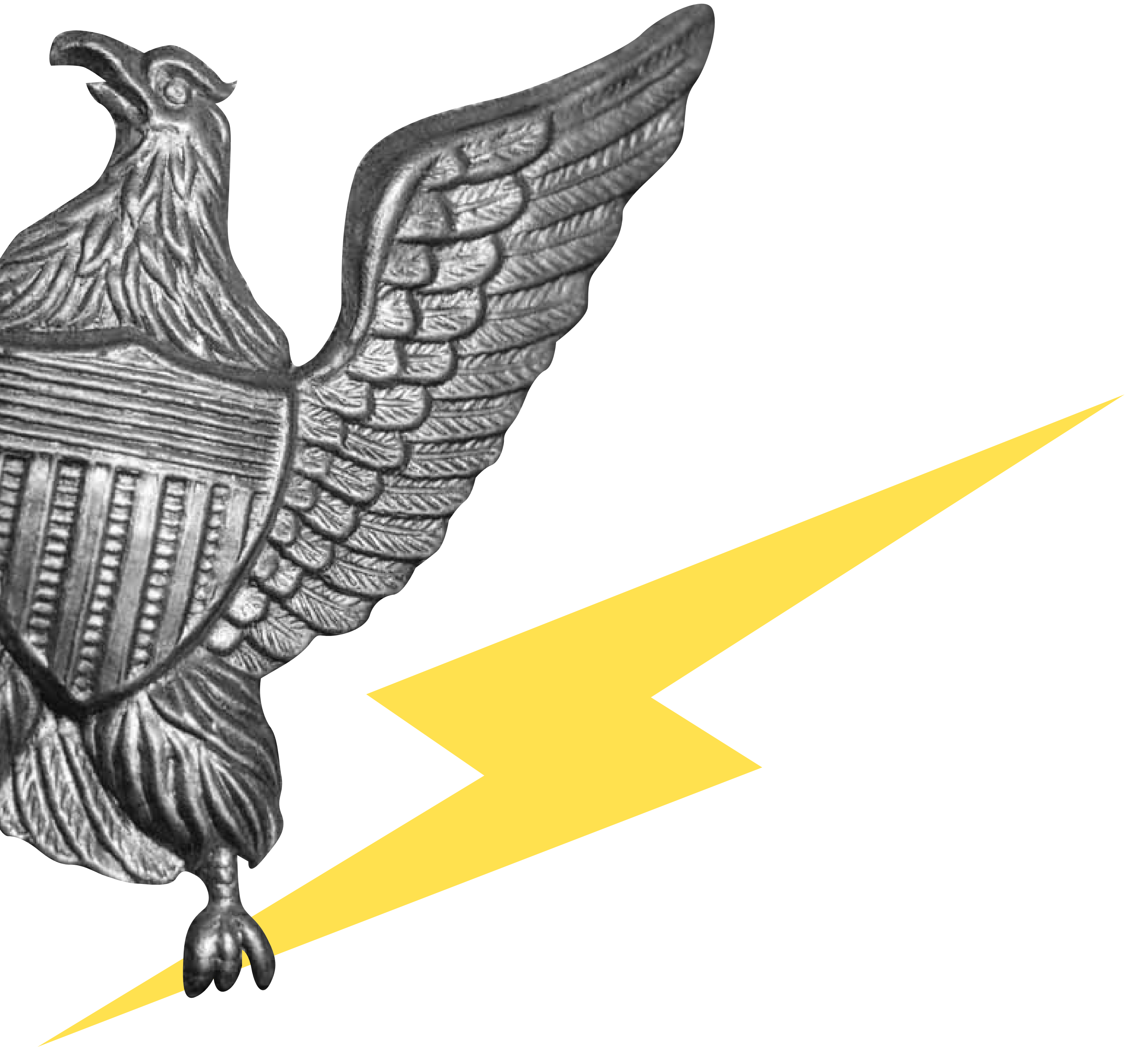
Whether you are a policy maker or energy producer, regulator or researcher, vendor or technology provider, we welcome your participation in this revolutionary undertaking—one that is critical to ensuring our nation's prosperity, national security, and public health and safety in decades and centuries.

ENERGY INDEPENDENCE AND SECURITY ACT OF 2007

TITLE XIII—SMART GRID

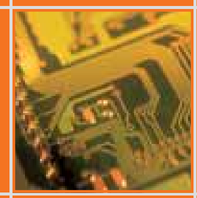
SEC. 1301. STATEMENT OF POLICY ON MODERNIZATION OF ELECTRICITY GRID.

It 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 that can meet future demand growth...









Moving Toward the Smart Grid—Progress on Many Levels

IN THE LAST FEW YEARS, UTILITY INDUSTRY LEADERS, TECHNOLOGY ENTERPRISES, FEDERAL, STATE, AND LOCAL ENTITIES HAVE INDEPENDENTLY OR IN PARTNERSHIP WITH OTHERS BEGUN THE STEADY PROGRESSION TOWARD A NEW TECHNOLOGY ECOSYSTEM.

On the federal level, the **ENERGY INDEPENDENCE AND SECURITY ACT OF 2007 ANNOUNCED THE SMART GRID AS A NATIONAL PRIORITY. THIS LEGISLATION CREATED A VARIETY OF NEW PROGRAMS AND GUIDELINES INCLUDING** supporting "smart grid" research and investment—a good first step—and establishing the Smart Grid Advisory Committee and the Smart Grid Task Force to make developing a Smart Grid a national priority.

Created in 2008, **DOE'S ELECTRICITY ADVISORY COMMITTEE** is a group of industry experts that advises the Department of Energy on strategies to implement the Energy Policy Act of 2005, the Energy Independence and Security Act of 2007, and on modernizing the nation's electricity delivery infrastructure. The Smart Grid Advisory Committee called for in EISA 2007 was formed as a subcommittee of **DOE's EAC.**

THE ELECTRIC POWER RESEARCH INSTITUTE has a variety of research, development and demonstration efforts developing new electric power delivery technologies that supports a smart grid vision.

THE GRIDWISE ARCHITECTURE COUNCIL is comprised of industry experts who are focused on interoperability of smart grid devices and systems; defining a framework that will enable vast scale interoperability to transform electric power operations in to a system that integrates markets and technology

THE GALVIN ELECTRICITY INITIATIVE, launched in 2005 in response to the massive East Coast blackout of August 2003, is headed by former Motorola chief Robert W. Galvin. Its aim is to create a power delivery system that is environmentally sound, fuel-efficient, resilient and robust; can withstand natural and weather-related disasters; and mitigate the potential damage caused by terrorist attack. Coined "the perfect power system," it provides affordable electricity to all consumers and allows consumers to control their own energy use to the extent they choose.

The **SMART GRID POLICY CENTER,** established in 2007, will conduct and promote research into smart grid policies and technologies to support the implementation and deployment of a smart grid. The Smart Grid Policy Center will become the center of competency on smart grid technologies and public policy issues.

The **GRIDWISE ALLIANCE** establishes Work Groups drawn from its members to address the challenges in successfully realizing a smart grid. Current Work Groups are focused on federal , regional, and state legislation and policy; implementation; and interoperability.

The Federal Energy Regulatory Commission (FERC) and the National Association of Regulatory Utility Commissioners (NARUC) have joined together in a collaborative dialogue on facilitating the transition to a smart electric gird. This **FERC/NARUC COLLABORATIVE** provides an opportunity for federal and state colleagues to work together on important new policies to support the vision of a smart grid.

The **U.S. DEPARTMENT OF ENERGY AND THE U.S. ENVIRONMENTAL PROTECTION AGENCY** are cosponsoring the National Action Plan for Energy Efficiency, Vision for 2025, whose goal is to achieve "all cost-effective energy efficiency by 2025." Gains in efficiencies—termed our "efficiency resource"—could meet 50 percent or more of the growth in demand anticipated between now and 2025.

The **AMERICAN PUBLIC POWER ASSOCIATION (APPA)** convened a Public Power Smart Grid Taskforce. The Taskforce includes representatives from public-owned utilities, nonprofits, and private entities to develop recommendations enabling public owned utilities to prioritize smart grid investments.

Edison Electric Institute's membership of Shareholder-Owned Utilities has made implementation of the Smart Grid a corporate goal for **EEI. EEI** seeks a rational evolution to the smart grid that focuses on the deployment of smart grid technologies as the value of those technologies can be shown.

The **U.S. DEPARTMENT OF ENERGY (DOE)** is supporting regional demonstration projects of smart grid technologies in Hawaii and Colorado. The DOE continues to fund a wide-range of research and development projects that support a smart grid.

A variety of state and regional smart grid initiatives and projects have been recently launched. These are a few examples. In the **PACIFIC NORTHWEST,** more than 200 smart energy enterprises have invested $2 billion to develop digital energy management technologies. With an expected investment of up to $100 million, **BOULDER, COLORADO** will be one of the first U.S. communities whose homes are all equipped with smart devices and software. In **MICHIGAN,** nearly 2 million smart meters are being installed in customer homes. In **TEXAS,** utilities and other companies are leading a variety of initiatives including investing in "broadband over power line" (BPL) technology. **CALIFORNIA** is a hotbed of smart grid initiatives that include millions of smart meters, roof top solar systems, battery storage, and other technologies.

[1] Mazza, Patrick, "Powering Up the Smart Grid: A Northwest Initiative for Job Creation, Energy Security, and Clean, Affordable Electricity," Poised for Profit in Clean Energy Report, July 2005. [2] Germano, Bruce, "Intelligent Electric Grids: Is the Future Here?", UTC Journal, 2007 Special Issue. [3] "Building the Energy Internet."

The GRIDWISE Alliance provides a forum where members representing a broad range of interests in the electricity sector can meet, exchange ideas, and work cooperatively on a common set of issues, with the goal of moving our industrial-age electric grid into the information age. In addition, the Alliance provides its members with opportunities to interact with senior policy makers on both the federal and state level who, together with industry, will transform the nation's electric power system.

GRIDWISE ALLIANCE

For more information please contact the ALLIANCE at info@gridwise.org GRIDWISE ALLIANCE 1155 15th Street, NW Suite 500 Washington, DC 20005 Phone: (202) 530-9740 Fax: (202) 530-0659 www.gridwise.org

Realizing a Smarter Grid

As demand for reliable power increases, energy costs rise, and protecting the environment becomes ever more imperative; we must revolutionize the way we generate, transmit, distribute, and manage electricity. Now is the time to use the power of digital technology to manage, measure and track energy as it moves from the supplier to consumer. We must re-energize our industrial era grid and bring it into the digital era.

It is time to realize a smart grid.

GRIDWISE ALLIANCE

Who We Are:
A coalition of private and public stakeholders who share a vision of a smarter grid. Our members include utilities, vendors, technology providers, academia, and other stakeholders.

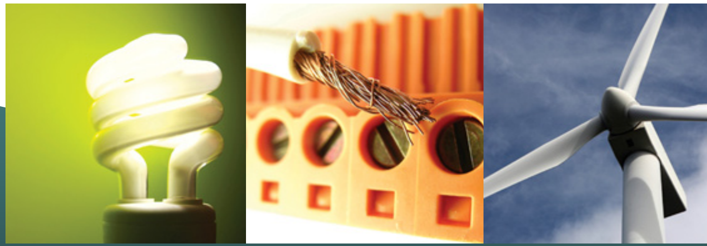
Our Mission:
To facilitate effective collaboration among all stakeholders, and to promote, educate, and advocate for the adoption of innovative smart grid solutions that will achieve economic and environmental benefits for customers, communities and shareholders.

Email: info@gridwise.org
www.gridwise.org

GRIDWISE ALLIANCE

Advocating for a Smarter Grid

Smarter Energy Starts with a Smarter Grid

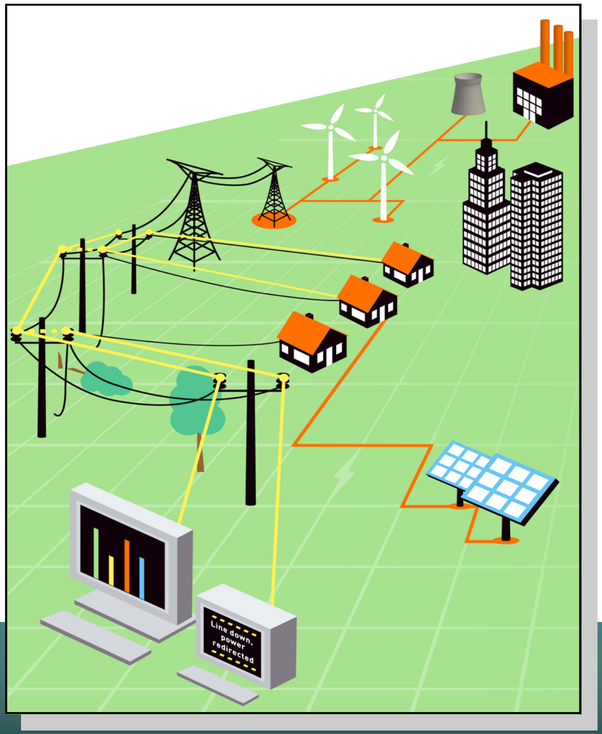


What is a Smart Grid?

A smart grid improves on our existing grid in a number of ways.

A smart grid will...

- Integrate electrical systems with telecommunications systems.
- Use high-voltage lines, digital controls, and automated analyses to instantaneously adapt to demands.
- Balance demand against supply more efficiently and securely.
- Accommodate clean renewable energy sources such as wind, solar, geothermal, etc.
- Allow utilities and consumers to communicate as never before.
- Be flexible and adaptable for future growth and innovation.
- Eliminate outages and brown-outs that cost businesses and manufacturers more than $100 billion yearly.



Why a Smart Grid?

Efficiency

A smart grid will provide an efficient electricity distribution system that uses digital technology to eliminate waste and improve reliability.

Reliability

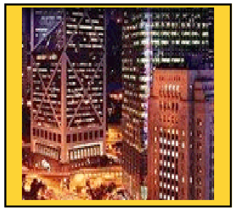
A smart grid will coordinate power from different sources , increase automation, and give utilities more information about when and where energy is being used—all increasing the grid's reliability.

Renewables

A smart grid will allow for the integration of electricity generated from renewable energy resources like wind, solar, geothermal, and biomass.

Economy

A smart grid will put an estimated $1.8 trillion back into the U.S. economy by 2020 through reduced energy use and improved reliability. The development of a smart grid will also increase jobs throughout the electric sector.



Security

A smart grid will strengthen the security of our critical infrastructure by making sure that power is available while anticipating and avoiding threats to the system's integrity.

Cost Savings

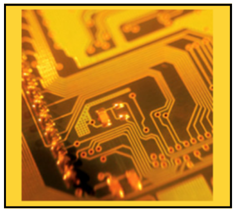
A smart grid will provide more efficient use of energy. Several demonstrations have shown that smart grid technologies have saved consumers money while easing strain on the grid.

Energy Independence

A smart grid is an important part of meeting President Obama's goal for energy independence. It will allow the integration of our own energy production using clean, renewable energy sources.

Consumer Choice

A smart grid will integrate new technologies like smart meters that will give customers more information about their household energy use allowing them to take greater control of their energy choices.



Climate Change

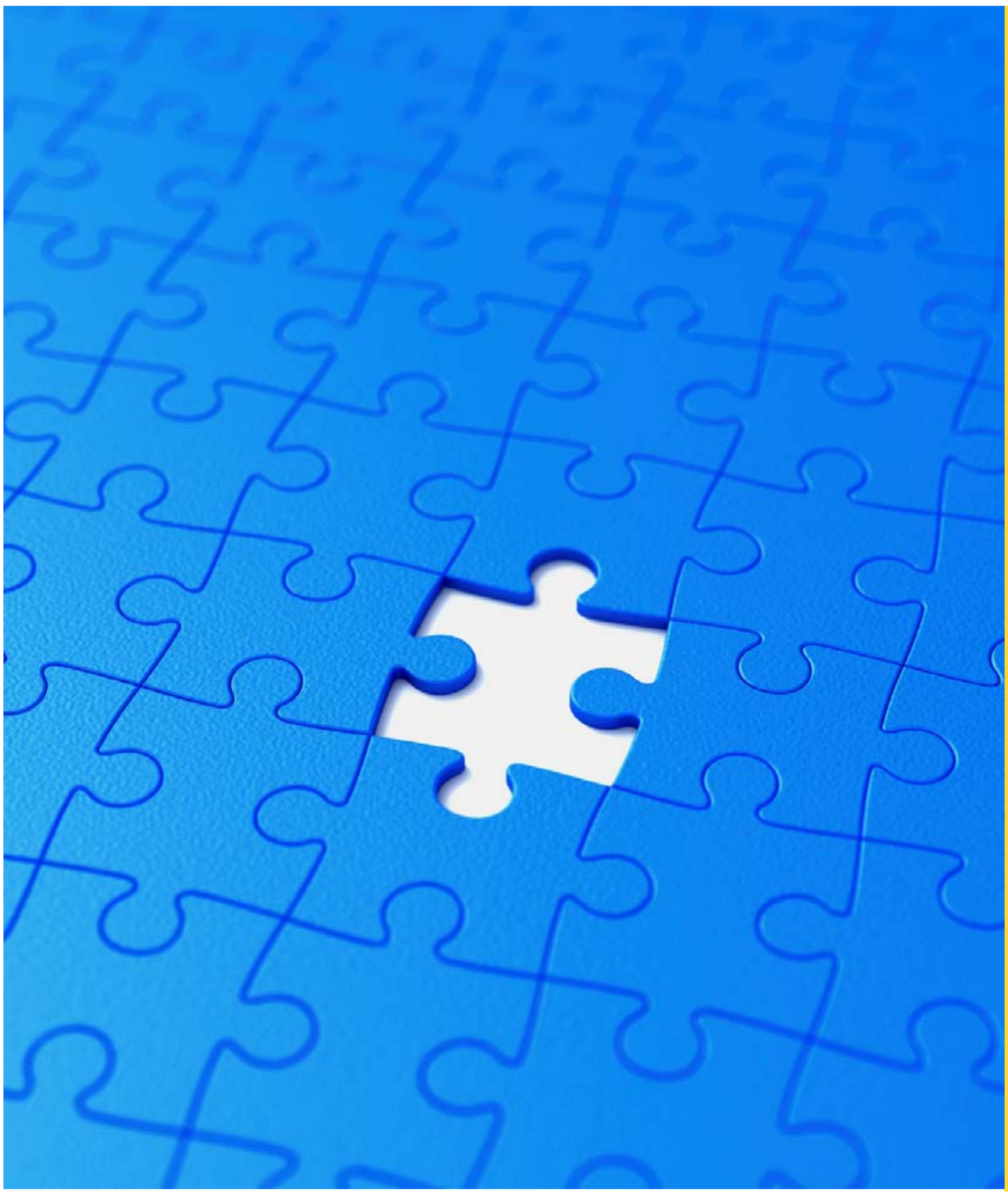
A smart grid will increase energy efficiency and integrate renewables reducing greenhouse gases and their environmental impact.

For More Information about smart grid visit:
www.gridwise.org

GRIDWISE ALLIANCE Advocating for a Smarter Grid

WHAT IS MISSING IN OUR FUNDAMENTAL KNOWLEDGE OF SMART GRID IMPLEMENTATION?

November 9, 2009 www.gridwise.org



This document was prepared in cooperation with the GridWise Alliance Implementation Work Group and Carl Imhoff, Battelle/PNNL.

The GridWise® Alliance – Advocating for a Smarter Grid

The GridWise Alliance, founded in 2003, is a consortium of public and private stakeholders which include utilities, IT companies, equipment vendors, new technology providers and academic institutions. The Alliance members are aligned around a shared vision of a smarter electric system that integrates the infrastructure, processes, devices, information, and market structure. This integration will ensure that energy can be generated, distributed, and consumed more efficiently and cost effectively resulting in a more resilient, secure and reliable energy system.

Table of Contents

I. Introduction

The Energy Security and Independence Act of 2007 (EISA) formalized the emerging interest and investment in “smart grid” in the U.S. It defined the general boundaries of smart grid concepts and framed the strategic interests that the nation had in the successful development and deployment of smart grid concepts. EISA, via Title XIII – Smart Grid, authorized a substantial increase in federal research and development (R&D) funding and called for public/private co-investment in major regional demonstrations of smart grid technology.

Pockets of smart grid implementations exist today; multiple demonstrations that span utility footprints, community footprints, and even regional footprints are in various stages of development. These efforts have arisen from local interests and needs and, at best, provide an ad hoc base of learning and results for consideration by the community at large.

Policy and regulatory dimensions of smart grid received attention in EISA with the call for federal coordination across agencies via a Smart Grid Task Force as well as a coordinated effort by state and federal regulators to examine regulatory innovation necessary to support successful implementation of smart grid concepts. In response, the Department of Energy’s (DOE) Office of Electricity Delivery and Energy Reliability convened the Federal Smart Grid Task Force (March 2008). In addition, the Federal Energy Regulatory Commission (FERC) and the National Association of Regulatory Utility Commissioners (NARUC) launched a joint collaborative on smart grid implementation in May 2008.

The GridWise Alliance recognizes the growing interest in smart grid and the substantial increase in planned demonstrations. The Alliance’s Implementation Work Group was established to improve and accelerate the progress of smart grid demonstrations and learn from these efforts for the benefit of nation-wide smart grid implementation. The Implementation Work Group sought to provide a regular summary of key research objectives that could maximize benefits extracted from investment in demonstrations. The Work Group also called for a common high standard of program evaluation and transparency, particularly for demonstrations receiving federal funding to insure that all stakeholders had access to credible and consistent information about these projects.

This document identifies gaps in knowledge about the implementation of smart grid technologies and recommends critical areas where information should be tracked and presented to understand the level of success of smart grid projects.

II. Smart Grid Knowledge Gaps

1. How do consumers respond to continuous requests to curtail demand?

Consumer participation over time in the face of repeated requests from utilities during peak demand days should be studied to better understand consumer reaction to demand response programs.

Preliminary demonstrations have shown strong consumer response to financial incentives for demand response, or utilities cycling off certain equipment (like air conditioning) during peak demand periods. It will be important to track these levels of participation and better understand customer response to calls for demand response since this tool is becoming more sophisticated and prevalent in the smart grid system.

2. How will transmission and distribution markets establish a common basis for regulatory innovation to support smart grid deployment?

Market interfaces for smart grid implementation at the distribution and transmission levels (ancillary services, bulk power markets, etc.) need to be evaluated and compared to establish a common basis for regulatory innovation to support smart grid implementation.

Elements of this issue include (but are not limited to) the following items:

a. Incorporation of environmental incentives into smart grid business models at the distribution and transmission levels.
b. Evaluation of consumer response and utility impacts of alternate rate structures, and evaluate the impact of the use of multiple rate structures versus single rate structures. Those structures may include real-time rates, critical peak pricing, peak rebate programs, simple two-tier rates, and traditional flat rates as part of a blend of rates in a given area.
c. Establishment of benchmarks for quantifying added values to support self-sustaining rollouts versus externally funded demonstrations.

3. How can the benefits of smart grid be quantified to demonstrate a host of claims?

It will be critical to test the impact of smart grid concepts on real-time distribution system optimization for economic benefits, energy efficiency and operational flexibility as well as customer service, outage management and enhanced emergency operations.

Most Advanced Metering Initiatives (AMI) and demand response demonstrations have focused on a narrow set of value propositions - typically peak demand management, billing efficiencies, and enhanced connect/disconnect services. The nation's energy policy agenda seeks higher energy efficiency from grid assets; demonstrations need to evaluate the real impacts on distribution balancing efficiency and improved asset management. Elements of this system include, but are not limited to, phase balancing, control of load power factor and harmonics, optimal voltage management, reduced peaks, automatic network reconfiguration, and substation asset sharing (which can defer substation upgrades and extend the life of transformers).

4. What will the framework be for system interoperability between new smart grid communications and markets and existing systems?

It will be important to understand the value delivered to all parts of the grid as new technologies are installed and data flows across legacy boundaries.

Our transmission system currently uses SCADA technologies which will be impacted when newer smart grid devices like synchrophasers are added to the grid. On the demand side, Energy Management Systems (EMS) will be affected by new smart meters and Home Area Network (HAN) systems. Demonstrations to date have had limited transfer of near real-time smart grid data across the traditional boundaries between the transmission, distribution, and customer interface systems. With more focus on integrated systems, we will begin to see more interaction along all parts of the grid. As newer technologies are installed, it will be important to test data flow across these traditional boundaries and the new paradigm of delivering value in both directions on the grid.

5. What measurements are necessary to understand how demand side controls impact the supply side during outages?

System operators need to be able to quantify demand side measures and their direct impact on the supply side of the grid.

Transmission operators need verification that the control resource represented by demand response is real, durable, and available needed to respond to a reliability event. Tools for representing available control resource and delivering it with high reliability need to be tested and the results shared with reliability councils and the North American Electric Reliability Corporation (NERC) committees to engage the operations stakeholders.

6. What types of regulatory support are necessary to provide meaningful demand response as renewable generation increases?

Validate the potential of aggregated demand response to provide meaningful fast regulation resources to support increased renewable generation.

Preliminary demonstrations have shown that real-time pricing extracts rapid and durable demand response that appears to offer value as "fast regulation" that would support integration of renewable generation resources and energy storage techniques. Emerging demonstrations need to validate that a meaningful amount of regulation resource could support a balancing area's ability to firm renewable generation.

7. What is needed to protect customer privacy in a two-way communications system?

Demonstrate models to provide customer privacy while still providing real-time response to low and high voltage operations.

Two-way communications will provide substantial knowledge of end-use activities. Methods need to be developed to demonstrate how to manage privacy issues to assure consumers and regulators that customer information is protected.

8. How can new digital transmission monitoring systems evolve into control systems?

Demonstrate the value of time synchronized data to support real-time control, an important step towards the goal of adaptive, self-healing grids.

The emerging Synchrophasor network being led by the DOE and NERC is nearing the point of sufficient coverage to enable wide-area monitoring and situational awareness. The next step for industry and government is to demonstrate the ability of time synchronized real-time smart grid data monitoring systems to achieve real-time control and advanced islanding and arming of fast grid transmission and distribution controls.

9. How can smart grid monitoring systems deliver lower reliability risks at the interconnection level?

Demonstrate the ability of smart grid monitoring systems to provide real time transmission and distribution system situational awareness and real-time alarming of impending reliability risks at the interconnection level.

High resolution, time synchronized data at the transmission and distribution levels have been, for the most part, implemented independently. An important next step for demonstrations is to link synchronized data with detailed system model and distributed computation, such as substation state estimators, into a coordinated monitoring and prediction system in order to enhance regional and local reliability operations.

10. How will the concept of distributed agents figure into the implementation of smart grid technologies?

Evaluate performance of "distributed agent" concepts and test interoperability as these systems evolve.

Distributed devices – or agents – have local intelligence and make decisions individually along the grid. These devices are being tested and considered for implementation in demand response demonstrations while key issues such as performance and compatibility with consumer preferences remain to be evaluated. Additionally, issues of interoperability need to be tested as these concepts are implemented at different levels of the power system and as systems evolve over time adding functions and changing communication platforms. These individual ultimately need to integrate seamlessly back to the operating utility.

11. What additional data is needed to demonstrate the benefits of smart grid?

Demonstrate the value of non-operational data collected from the smart grid to improve planning, asset management, and decision support for the power delivery system.

Smart grid communications and sensor technology enable the capture of specific equipment performance characteristics, equipment load profiles, system disturbances and events, and condition monitoring data. This information can be coupled with AMI data from the meters for detailed analysis of asset performance and system requirements. Decision support processes can be improved for system planning; asset utilization; operations and contingency response; asset life cycle management including transparent decisions for equipment upgrades retrofits, or replacements; and asset maintenance based on condition monitoring and assessment. Requirements for asset monitoring continue to evolve and grow.

III. Common Requirements for Qualifying Smart Grid Demonstration Projects

The national investment in major regional smart grid demonstrations can deliver the most value to the nation's smart grid agenda if they meet common standards for evaluation and if a broad population of regulatory models is covered in the demonstrations. Basic guidelines are suggested below.

A. Seek substantial demand response demonstrations (20,000+ premises) in four main regulatory footprints.

The intent is to capture a rich set of results depicting consumer behavior, performance of various rate structures, improvements in utility performance at low and high voltage levels, and the ability to leverage smart grid communications to support ancillary services markets where applicable. The primary regulatory footprints of interest include the following:

1. Investor-owned utilities (IOU) in a traditional vertically integrated utility environment (no market structures);
2. IOU in a market environment run by an Independent System Operator (ISO);
3. Tax Exempt public utility with municipal utilities and Public Utility Commissions serving as the Load Serving Entities; and
4. Electric Cooperatives/Rural Electrification Administration (REA) structure with Generation and Transmissions (G&T's) providing high voltage delivery and base load power.

B. A common standard for program evaluation needs to be set for projects attracting federal investment per the EISA Title XIII guidance to ensure that results are available and useful for review by stakeholders from regulatory to utility to policy to the vendor community.

The nation has a sense of urgency to address a range of energy issues including costs, constrained infrastructure, increased domestic content, and reduced carbon emissions. Regulators and policy groups need a substantial base of program results and data upon which to frame the next generation of regulatory concepts to encourage prudent implementation of the smart grid at a pace that serves the national energy imperatives.

GRIDWISE ALLIANCE Advocating for a Smarter Grid

HANDBOOK FOR ASSESSING SMART GRID PROJECTS

November 19, 2009

www.gridwise.org

Prepared By:

KEMA

Prepared for the GridWise® Alliance by KEMA, Inc. Authored by Valerie Nibler and Ralph Masiello with contributions from Ron Chebra, Tim Pettit, Miriam Goldberg, and Rob Wilhite.

The GridWise® Alliance – Advocating for a Smarter Grid

The GridWise Alliance, founded in 2003, is a consortium of public and private stakeholders which include utilities, IT companies, equipment vendors, new technology providers and academic institutions. The Alliance members are aligned around a shared vision of a smarter electric system that integrates the infrastructure, processes, devices, information, and market structure. This integration will ensure that energy can be generated, distributed, and consumed more efficiently and cost effectively resulting in a more resilient, secure and reliable energy system

Table of Contents

Exhibits

I. Introduction

About

This *Handbook for Assessing Smart Grid Projects* was developed for the GridWise Alliance, a diverse group of smart grid stakeholders that includes system operators, utilities, manufacturers, universities, software and communications companies, investors, and consultants. KEMA, Inc. took a lead in writing the handbook with a great deal of input from Alliance members as well as the Edison Electric Institute and their members.

This handbook is designed to serve as a reference tool for those organizations and entities that are developing and/or assessing a high quality smart grid project. The handbook provides a legislative background and citations, and lays out a series of metrics that could be considered when developing or assessing a project.

This handbook does not seek to be the sole source of understanding smart grid deployment, but should be used as guidance for those who wish to gain a better understanding of the costs and benefits of their project. Care should be taken to follow any project development and reporting procedures required by funding entities such as the Department of Energy.

Purpose

As smart grid projects begin massive deployment with Federal, private, public, and rate-based funds, questions will be asked as to the efficacy of those projects. The GridWise Alliance undertook this project in an effort to identify metrics that were important to evaluating the benefits of smart grid projects. Data collection, measurement and verification will all be important as Federal and state energy and climate policy takes shape and the electric grid begins its transformation to a cleaner, more intelligent ecosystem. This handbook was prepared by KEMA, Inc. with the GridWise Alliance to identify key metrics that smart grid projects should meet in order to be deemed high quality projects. The purpose of this paper is:

- To suggest key metrics for project developers to use when developing smart grid projects.
- To describe a process allowing stakeholder participation in meeting these metrics and for identifying weighting of metrics.
- To recommend a process for monitoring and reporting on effective use of smart grid funding, whether through the Federal, State or private investments.

- To ensure efficiency in contracting procedures, whether done on a Federal or State level.

II. Approach

To develop the suggested metrics, the American Recovery and Reinvestment Act of 2009 (Recovery Act) was thoroughly analyzed to understand its objectives and to identify all provisions that relate to the development of a Smart Grid. This led to an examination of the Smart Grid programs in Title XIII of Energy Independence and Security Act of 2007 EISA, which was amended and funded under the Electricity Delivery and Energy Reliability provision in the Recovery Act. The Initial Implementing Guidance for the Recovery Act from the Office of Management and Budget (OMB) was a key resource for understanding the planning and implementation requirements for various aspects of the Recovery Act.

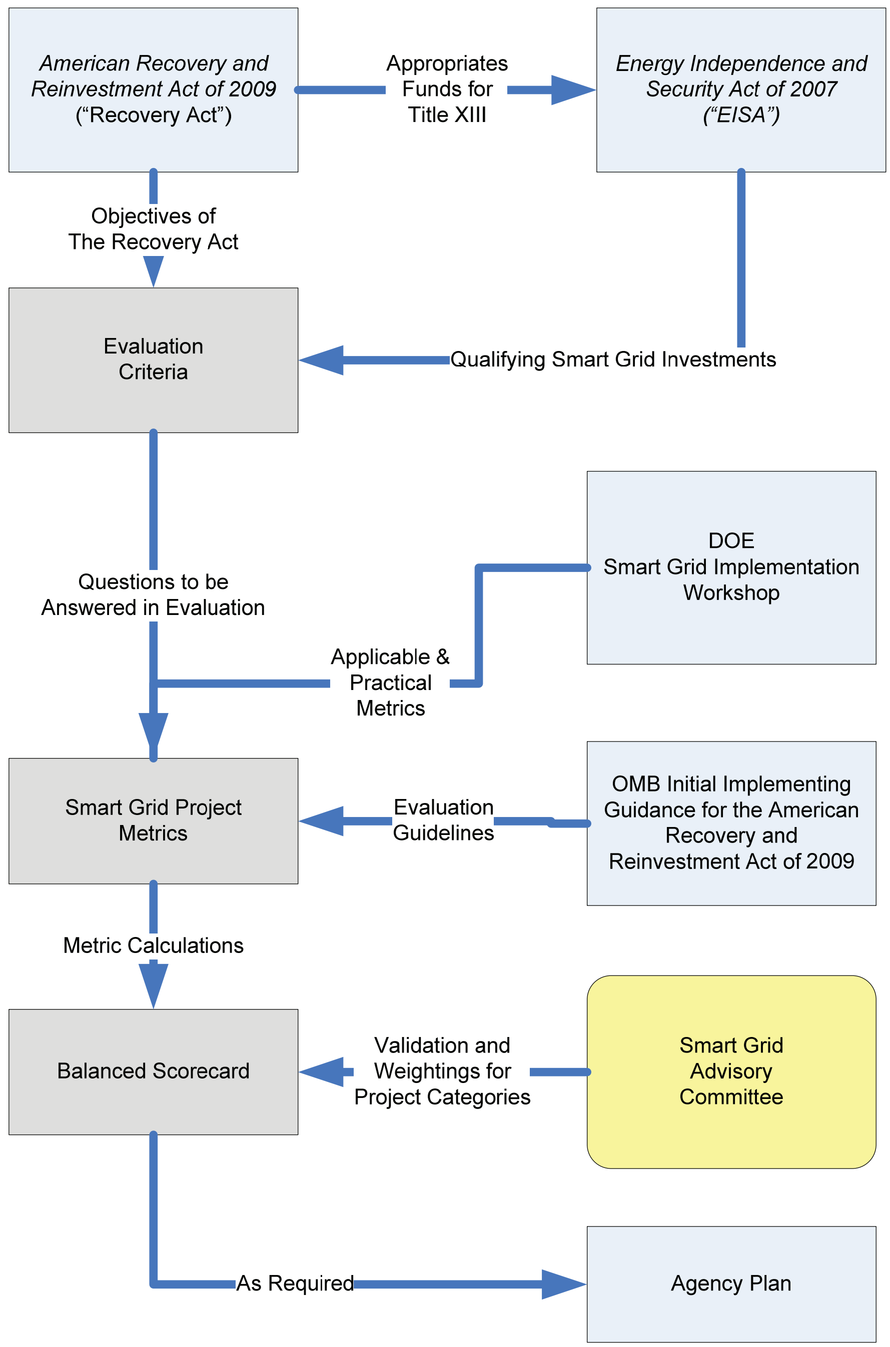
Prior and ongoing Smart Grid program efforts by the Department of Energy (DOE) and other stakeholder groups, were also leveraged, including the National Energy Technology Laboratory's (NETL) Modern Grid Initiative and work on key Smart Grid implementation metrics completed in June 2008 at the DOE's Smart Grid Implementation Workshop. From the workshop's key Smart Grid implementation metrics, metrics were selected that are applicable and practical for the purpose of evaluating project applications. Smart Grid business cases, regulatory filings, and ongoing utility performance reporting were drawn upon to identify relevant metrics.

To aid with comparative evaluations, a method for weighting the metrics is needed. Rather than suggest weightings, this paper suggests a proven methodology for developing weightings when complex metrics are in use and when different stakeholders have different perceptions of the relative importance of each metric.

This handbook also describes a process for publishing the metrics and weightings, applying them to grant applications, and disseminating results at a high level. Finally, a summary is provided on which metrics can be monitored and reported by project contractors and grant recipients and how these can be reported by DOE or other oversight agencies.

Exhibit 1 provides an overview of the approach used to develop the recommended metrics for assessing Smart Grid projects.

Exhibit 1: Metrics Development Approach



III. Using the Metrics

Few, if any, Smart Grid projects are likely to impinge on all the areas that the metrics in Appendix A cover. While a broad regional "demonstration" project might conceivably address all aspects of Smart Grid from "behind the meter" to the generator, the typical project will be focused on one or two of the domains. Going forward, utility project initiatives, which must be funded by state or municipal bodies via a regulatory approval process, are likely to be focused on specific domains.

Therefore, the metrics have to be selected for use in a given project business case in light of the purpose of the project.

Additionally, these are not metrics for a "scorecard" use where 100 is perfect and 65 is a pass-fail threshold. Rather, they are a compilation of the benefits and impacts that can be claimed and assessed in a project business case.

The DOE’s Smart Grid Clearinghouse and other initiatives in the states will begin to collect project implementation data that can help build a picture of numerics typical of these metrics, thus continually informing the process.

IV. Defining and Categorizing Smart Grid Projects

Developing relevant and effective metrics for evaluating Smart Grid projects requires that the meaning of a Smart Grid be clearly defined. Though many Smart Grid definitions exist, for the purposes of evaluating Smart Grid projects, this paper draws upon the definitions provided in EISA, Section 1301; Section 1306(b) - Qualifying Smart Grid Investments; and Section 1306(d) - Smart Grid Functions.

EISA, Section 1306 enumerates nine categories of expenditures that are authorized and eligible for matching funds. This paper focuses on the metrics that apply to Utility Investment Projects which are generally complex with many cost-benefit factors and frequently where multiple Smart Grid technologies and project types come together.

The GridWise Alliance recommends that smart grid projects could consist of:

- Retrofits to transmission apparatus with Smart Grid capabilities;
- Transmission monitoring, control, and optimization including sensors, communications, and computer systems and software;
- Distribution monitoring, control, and optimization including sensors, communications, and computer systems and software;
- Smart Grid technologies focused on renewables facilitation;
- Advanced Metering including advanced meters, communications infrastructure, and computer systems and software;
- Communications infrastructure to support Smart Grid including distribution automation and advanced metering;
- Microgrids capable of high reliability/resiliency and islanded operation;
- Integration of Distribution Automation (DA), Feeder Automation (FA), Advanced Metering Initiatives (AMI), and microgrid technologies;
- Technologies to assist in the efficient integration of plug-in hybrid vehicles;
- Consumer integration into energy markets and grid operations;

- IT, communications, and field automation projects concentrated on achieving compliance with Cyber Security standards.

Appendix B provides additional definition of these categories.

V. Technological Subsets of Smart Grid Initiatives

Implicit in the Recovery Act and prior DOE work on Smart Grid is recognition of different categories of Smart Grid technologies and applications ranging from new transmission apparatus and controls to smart meters and integration with home area networks (HAN). The different technological categories focus on achieving different objectives of the Recovery Act to varying degrees; that is, not all technologies address all objectives in a comparable fashion. How can project evaluators ensure that funding is sufficiently and fairly allocated so as to appropriately cover the broad universe of Smart Grid technologies?

The GridWise Alliance membership broadly supports all variations of Smart Grid projects and that it is important to deploy projects that span the broad domain of Smart Grid technologies.

VI. Evaluation Metrics

i. *Relationship of Smart Grid Technologies to Evaluation Factors*

Different Smart Grid projects with varying content in different categories of activity will match up with different evaluation factors and criteria differently. A set of criteria and corresponding metrics that span all of the Smart Grid project categories and qualifying Smart Grid investments identified in EISA, Section 1306 have been developed. Project evaluators may develop weighting factors or other mechanisms for selecting which metrics are best used for different kinds of projects. Not all metrics are applicable to all types of projects.

EISA, Sections 1304(b) and 1306 both stipulate that eligible investments must use open protocols and standards when available.

ii. *Metrics Development*

The recommended metrics for guiding Smart Grid project funding were developed using the results of the DOE's Smart Grid Workshop report on national Smart Grid metrics, which were assessed for applicability to this initiative and categorized within the evaluation factors from the legislation. Included in these recommendations were considerations for the practicality of applying quantitative metrics to track, assess, and report. Many of the workshop criteria were intended to measure success levels of the penetration and development of Smart Grid on a regional or national scale and are not applicable to a single project. Examples include measures of venture capital funding, and development of companies exceeding $100M in market capitalization. Others are useful measures of Smart Grid project impacts (e.g., improvement in System Average Interruption Duration Index (SAIDI)) for the purposes of developing metrics. Also considered was whether the particular metric was already included in Smart Grid business case development and/or regulatory filings. Metrics that are familiar to the Smart Grid community and already calculated in an intensive review process for large-scale projects are more likely to be successfully applied and submitted with proposals in a timely manner. Those which have too many issues identified in the workshop report and which are not typical today are likely to delay project proposals and evaluations. An assessment of the workshop metrics for this purpose is shown in Appendix C.

Some of the legislative objectives in the Recovery Act are simply not in the workshop results or, in some cases, in typical business case and filings. However, these are also likely among the most critical of the Recovery Act's objectives – particularly job creation, environmental impact (in terms of renewables facilitation and energy delivery efficiency), and the engagement and participation of the consumer. With these metrics, it is important that project evaluators provide guidance as to their definition and direction as to how to apply them in developing and measuring a project.

Using this process, a suggested list of metrics under each objective has been created. This is shown in Exhibit 2 and the detailed explanation of each metric development is shown in Appendix A.

Exhibit 2: Results

Evaluation Criteria	Metric
Economic Stimulus Effect	
Job creation plans and estimates	
Timing of job creation	Direct jobs and wages retained and/or created; normalized to #jobs/$000 of project cost
	Indirect supply chain jobs and wages as above
Impact on local economy	Wages and purchases spent in local economy times multiplier effect
Stimulation of a Smart Grid business ecosystem	Quantitative but subjective and hard to assess on a project basis
Impact on energy costs to consumers	% and $ decrease in consumer energy costs
	Consumer savings- average $ and % change in consumer annual bill by class
Number or extent of new programs/services being offered	Qualitative
Number of existing smart grid implementations in the state (to encourage geographic dispersion)	Qualitative
Other	As proposed
Energy Independence and Security	
Facilitation of renewable energy	Additional capacity for accommodating incremental renewables - MW and % peak MW and & energy; probably best described qualitatively
	% of DG / renewables that can be sensed and controlled
	Facilitation of distributed renewables - projection - MW, % peak MW; % energy
	MW and % increase in maximum remote renewable resource capacity the system can accommodate when possible to quantify
Electric Vehicle / Plug-in Hybrid Electric Vehicle integration	Qualitative

Evaluation Criteria	Metric
	# PHEV charging connected to V2G services
	Projected impact in terms of # of PHEV added
Demand Response management	# customers and coincident peak MW participating
	MWH saved at coincident peak
	MW reduction at coincident peak
	Market price impact
System Efficiency	% improvement in losses
	$ and % improvement in costs of failed equipment
	Improvement in system congestion costs when possible to evaluate.
Forecast of customer participation in demand response and conservation programs	# of customers and MW
Greenhouse gas emissions reduction potential	Tons GHG and per MWH; also tons GHG / customer
Power System reliability impacts	SAIDI improvement
	Reduced restoration time from major disruptions
	Reduction in major outages
	Improvement in Loss of Load Probability
Amount of transmission, distribution and substation automation in project	Increase in IED penetration integrated to SA and control systems
	# / % of lines, feeders and stations to be automated
Integration and Interoperability	
Links to the state energy assurance plan (required of all governors)	% fulfillment
Integration with state/local energy efficiency and conservation programs	Qualitative
Degree to which direct consumer participation is encouraged	Attractiveness of customer value proposition
	Open protocols and open business model to 3rd party products / services
Plans for measurement of customer participation and adoption	Qualitative
Interoperability of smart grid technologies	Qualitative

Evaluation Criteria	Metric
Use of Open Protocols	Qualitative
	% improvement in # of IEDs and controllable apparatus using open protocols
	Compliance to Security needs
Business Plan Robustness	
Completeness of technology plan and maturity of chosen technologies	Qualitative
Outcome of cost-benefit analysis which includes qualitative factors such as benefits to society	Qualitative
Plans for interim reporting on progress	Not a metric; specified by DOE
Implementation plan	Assess per FAR
	Risks - cost, schedule

VII. Evaluation Process

In order to apply these metrics to a proposed project and arrive at a balanced scorecard result suitable for comparing project proposals, project evaluators will need to develop weightings for each metric appropriate to the Smart Grid category being proposed.

One approach to developing the weightings (and gaining some acceptance of the metrics) for DOE to consider is the "Analytical Hierarchical Process" or AHP. AHP is a process for developing weightings of multi-factor metrics that are not easily quantified and where different stakeholders have different perceptions of the importance and value of each metric. AHP has an accepted theoretical background, is widely used in project evaluations in a number of domains, and has been applied to Smart Grid and related project assessment criteria development in the past. It is supported by a number of commercially available software tools. It is a transparent process wherein stakeholders interact to develop relative comparative pairwise weightings and then which rationalizes those weightings in a logical and mathematical framework. Appendix D provides additional details on AHP.

VIII. **Reporting**

The OMB Guidance spells out periodic agency reporting requirements on agency programs under the Recovery Act. The Guidance also points to existing Federal regulations and procedures for monthly cost and progress analysis and reporting by contractors and grantees. This paper does not attempt to amplify on these well-understood processes.

This paper, however, suggests that on some basis the funding recipient report on project performance against the evaluation criteria. The evaluation metrics that are calculated in the original project application and audited/modified/accepted by project evaluators should be derived from a set of calculations and assumptions that were transparent in the application and consistent with accepted definitions and Federal and state guidance. As such, they are subject to change as inputs to those calculations change. After deployment, the funding recipient should assess the system performance metrics (reliability, costs, consumer participation, etc) that were derived and report on planned versus actual results. A final report should include a reconciliation of planned versus actual metrics and scorecard results.

The Federal government in coordination with states should establish a database of metrics and scorecard results on proposed and awarded projects plus the evolution of metrics through the project and as finally reported. This database can be used to accomplish a number of beneficial results:

- Publication of it allows likely future project business cases, whether applying for Federal or state funding or not, to fine tune their proposed metrics and scorecards and to understand where the assumptions and calculations have changed with events.
- DOE will ultimately possess a database of planned and actual metrics that will be useful to the industry in future Smart Grid project planning on a commercial basis. This will also be useful in future regulatory processes.
- DOE will have a basis for periodic agency reporting of the planned and actual metrics and scorecards on an overall basis for analysis.

IX. Summary

A set of metrics for grant application evaluation and scoring were adapted from the results of recent DOE workshops with industry stakeholders that developed broad Smart Grid implementation success factors. Typical technical and economic metrics already well understood and developed in Smart Grid business case development and regulatory filings are used and mapped to the relevant workshop metrics. A process of ratifying the metrics and developing weightings for them is described that would make use of an accepted scorecard development methodology, the Analytical Hierarchical Process.

X. References

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Appendix A – Recommended Metrics

Evaluation Criteria	Metric	Description	Applicability
Job creation plans and estimates			
Timing of job creation	Direct jobs and wages created; #jobs/$000 of project cost	Net new jobs and wages of utility and project contractor employees, linked to project tasks and durations. Example: installation of 200,000 meters at 4 hrs/meter over 6 months results in 800 installers and 40 supervisors. Result should be in # of jobs and # of jobs / project cost. Profile of jobs and wages over time to be provided.	Typical with Major AMI Projects; less applicable to T&D projects
	Indirect supply chain jobs and wages as above	Suppliers estimate that project will result in XX incremental jobs over a time period incrementally greater than if project had not gone forward. Example: manufacturing, test, and delivery of 200,000 meters at 0.25 hours /meter over 6 months results in 100 jobs and 10 supervisors. Jobs are net of avoided layoffs and new hires/ contractors.	Multiplier times Procurement content in project

Evaluation Criteria	Metric	Description	Applicability
Impact on local economy	Wages and purchases spent in local economy times multiplier effect	DOE should publish Federally accepted multipliers for local regions. Proposing entities should use these for utility, contractor, and supplier jobs and wages to estimate additional regional jobs.	Broadly applicable as economic multiplier
Stimulation of a Smart Grid business ecosystem	Quantitative but subjective	If the project is expected to create / sustain direct and indirect supplier businesses, this should be described and quantified where possible. Examples could include factors such as % increase of revenues of Smart Grid technology/product supplier (jobs already counted above, note) or stimulation of NN local business enterprises / franchises installing consumer side products (PV, example). This latter may or may not be already counted in the local economic multiplier effect based on uniqueness of procurement and business opportunity. DOE will have to develop a process for scoring these claimed impacts.	Not applicable to most projects

Evaluation Criteria	Metric	Description	Applicability
Impact on energy costs to consumers	Projected % and $ decrease in consumer energy costs	Should be weighted more heavily if a proposed tariff than if a projected change. Also, rate increases are negative factors.	Typical for Demand Response Projects Only
	Projected Consumer savings- average $ and % change in consumer annual bill by class	Projected on a per consumer basis by class as is typical in regulatory filings today	Typical for Demand Response Projects Only
Number or extent of new programs/services being offered	Qualitative	Proposal should describe new services offered and an estimate of the consumer acceptance/participation. DOE will develop a methodology for scoring such	Applies to AMI / DR Projects integrated with behind the meter resources
Other	As proposed	Freedom for proposer to identify other economic benefits. Example: improved reliability reduces exodus of high technology firms. Reduced rates attract additional business.	Should encourage applicants to identify new types of benefits
Facilitation of renewable energy	Additional capacity for accommodating incremental renewables - MW and % peak MW and & energy	Could be as a result of increased transmission capacity (or reduced stability limit derating); could be as a result of peak reduction on distribution feeder; whatever rationale and calculation that can be	Difficult to do except in special cases today.

Evaluation Criteria	Metric	Description	Applicability
		supported	
	% of DG / renewables that can be sensed and controlled	Renewables and DG need to be integrated with Smart Grid and system operations via sensing, communications, control, and integration with system computer systems	Applies to SCADA, AMI, Distribution Automation
	Facilitation of distributed renewables - projection - MW, % peak MW; % energy	Calculation/estimate of additional distributed renewables as a result of technical support, integration technologies, consumer business propositions and value. Also fossil fuel offset	Applies to Above plus new planning and operations systems
	MW and % increase in maximum remote renewable resource capacity the system can accommodate	Increased transmission capacity to access remote renewables due to Smart Grid technologies. (this metric will only be applicable in selected instances)	Difficult to know except in special cases (example – special wide area protection)
Electric Vehicle / Plug-in Hybrid Electric Vehicle integration	Qualitative	Description of specific programs / customer participation offerings to attract PHEV	Applicable to EV/PHEV aspects of AMI and DA projects

Evaluation Criteria	Metric	Description	Applicability
	Projected # PHEV charging connected to V2G services	Projection of how many PHEV will be connected to Vehicle to Grid functionality for managed charging	Applicable to EV/PHEV aspects of AMI and DA
	Projected impact in terms of # of PHEV added	Programs to support / enable projected # of PHEV where projection source is regional, auto industry, governmental	Applicable to EV/PHEV aspects of AMI and DA
Demand Response management	Projected # customers and coincident peak MW participating	Per existing program filings. Calculated by revenue class	Applicable to AMI, DA, and behind the meter integration
	Projected MWH saved at coincident peak	Per existing filing methodologies, calculated by revenue class	Applicable to EV/PHEV aspects of AMI and DA
	{Projected MW reduction at coincident peak	Per existing filing methodologies, calculated by revenue class	Applicable to EV/PHEV aspects of AMI and DA
	Projected Market price impact	Per market simulations using accepted methodologies	Typical of Demand Response Projects in Deregulated Markets
System Efficiency	% improvement in losses	Reduction in losses via voltage control, peak reduction, use of storage, etc.	Typical of distribution volt/var control

Evaluation Criteria	Metric	Description	Applicability
	Projected $ and % improvement in costs of failed equipment	This metric summarizes the economic impacts of condition monitoring, condition based maintenance, asset management, and other operational techniques relying on sensors, systems integration, and advanced applications software	Goal of asset management programs utilizing condition monitoring
Projected reduction in congestion costs	Congestion Costs $$	Reduction in Congestion Costs as a result of increased limits via monitoring / calculations or via new algorithms	Difficult except in special cases
Forecast of customer participation in demand response and conservation programs	# of customers and MW	As per today's typical filings	Applicable to AMI, DR, and behind the meter projects
Greenhouse gas emissions reduction potential	Tons GHG and per MWH; also tons GHG / customer	Weighted per GHG norms; includes loss reduction, renewables increase, effect of conservation, and secondary effects such as reduced utility truck mileage	Applicable to demand response and energy efficiency; also to projects that alter system generation dispatch
Power System reliability impacts	SAIDI improvement	Per filings today	Applicable to many T&D automation and demand

Evaluation Criteria	Metric	Description	Applicability
			response projects
	Reduced restoration time from major disruptions	Projected from utility applicant experience and/or benchmark data; expressed as % reduction in the total major disruption customer outage hours (area under duration curve)	Applicable to Distribution automation
	Reduction in major outages	Not quantifiable today as incidents are too infrequent. Description of how outages will be avoided and why; relation to historical where possible; projected additional threat due to load growth, renewables growth, etc	Applicable to transmission optimization and control
	Improvement in Loss of Load Probability	Calculated improvement in system reliability due to Smart Grid technologies at the transmission level, including Synchrophasor, FACTS and other technologies, advanced software systems, asset management, and other technologies	Applicable to transmission optimization and control
Amount of transmission, distribution and substation automation in project	Increase in IED penetration integrated to SA and control systems	Increase in digital vs. analog/electromechanical technology and full utilization via comms and	Applicable to transmission and distribution

Evaluation Criteria	Metric	Description	Applicability
		integration per Smart Grid workshop discussions	automation projects
	# / % of feeders and stations to be automated	Comment: projects that deploy IEDs w/o substation, comms, and back office systems do not qualify	Applicable to transmission and distribution automation projects
Links to the state energy assurance plan (required of all governors)	% fulfillment	Exposition of contribution of renewables, demand management, and reliability projections to state plan. Could measure extent to which project fulfills state objectives but is not a comparable metric	Broadly applicable in a descriptive sense. Quantitative for demand response and renewables
Integration with state/local energy efficiency and conservation programs	Qualitative	Exposition of how project fulfills state objectives. And how to avoid double counting	Applicable to demand response, behind the meter integration
Plans for measurement of customer participation and adoption	Qualitative	Description of plans for end use consumption measurement; total household/business measurement; and statistical analysis of same	Applicable to demand response, behind the meter integration
Interoperability of smart grid technologies	Qualitative	Description of standards to be employed; justification of any	Applicable to all Smart Grid projects

Evaluation Criteria	Metric	Description	Applicability
		standards not embraced; plans to validate the interoperability; description of any new integration points or techniques. Decision not to use standards should weigh very negatively	
Use of Open Protocols	Qualitative	Binary yes / no; need a commitment to future open standards when available	Applicable to all Smart Grid Projects
	% improvement in # of IEDs and controllable apparatus using open protocols	The relative % of system IEDs and controllable apparatus that are integrated via open protocols	Applicable to transmission and distribution automation
	Compliance to Security needs	Assurance of levels of security consistent with industry practices and emerging standards	Applicable to transmission and distribution automation
Degree to which direct consumer participation is encouraged	Attractiveness of customer value proposition	Financial value to customer; extent to which is market tested; extent of hurdles to customer participation	Applicable to Distribution automation, AMI, and behind the meter integration
	Open protocols and open business model to 3rd party products / services	Qualitative description of provisions for 3rd party products and services (also part of ecosystem above)	Applicable to AMI and behind the meter integration

Evaluation Criteria	Metric	Description	Applicability
Outcome of cost-benefit analysis which includes qualitative factors such as benefits to society	Qualitative	BCA per filings. Include description of benefits, avoided costs, and costs borne by stakeholders to achieve benefits	
Plans for interim reporting on progress	Not a metric; specified by DOE		
Implementation plan	Assess per FAR		
	Risks - cost, schedule		

Appendix B – Smart Grid Project Categories Definitions

- **Retrofit of transmission apparatus with Smart Grid capabilities**: flexible AC transmission technologies; high-efficiency technologies (e.g., low-loss or superconducting technologies); high-speed switchgear; new voltage transient suppression technologies; environmentally-friendly technologies (lower profile transmission towers, oil-free or gas-free apparatus) new technologies targeted at renewables integration (e.g., novel undersea cables for offshore wind). Storage is explicitly called out in the Recovery Act and is both a technology that can be applied as a generation, transmission, distribution, or customer resource.

- **Transmission monitoring, control, and optimization**: sensors, communications, automation systems, asset-condition monitoring systems, planning and control room applications, including computer systems and software.

- **Distribution monitoring, control, and optimization**: sensors, automation systems, asset-condition monitoring systems, planning and control room applications, including computer systems and software including: feeder and substation automation with particular provisions for reducing peak and off-peak energy consumption; integrating high renewable levels, integrating consumer-side resources and demand response; improving reliability; reducing losses; improving resiliency against major disturbances – physical and cyber, natural, accidental, and deliberate. Also apparatus with new controllability, efficiency, or environmental-direct benefits.

- **Smart Grid technologies focused on renewables facilitation**: there are a number of technology "gaps" associated with support for high levels of renewable resources ranging from apparatus (inverters capable of providing voltage var support, governor response, and power system stabilization) to protection/automation systems (specific wide-area protection schemes aimed at high RP levels); feeder and station protection and automation systems developed for high local renewables penetration, and protection systems developed for high behind the meter or distributed renewables on distribution circuits), and analytic applications (forecasting, scheduling, and optimization tools which are developed for the high levels of uncertainty associated with some renewable portfolio projections).

- **Advanced Metering**: two-way metering capable of a variety of functionality including real-time pricing; remote connect/disconnect; integration of electric vehicles (EVs) and home area networks (HAN) at some level; power quality sensing and communications.

- **Communications infrastructure projects** associated with enabling utility-wide coverage for distribution automation, advanced metering, distributed generation, storage, and other resources. Distribution communication networks for smart grid capabilities: facilitating a network dedicated to the increased use of sensors installed throughout the distribution grid and other real-time, automated, interactive technologies required by the smart grid. For communications concerning grid operations and status, distribution automation, integration of renewable, Advanced Metering and microgrids.

- **Microgrids capable of high reliability/resiliency and islanded operation**: Advanced microgrids integrated with distributed generation and storage, bridge distribution systems, and consumer technologies.

- **Integration of Distribution Automation (DA), Feeder Automation (FA), Advanced Metering Initiatives (AMI), and microgrid technologies**: microgrids that are integrated operationally with utility Smart Grid systems.

- **Technologies to assist in the efficient integration of Plug-In Hybrid Vehicles**. Charging control, communications, computer systems and software, and distribution automation associated with PHEV integration with grid and market operations.

- **Consumer integration into energy markets and grid operations**: systems that communicate market information to customers and enable them to make decisions which impact markets as well as facilitating integration of grid operations with consumer decision making. Systems for integrating EVs with Smart Grid fall under this category.

- **Cyber Security projects** involving IT technologies, communications, and field smart grid components that are specifically targeted at achieving system compliance with cyber security standards.

Appendix C – Smart Grid Workshop

Smart Grid Workshop Metric	Rating	Issues In Workshop	Factor In AMI / SG Filings Today	Issue For DOE SG Metrics	DOE Stimulus Scorecard Basis
Enables Informed Participation by Customers					
% of customers capable of receiving information from the grid	H	Communications infrastructure acknowledgement of signals customer actual response technical penetration and standards	Yes	Yes	High
% of customers opting "in" or delegating authority	H	Definition, sources, demographics	Forecast as part of Benefit Cost Analysis (BCA)	Maybe	Medium
# of comms enabled behind the meter devices	H	Definition, product life cycles, what to include	Not under utility control at all	No	No
# of customer side devices interacting with the grid	H		Could be forecast for renewables and Electric Vehicle (EV)	Maybe	Medium/High
Amount of load managed	M	vs. business as usual, impact of information availability, measurement	Forecast as part of BCA	Yes	Yes
Measurable energy savings by customers	H	Definitions, load growth, EE vs. SG savings	Forecast as part of BCA	Yes	Yes
% of customers on 2-way TOU metering (actual)	M		Yes	Yes	Yes
# of participation options available to customers	M		Tariff issue often not addressed in SG filings	Yes	Yes
AMI Mkt penetration	M		Not relevant	No	No
MW of demand response / # of customers with DR	L		Forecast as part of BCA	Yes	Yes

Smart Grid Workshop Metric	Rating	Issues In Workshop	Factor In AMI / SG Filings Today	Issue For DOE SG Metrics	DOE Stimulus Scorecard Basis
% of successful rate recovery on smart grid investments	L		No	No but PUC endorsement needed	Yes as PUC endorsement
MW of DG / # of customers with DG	L		Forecast as part of BCA	Yes	Yes
Elasticity of demand in regional markets	L		Not Usually Today	Maybe	???
Reduction in CO2	L		Not Usually Today	Yes	Yes
ASCI point improvement	L		No	No	No
Accommodates all Generation and Storage Options					
% of grid networked to standards	M	Standards, FERC participation, non-IOU DER	No	Yes	Yes
% of Real Time (RT) DG & storage that can be controlled	M	Standards, data definition, needed R&D	No	Yes	Yes
% of load (energy) served by DG/renewables	M	Defining baseline, data management, validation	No	Yes	Yes
# of days to process DG applications	M	Single data base, many procedural issues	No	No	No
% of off system renewables served by storage	H	Visibility of Renewable; operational status of storage			
Improvement in load factors	M	Metering, multiple impacts, data validation	Usually Part of BCA	Yes	Yes
% completion of comms infrastructure to support DG and storage	M		Yes	Yes	Yes
Ability for scheduling and forecasting	L		No	Not for SG projects	No

Smart Grid Workshop Metric	Rating	Issues In Workshop	Factor In AMI / SG Filings Today	Issue For DOE SG Metrics	DOE Stimulus Scorecard Basis
Ability to accommodate 50% non-dispatchable generation by 2020	L		Not Usually	Link to any National RPS Goal	Maybe
Capacity of fossil gen retired	L				
Ability to sense DG presence	L		No	Yes	Yes
Ability to sense and measure DG physical effects	L		No	Yes	Yes
Address intermittency	L		No	No	No
Enables New Products, Markets, Services					
Degree of Regulatory Recovery for Alternative Solutions	H	Data base and funding, definition, non IOU,	No	PUC Endorsement	Yes - PUC Endorsement
Number of New SG related $100M enterprises	M	SG as sole driver; definitions; sources of data; proprietary data	No Applicable	No	No
# of products with end to end interoperability certification	M	Who certifies; scope of standards; validation; source of data	Not Applicable	No	No
Amount of VC funding for SG startups	M	Source and validity of data; what to count	Not Applicable	No	No
# of New Residential products vs 2 yrs prior	M	Definitions; who tracks;	Not Applicable	No	No
Expected availability of service	M		No	No	Yes
Venture Capital (VC) funding	M		Not Applicable	No	No
# households with Home Automation Network (HAN)	M		No	No	No
# consumer owned generation types	L		Yes	Yes	Yes

Smart Grid Workshop Metric	Rating	Issues In Workshop	Factor In AMI / SG Filings Today	Issue For DOE SG Metrics	DOE Stimulus Scorecard Basis
n# of MW saved and business models capitalizing on savings	L		Usually in BCA	Yes	Yes
Per capita electricity use	L		No	No	No
BCA and NPV of project	L		Yes	Yes	Yes
# of EV charging off peak	L		No	Maybe	Maybe
Optionality value of savings	L		No	No	No
Consumption efficiency by users	L		Yes	No	No
# new standards	L		Not Applicable	No	No
# of title 13 related generization plans	L		Not Applicable	No	No
Per capita avoidance of GHG	M		No	Yes	Yes
Provides Power Quality Needs for Digital Economy					
#Devices/Reliability Improvement	H	Definitions and determination	Yes	Could be in BCA	Maybe
# Power Quality Measurements per customer	H	What is actually useful	Yes	No	No
# Power Quality Incidents that can be anticipated and identified	H	Definition; cause, standards	Yes	No	No
# States with Power Quality performance rates	M		Not Applicable	No	No
# customer complaints re Power Quality	H	Definition, attribution to SG	Yes	No	No
# PQ devices sold and installed	M		No	No	No
Open architecture of devices	L		No	No	No
$ of sensitive loads with immunity	M		No	No	No

Smart Grid Workshop Metric	Rating	Issues In Workshop	Factor In AMI / SG Filings Today	Issue For DOE SG Metrics	DOE Stimulus Scorecard Basis
# customer choices for PQ levels	M		No	No	No
DG level where VR is economic	L		No	??	??
Cost to economy of PQ	L		No	??	??
Optimizes Asset Utilization and Operating Efficiency					
Transmission					
# assets deferred and timing	H	Tracking; must maintain performance	Sometimes in BCA	Yes	Yes
# of MW involving V / VAR control	M	Definitions, what technologies	No	Yes	Yes
# assets with condition monitoring an diagnostics	H	Tracking by category; definitions	No	Yes	Yes
# lines with dynamic ratings	M		No	Yes	Yes
3 miles of line with advanced materials and devices increasing capacity	M	Definitions, better metrics	No	Yes	Yes
Distribution					
MW of DG as dispatchable assets	H		Yes	Yes	Yes
% SG enabled apparatus	H		No Usually	Yes	Yes
# MW with V VAR controls	M		Not Usually	Yes	Yes
# customers connected per automated segment	M		No	Maybe	Maybe
Consumer					
# smart meters	H	% two way; openness; functionality	Yes	Yes	Yes

Smart Grid Workshop Metric	Rating	Issues In Workshop	Factor In AMI / SG Filings Today	Issue For DOE SG Metrics	DOE Stimulus Scorecard Basis
# customers with TOU rates	L	Link to meter deployment; available vs. utilized	Yes	Yes	yes
MW dispatchable demand response	M	Available vs. utilized	Yes	Yes	Yes
General					
# IEDs deployed	M	Definitions; track by assets monitored	No	Yes	Yes
# IEDs with full communications	M		No	Yes	Yes
# IT applications integrated	M		No	No	No
# of Phase Measurement Units (PMUs) deployed	M		No	Yes	Yes
Addresses Disturbances via Automated Prevention, Containment, and Control					
% of assets that are monitored, controlled, or automated	H	Variations; definitions; standards	Yes	Yes	Yes
% of nodes and customer interfaces that are monitored	H	What assets qualify; definitions; standards; variations	Yes	Yes	Yes
Level of deployment of common communications infrastructure	H	Definitions; standards development; current state	Yes	Yes	Yes
% of system that can be fed from alternative sources	H	Variations; not always a valid approach	No	Yes	Yes
geographic coverage, numbers, MW covered by PMU	H	Definitions; actual usage	No	Yes	Yes
Amount of focused disturbance location	M		Yes	Yes	Yes
Extent of cbm	L		No	Yes	Yes
Db level of 5th & 7th harmonics	L		No	No	No

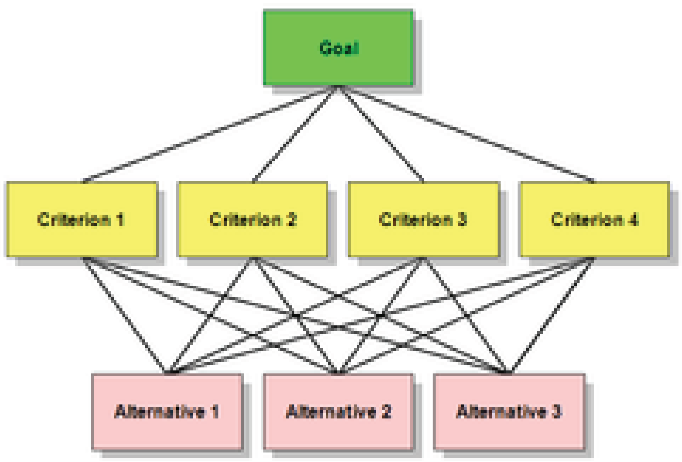
Smart Grid Workshop Metric	Rating	Issues In Workshop	Factor In AMI / SG Filings Today	Issue For DOE SG Metrics	DOE Stimulus Scorecard Basis
MW in RTP and DSM	L		Yes	Yes	Yes
# of automated grid operations	L		Can be in BCA	No	No
Amount of system visibility	M		Not Explicit	Yes	Yes
extent of data exchange/interoperability	L		No	Yes	Yes
(N-X) reliability	M		No	No	No
% of load /MW of storage	M		No	Yes	Yes
Amount of networked distribution	L		No	No	No
Smart Grid roadmap	L		No	Yes	Yes
# breaker cycle faults/yr	L		No	No	No
% of circuits > 1 switch	L		No	No	No
# sections w dist loc	L		No	No	No
Restoration time	M		No	No	No
# prevented disturbances	L		No	No	No
# outages/duration	M		Usually in BCA	Yes	Yes
Customer sat	L		No	No	No
# regional outages	L		No	No	No
Operational errors (disconnects)	L		No	No	No
System efficiency	L		Loss reduction in BCA	Yes	Yes
Feeder lvl quality metrics	L		No	No	No
Maintenance cost per unit availability	L		Sometimes in BCA	Yes	Yes
Resilient against all hazards					
% operating entities that exhibit progressively mature resiliency behavior	H	Specificity; willingness to respond; who actually owns/maintains affected systems;	No	No	No

Smart Grid Workshop Metric	Rating	Issues In Workshop	Factor In AMI / SG Filings Today	Issue For DOE SG Metrics	DOE Stimulus Scorecard Basis
Measure of # alternative paths of supply	H	Data availability and validity; baseline;	Sometimes in BCA	Yes	Yes
Qualified operating margin that is needed to ensure resiliency	H	Knowing ultimate capacities; knowing real time state; information sharing	No	No	No
Adjusting standard metrics to capture physical/cyber attacks	H	Agreement re new codes; privacy and reporting issues;	No	No	No
DOD cyber system metrics	L				
Training	L				
# interconnected urban substations	L				
# successful cyber attacks	M				
# domains penetration tested	M				
# CIP standards addressing SG	L				
NERC CIP compliance	L				
# devices meeting CIP	L				
Cyber security issue repair time	L				
Physical threat identification time	L				
# physical threat attempts	L				
# physically hardened distribution facilities	L				
Reduction in critical load outages	L				
% of DG/DR automation	L				
Failures to conflicting procedures	L				
# hazard events detected	L				

Smart Grid Workshop Metric	Rating	Issues In Workshop	Factor In AMI / SG Filings Today	Issue For DOE SG Metrics	DOE Stimulus Scorecard Basis
System availability	M				
Enhanced recoveries via SG	M				
Event impact reduction	L				
# of assets for which risk assessment is done	H				
Dollar loss per unit time	L				
# secondary assets affected	L				
Additional Stimulus SG Metrics					
Stimulus Effects					
Utility jobs lost/created	H		Yes	Yes	Yes
Contractor jobs	H		Yes	Yes	Yes
Supplier jobs	M		No	Yes	Yes
Expense timing	H		Yes	Yes	Yes
Retraining	M		Sometimes	Yes	Yes
Facilitation of Renewables					
Facilitation of EV/PHEV					

Appendix D – Analytical Hierarchical Process

The Analytic Hierarchy Process (AHP) is a structured technique for helping people deal with complex decisions. Rather than prescribing a "correct" decision, the AHP helps people to determine one that suits their needs and wants. Based on mathematics and psychology, it was developed by Thomas L. Saaty in the 1970s and has been extensively studied and refined since then. The AHP provides a comprehensive and rational framework for structuring a problem, for representing and quantifying its elements, for relating those elements to overall goals, and for evaluating alternative solutions. It is used throughout the world in a wide variety of decision situations, in fields such as government, business, industry, healthcare, and education.



A Simple AHP Hierarchy

Several firms supply computer software to assist in using the process.

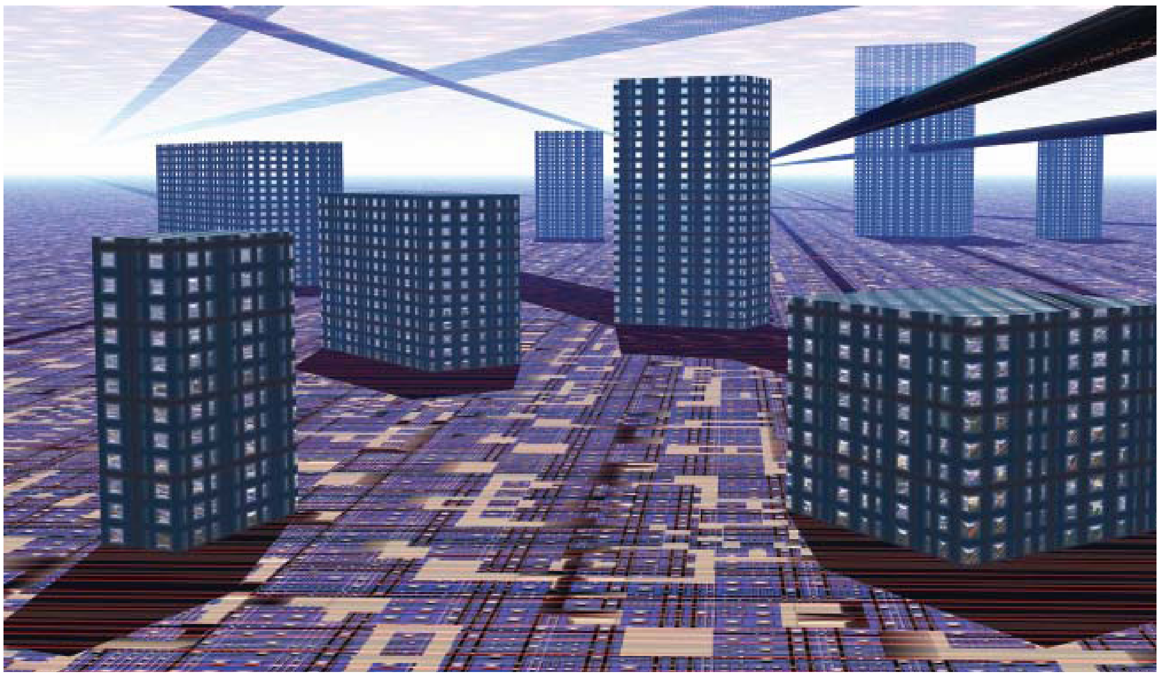
Users of the AHP first decompose their decision problem into a hierarchy of more easily comprehended sub-problems, each of which can be analyzed independently. The elements of the hierarchy can relate to any aspect of the decision problem—tangible or intangible, carefully measured or roughly estimated, well- or poorly-understood—anything at all that applies to the decision at hand.

Once the hierarchy is built, the decision makers systematically evaluate its various elements, comparing them to one another in pairs. In making the comparisons, the decision makers can use concrete data about the elements, or they can use their judgments about the elements' relative meaning and importance. It is the essence of the AHP that human judgments, and not just the underlying information, can be used in performing the evaluations. [1]

The AHP converts these evaluations to numerical values that can be processed and compared over the entire range of the problem. A numerical weight or priority is derived for each element of the hierarchy, allowing diverse and often incommensurable elements to be compared to one another in a rational and consistent way. This capability distinguishes the AHP from other decision making techniques.

In the final step of the process, numerical priorities are derived for each of the decision alternatives. Since these numbers represent the alternatives' relative ability to achieve the decision goal, they allow a straightforward consideration of the various courses of action.

The U.S. Smart Grid Revolution
KEMA's Perspectives for Job Creation



Prepared for the GridWise Alliance

January 13, 2009

The GridWise Alliance® is a consortium of electricity industry stakeholders that advocates a vision of an electric system that integrates the infrastructure, processes, devices, information and market structure so that energy can be generated, distributed, and consumed more efficiently and cost effectively; thereby achieving a more resilient, secure and reliable energy system. Its 75 members include utilities, IT companies, equipment vendors, new technology providers and educational institutions.

Table of Contents

Table of Contents

Exhibits

1. Executive Summary

During the next four years, KEMA's projection anticipates that a potential disbursement of $16 billion in Smart Grid incentives would act as a catalyst in driving associated Smart Grid[1] projects that are worth $64 billion. The impact of these projects would result in the direct creation of approximately 280,000 new positions across various categories, of which more than 150,000 will be created by the end of 2009. Furthermore, we estimate that nearly 140,000 new direct jobs would persist beyond the Smart Grid deployment as permanent, on-going high-value positions.

The indirect jobs, while more difficult to quantify, are substantially larger. Smart Grid is universally understood to be the key enabling technology for the nation's ambitions for renewable energy development, electric vehicle adoption, and energy efficiency improvements. In the absence of Smart Grid investments, many more hundreds of thousands of jobs in these related sectors will either be deferred or not created due to the inability of the electric infrastructure to incorporate these new technologies. Smart Grid is to the electric energy sector what the Internet was to the communications sector and should be viewed and supported on that basis.

Job creation projections by category are summarized in Exhibit 1. These jobs are created by Smart Grid projects which are already planned and "shovel ready"; however, some await final regulatory approval. The impetus of Smart Grid incentives should result in rapidly advancing the approval and commencement of these projects in 2009, in time to spur the employment growth forecast between 2009 and 2012, as shown in Exhibit 2, and to create 150,000 new jobs by the end of 2009.

[1] The term "Smart Grid" in this document refers to the networked application of digital technology to the energy delivery and consumption segments of the utility industry. More specifically, it incorporates advanced applications and use of distributed energy resources, communications, information management, advanced metering infrastructure (AMI), and automated control technologies to modernize, optimize, and transform electric power and gas infrastructure. The Smart Grid vision seeks to bring together these technologies to make the grid self-healing, more reliable, safer, and more efficient, as well as empower customers to use electricity more efficiently. It also seeks to contribute to a sustainable future with improvements to national security, economic growth, and climate change.

Category	Deployment Period (2009 to 2012)	Steady State Period (2013 to 2018)	Comments
Direct Utility Smart Grid	48,300	5,800	Direct utility jobs created by Smart Grid programs
Transitioned Utility Jobs	-11,400	-32,000	Utility positions (e.g. meter reading) transitioned to other roles
Contractors	19,000	2,000	External installation and service providers
Direct Utility Suppliers	117,700	90,000	Smart Grid equipment suppliers (e.g., metering)
Indirect Utility Supply Chain	79,300	22,500	Suppliers to Direct Utility Suppliers
New Utility / ESCO Jobs	25,700	51,400	New jobs from new Smart Grid business models
Total Jobs Created	**278,600**	**139,700**	Total new jobs at end of each period

Exhibit 1: Total Smart Grid Jobs Created and Transitioned

These positions would result from a number of key factors that are driven by the accelerated deployment of Smart Grid technologies and systems over the next 10 years. The analysis examines the net impact of increased jobs that would be required to satisfy the needs in the following areas:

- Direct Utility Smart Grid - this category is the net of the addition of new skills and transition of displaced, lower-skilled workers
- Contractors – employees and/or outside services providers who would be employed to accelerate the installation and deployment of these services
- Direct (Tier 1[2]) Utility Suppliers - supply chain providers whose equipment would be procured and deployed by utilities. This would include:
  - Meter manufacturers
  - Intelligent Transmission and Distribution (T&D) automation device producers
  - Communications system products and services providers

[2] Tier 1 suppliers are those firms that sell complete products and systems directly to utilities.

- Software system providers and integrators
- Indirect Utility Supply Chain – suppliers of raw materials and finished components to the direct, Tier 1, equipment manufacturers. Many meter manufacturers, for example, source components from third-party suppliers, who are expected to meet the volumetric requirements associated with market growth
- New Utility/ Energy Service Companies (ESCOs) - providers and aggregator jobs created in the broad "Energy Services" sector, whether at utilities or other independent firms, which would be derived from the richer and more varied business of structuring and managing consumer relationships with energy providers. While largely non-existent today, there is considerable expectation that multiple products and cottage industries will emerge in relation to the broader adoption of automation and communications technologies by the utility industry. As previously referenced, this includes new jobs formed for related service industries, including the installation, servicing, and operation of new technologies such as rooftop solar energy and Home Area Network devices and systems such as thermostats, display units and other new technologies.

- Additionally, there are many Industries related to the utility sector whose business will be accelerated by the adoption of these devices. Job creation in these industries is not calculated as part of the Smart Grid jobs creation those jobs are often quoted under the heading of those industries. This would include:
  - Renewable Energy Source suppliers whose jobs would be stimulated and accelerated by the advancement of enabling technologies
  - Distributed Generation suppliers of products and services for which demand would increase as a result of increasing end-user demand for the products
  - Plug-in Electric Hybrid Vehicles (PHEV) providers whose products have a success dependency on supporting charging and billing systems

The jobs created are shown over time in Exhibit 2 below.

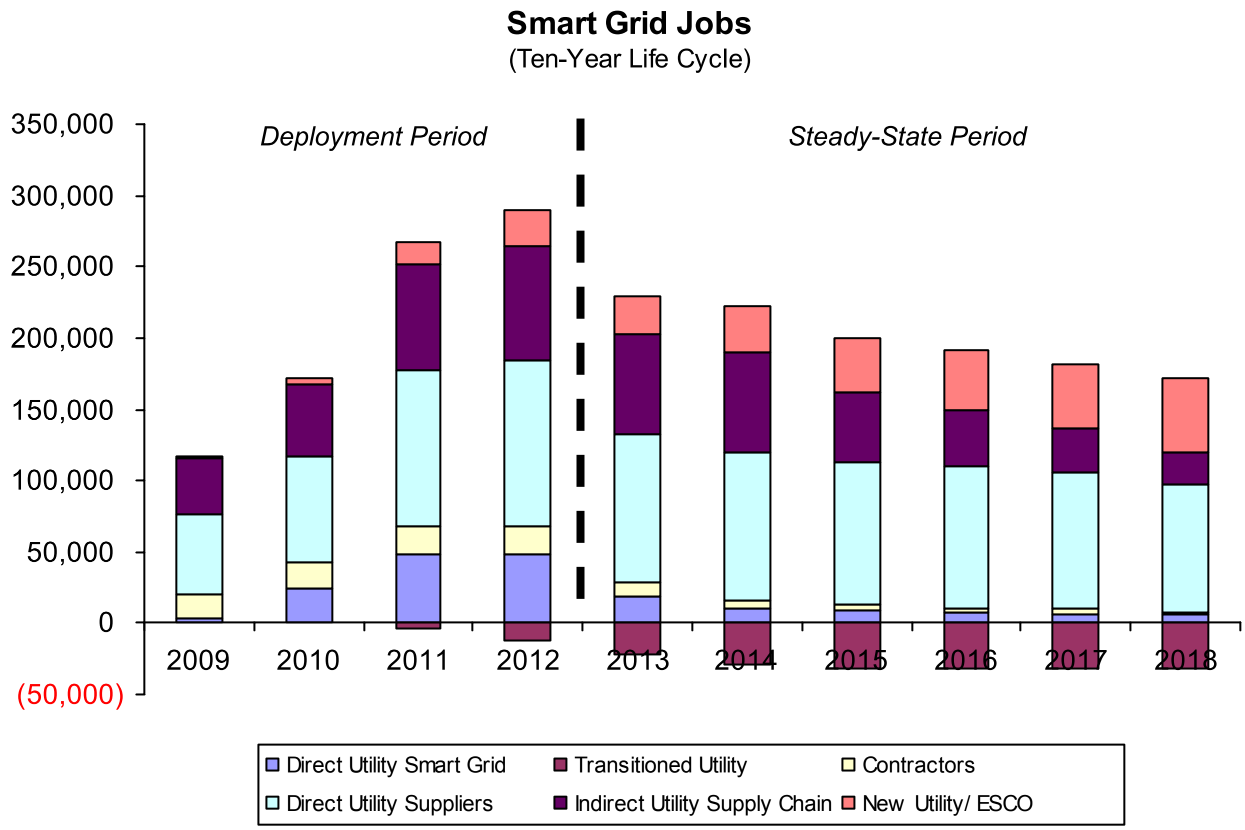


Exhibit 2: Smart Grid Jobs, Ten-Year Life Cycle

The remainder of this document provides further detail on how these projections were derived, including references to key data sources and key assumptions used in the analyses. Subsequent content is arranged as follows:

- Chapter 2 – provides further context and background regarding the Smart Grid revolution and expected impacts to related technology products and service industries.
- Chapter 3 – describes the methodology used to provide these employment projections.
- Chapter 4 – provides a summary and outlines a number of key recommendations for moving forward.

2. Background

Smart Grid is a vision for the electric delivery system of the future. The Smart Grid envisions an entirely transformed electrical infrastructure. It will embody a network of devices as vast, interconnected, automated, and interactive as the Internet. Utilities and consumers will accrue returns through the convergence of power delivery and information technologies to achieve improved reliability, reduced O&M costs, avoidance of new capacity, and increased customer satisfaction. Smart Grid includes advanced sensing, control, communications, and analytic technologies such as Advanced Metering and T&D Automation. The GridWise™ Alliance believes that Smart Grid will[3]:

- Utilize information technologies to revolutionize energy systems as they have revolutionized other aspects of U.S. business.
- Create value for all participants by developing and deploying technology solutions that cross enterprise and regulatory boundaries.
- Enhance security and reliability through an information-rich power grid that is flexible and adaptive.
- Empower consumers to benefit from their participation in the operation of the power grid.

This job creation analysis focuses in detail on the Advanced Metering and T&D automation aspects of Smart Grid, but also touches on the related new business opportunities around energy services, renewable installation and services, and home automation.

2.1 AMI Activity in the U.S.

The current Smart Grid activity in the United States mostly reflects activity undertaken to implement Advanced Metering Infrastructure (AMI). It is a generally accepted concept that AMI is often a precursor or foundational element to Smart Grid, or that the activity of Smart Grid efforts would incorporate levels of AMI.

Presently, Duke Energy is the only utility whose regulatory business case filing explicitly embodies both AMI and Smart Grid efforts in a full deployment scenario. Since the infrastructure that most utilities consider when they file their AMI plans supports Smart Grid, a foundational premise of this white paper is that the utilities who are filing their AMI business cases are also including elements of Smart Grid.

[3] GridWise Action Plan. (2008). A Joint Effort by the U.S. Department of Energy and the GridWise Alliance.

Presently, approximately 70 utilities have filed some form of AMI plan which also include pilots of this technology. Many have also filed business cases for implementation approval with their respective regulatory body. This activity represents progress in nearly 30 states.

Assuming a full-scale implementation for these AMI programs, the total number of electric meters that would be involved represents a potential of more than 70 million meters, though the total number of projects that are approved to-date represent a market size of approximately 30 million meters. Likewise, since many of these projects are in early stages of deployment or are in limited deployment pilots, fewer than 1 million AMI devices are actually deployed.

Exhibit 3 outlines major AMI projects and their respective deployment schedules. It is important to note that the most significant full-scale deployments have been approved in only two State jurisdictions: California and Texas. The programs in these states alone account for over 50% of the current deployment figures for AMI.

Typical AMI and Smart Grid regulatory filings present a business case with favorable benefit-to-cost ratios that may also include social benefits such as improved reliability and lower wholesale energy prices at peak. When these societal benefits are also factored in, the overall consumer benefit will further improve the financial attractiveness of AMI and Smart Grid as an investment.

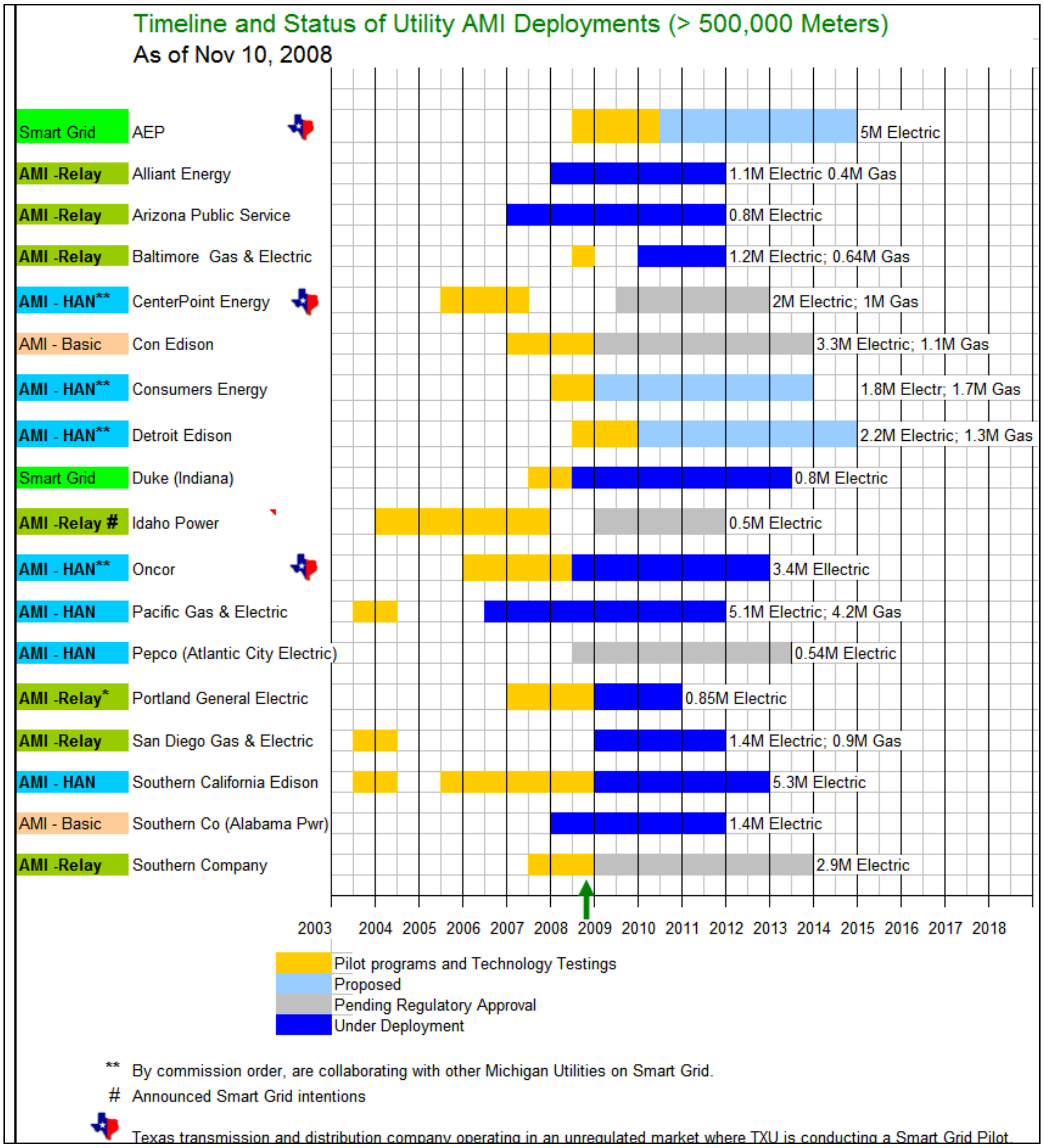


Exhibit 3: Current AMI Project Landscape

2.2 Smart Grid Activity in the U.S.

AMI is a preliminary technology to a Smart Grid development strategy. The incorporation of T&D monitoring and control adds an additional strategic aspect. Presently, only a handful of U.S. utilities have successfully embarked on wide-scale Distribution Automation independent of AMI. Based on our analysis, adding T&D automation to an AMI program to encompass more Smart Grid functionality adds approximately 30% to 40% to the total AMI costs of a full-scale meter program, while it significantly contributes to the economic benefits that would be attributed to improved T&D reliability, preventative maintenance, and asset-life extension.

Today, a typical U.S. utility plans a deployment period of 5 or more years for AMI or Smart Grid. Factors that limit the potential program acceleration are primarily attributed to capital spending constraints, workforce reduction issues, and supply chain barriers. While the customers that are first to receive advanced meters or be served by automated distribution circuits start to see direct benefits immediately, the broader social benefits and cost savings to the utility normally are not fully achieved until the deployment reaches a critical mass. Therefore, significant benefits would accrue to customers, utilities, and society in general by accelerating these programs.

If every major U.S. utility embarked on Smart Grid deployment today, the nation would be positioned with the majority of the end customer's part of a Smart Grid network. *The nations' energy infrastructure would be "renewable ready" and "electric vehicle ready" and would not be a limiting factor or obstacle to other key energy initiatives.* With a full deployment of Smart Grid, the nation's electric supply system would also achieve higher reliability and be more supportive of energy efficiency and customer choice endeavors.

2.3 Smart Grid Technologies

Exhibit 4 (adapted from the KEMA book, Utility of the Future[4]) illustrates the technology transitions that would occur at the current rate of progress by an aggressive utility. These tables outline technologies that are expected to be primarily developed in the United States and that are going through prolonged pilot and evaluation stages in the utility industry.

A major federal Smart Grid initiative would spur more rapid adoption of these selected Smart Grid technologies and could cement U.S. technological and industrial leadership in areas that are a marriage of the Information Technology and energy industries.

[4] ***Utility of the Future: Directions for Enhancing Sustainability, Reliability and Profitability, Volume 1***, Ralph Masiello, Hugo van Nispen, Robert Wilhite, and Ray Huizenga, ISBN 978-0-6152-7035-7.

Technology	2008	2012	2020
Advanced metering	Pilot Projects Filed	Pilots Being Deployed	Full Implementation
T&D Sensors	Substation based transducers	Feeder circuit transducers	Dynamic Radio Frequency Identification sensors everywhere
Distribution Protection Adaptive for DG	N/A	Fault Current Limiters, dynamic protection	Integration with Distributed Generation systems
Building Energy Management Systems Integration	Limited Functionality	Enhanced building automation	Agent Based Integration
Circuit and Substation Energy Storage	Handful of Pilots	Pilots routine and targeted deployment on problem circuits	Commonplace integrated in support of distributed renewables and EV
Centralized Renewable Generation supported by Flexible Alternating Current Transmission and Energy Storage	N/A	Piloted	Routine
High Temperature superconducting cable	A few short distance pilots planned	Technology is accepted	Routine in urban settings
Integration of Behind-the-Meter Systems	Hobbyist	Early adopter	Part of routine LEEDS standards and carbon neutral homes
Market Integration of Distributed Renewable Generation	N/A	Available in all markets	Routine
PHEV / EV Integration	N/A	Controlled charging	Vehicle-to-Grid applications and market integration
Six-sigma Integrated Micro-Grids	Piloted	Routine in new office parks and subdivisions	Being retrofitted on a widespread basis
Smart Asset Management Systems	Atypical; lack of data and data integration; lack of condition monitoring	Condition monitoring widespread	Extensive data bases and analytics deployed

Exhibit 4: Technology Transitions

The utility industry appears to be prepared to ramp-up production and delivery volumes if utilities can find the funding to move forward. Almost every U.S. T&D utility would likely be deploying Smart Grid at a faster pace if its regulatory approval and capital sourcing costs were more certain.

2.4 Renewable Portfolio Standards in the U.S.

Another growing trend, and an initiative worthy of note, is that over 30 states currently have established Renewable Portfolio Standards (RPS). These standards have established various targets that range from 10% to 30% of total generation provided by these sources of supply over the next few years and decades. Exhibit 5 shows the current status of the activity in the U.S.

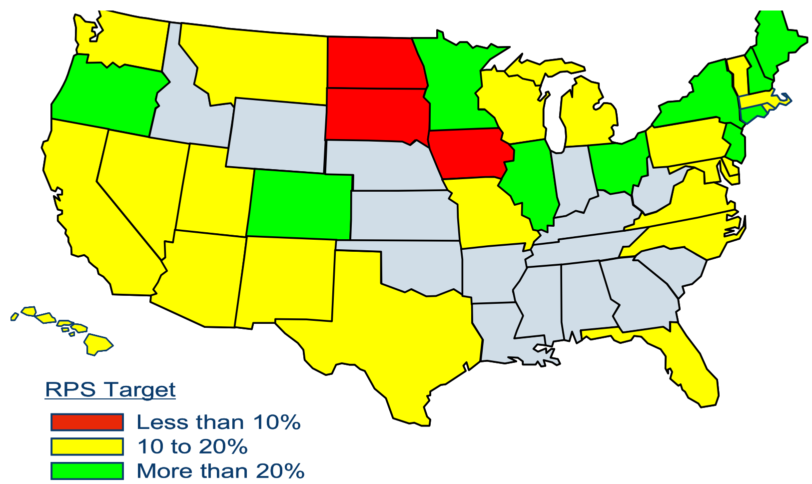


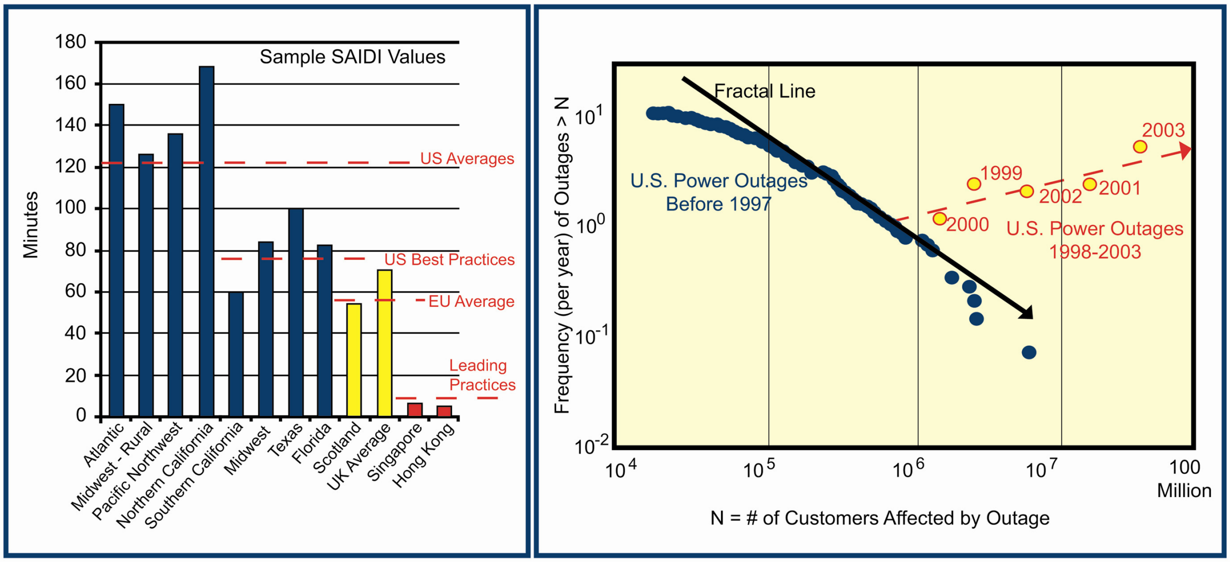
Exhibit 5: State Status of RPS (October 2008)

AMI and Smart Grid are essential to effectively integrate, manage and operate these resources. The intrinsic capability to provide net metering (separately monitoring and calculating power supplied to and from the grid) and conditioning and controlling the grid to support these resources is a core requirement to enable these programs.

2.5 Electric Service Reliability in the U.S.

System reliability in the U.S. is inadequate in comparison to the electric grid stability figures being achieved in other nations. This is not just a steady-state condition; the current trend indicates that our grid stability has actually been eroding in recent years. This condition can primarily be attributed to our aging electric infrastructure as shown in Exhibit 6.

The future of the every U.S. business is critically dependent on reliable and sustainable electric power. Reversing this current downward trend is critical to maintaining a world-leading economy in the 21st century.



Source: KEMA research, Roger N. Anderson - Columbia University

Exhibit 6: Leading Practices in Achieving SAIDI Values

Energy Storage is another dimension of the Smart Grid that has increased its technical and economic feasibility in just the past year. Advanced storage technologies are finding their way into small-scale generation (wind farm), T&D, and end-user applications. Storage can help with the variability / low capacity factor of renewable generation and is a "consumer-friendly" way to match generation to demand. Almost all the candidate storage technologies in pilot or early commercial deployment are developed in the United States. Support for energy storage as part of Smart Grid project will help develop and preserve a U.S. manufacturing base for this advanced technology, which is critical not only to Smart Grid and renewable resources but also to a future U.S. EV and PHEV industry.

2.6 Experiences of Other Industries

Other utility industries have generated considerable economic activity and job growth as they have incorporated new IT capabilities, with two examples being the cable industry and cellular telephone industry. These industries could be indicators of the job creation potential from investing in the Smart Grid.

2.6.1 Cable Industry

A 2008 study entitled "An Analysis of the Cable Industry's Impact on the U.S. Economy" [5] reports the following:

- Since 2002, direct and indirect employment attributable to the cable industry has increased by almost 367,000 jobs. This growth amounts to nearly five percent of all net new jobs created by the U.S. economy over this five-year period
- Even considering only those employment increases attributable directly to cable operators, growth since 2002 totals about 53,000 jobs – or 0.7 percent of net U.S. job growth
- Cable's economic impacts are spread throughout all major sectors of the U.S. economy. The largest impacts are in the information, services and manufacturing sectors, each of which are critical to both the growth and the overall health of the economy.

2.6.2 Cellular Telephone Industry

Wireless services are among the industries with the highest job growth. According to the Cellular Telephone Industry Association (CTIA)[6]:

- Direct Wireless Carrier employment has grown at a rate of 4.1% annually
- The total estimated direct employee count for June 2008 is nearly 268,000
- The employee to subscriber ratio has reached a plateau of approximately 1.1 direct employees per 1,000 customers. This has been relatively flat for the past 4 years, indicating a period of process optimization.

[5] Bortz Media & Sports Group, Inc. (2008). *An Analysis of the Cable Industry's Impact on the U.S. Economy.*
[6] CTIA. (2008). *Wireless Quick Facts, Mid-Year Figures*. Retrieved Dec. 22, 2008 from http://www.ctia.org/

3. Methodology and Calculations

3.1 Overview

The investment and installation of smart meters at the end of the energy supply chain (point-of-sale) will have a catalytic effect on other industries and aspects of the Smart Grid, as illustrated in Exhibit 7.

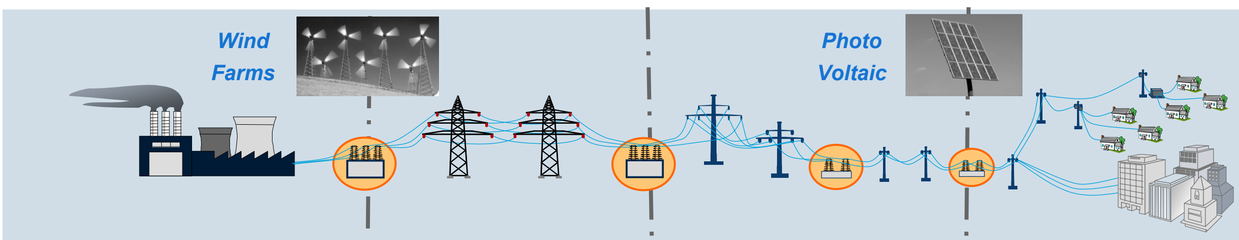


Exhibit 7: Energy Supply Chain

Some of these transformational aspects have already been outlined in the area of T&D, where the detailed point-of-sale data will result in greater reliability and efficiency, especially as the power grid transforms our work force into high-tech, industry leader roles. However the following “knock-on” effect of advance power supply and distribution of energy needs to be considered:

- Residential smart meter deployment is expected to stimulate home automation and the production of smart appliances for integration into the self energy-managed and programmable home.

- The smart meter is fundamentally a point-of-sale device and integrated with home automation and smart appliances will provide valuable buying / habit data which we have seen spur our economy in recent years when used in the food supply chain.

- Distributed generation, especially in the form of roof-top, photovoltaic units, can be more feasibly deployed with a Smart Grid deployment. Current utilities have a need to bring this resource under grid control for reliability and efficiency reasons. The deployment of this technology can result in a new industry base of suppliers, installers and software management developments at the domestic end of the energy supply chain.

- Industrial facilities such as automobile manufacturing, automobile retrofit, petrochemical, chemical, paper and pulp, packaging, glass and steel, and others, would benefit from a smart deployment of their “micro-grids” within their facilities, along with a smart coupling to the main grid, facilitating the optimization of inside–the-fence generation and power buying and selling transactions with the utility.

The analysis in this report focuses on the following four industry segments:

- Direct utility employees
- Contract utility employees
- Supply chain labor
- Related industry labor
- Broad industry labor

3.2 Direct Utility Employees Job Estimate

3.2.1 Overview

Implementing a Smart Grid represents an enterprise-wide initiative and impacts virtually the entire utility organization. Therefore, these projects will require a wide range of new skills, education, and talent. The following list describes the typical position types that will have full-time job allocations at some level. These jobs would be expected to be filled by a mix of existing utility employees and outside consultants.

Typically, utility jobs such as equipment installation and testing require specific training and experience. It normally takes several years to qualify to do this work. Given the level of training required for these jobs, the use of outside resources in this area would be limited to existing outside contractors that are already are under contract to utility companies. However, there could be more extensive use of outside resource for IT, communications, and other system integration and support services.

Smart Grid Position	During Implementation	Steady-State Position
Project Office Leadership		
o Project Manager	X	
o Executive Assistant	X	
o Lead Consultant	X	
Program Support		
o Scheduler(s)	X	
o Budget Analyst	X	
o Contacts Administrator	X	X
o Resource Manager	X	
o Communications Manager	X	
o Change Management Lead	X	
o Legal support	X	
Quality Assurance		
o Vendor Management	X	
o Test and Verification Supervisor	X	
o Performance Analysis	X	
Planning		
o Requirements Development Mgr.	X	
o Business Case Manager	X	
o Telecom/Communications	X	
o IT Interface (software, DB)	X	
o Grid Upgrades (e.g., Dist. Auto.)	X	
o Regulatory support for rate planning	X	
o Marketing and Outreach planning	X	
Functional Support		
o Rate Design Implementation	X	
o Marketing Implementation	X	
o Public Relations	X	
o Revenue Cycle services	X	
Implementation Operations & Support		
o Supply Chain and Inventory Mgmt.	X	X
o Logistics	X	X
o Meter Receipt Testing	X	X
o Meter disposal	X	X
o Meter Installation (incl. field testing)	X	X
o Grid Component Installation Mgmt.	X	
o Transformers	X	

Smart Grid Position	During Implementation	Steady-State Position
o Reclosers	X	
o Breakers	X	
o Sensors	X	
o Communications Installation Mgmt.	X	X
o IT software upgrades, replacement and new applications	X	X
o CIS	X	
o AMI	X	
o MDM	X	
o WAM	X	
o Net Metering Applications	X	
o OMS	X	
o DMS/SCADA	X	
o Demand Response	X	
o Asset Management	X	
o Customer Service (Call centers, account managers)	X	X
Functional Specialists		
o Special Metering	X	X
o Outage Management	X	X
o Net Metering (Solar, Wind, other DG)	X	X
o Prepaid Services	X	X
o Demand Response	X	X
o Special Billing	X	X
o Vehicle to Grid	X	X
o Theft prevention	X	X
o Field Technical support	X	X
o Distribution Automation	X	X
o System Planners & Engineers	X	X
o Asset Management	X	X
o Power Quality	X	X

3.2.2 Methodology

This analysis used the actual regulatory cost data from Duke Energy's recent filings of its Smart Grid deployment plans in both Indiana and Ohio. Duke Energy has a Smart Grid filing that has been used as a basis to in this analysis to project a nationwide level of job creation, based on the premise that similar Smart Grid projects would be implemented across the U.S. Duke Energy is the only major utility in the U.S. that has filed a business case with their regulator to install a complete Smart Grid (for part of their service territory). Duke also has over 800,000 electric meters for which they are proposing to implement a Smart Grid infrastructure, as well as roll out advanced metering.

Duke Energy is including Smart Grid elements to provide two-way communications and, where appropriate, remote control and automation features. This includes replacing outdoor oil circuit breakers, upgrading substations with Substation Automation systems and two-way communications, replacing the relays in circuit breakers, changing out the controls on capacitors and station load tap change transformers/regulators, providing sectionalization capabilities for the grid, and implementing self-healing technology.

Because the assumptions and methodology used to estimate the utility direct job creation is paralleled by those used for other job categories, we explain it in some detail. Exhibit 8 shows key assumptions used in the calculation.

Key Parameter and Assumption	Value
Total number of households	125,000,000
Total number of businesses	25,000,000
Total estimated number of meters	150,000,000
Percentage AMR	15%
Total non AMR	127,500,000
Total number of AMI meters installed in 2008	1,000,000
Total potential	126,500,000
Average cost of an AMI project per 1 million customers over 15 years	500,000,000
Total AMI project market estimate	$ 63,250,000,000
Eligible electric meters	128,000,000
Percent spent in start year	15% (75 M)
Percent spent in second year	25% (125 M)
Percent spent in third year	30% (150M)
Percent spent in fourth year	15% (75 M)
Percent spent in fifth thru end	15% (75 M)
% started in year 1	30%
% started in year 2	40%
% started in year 3	25%
% started in year 4	5%
Average number of years to deploy a Smart Grid system	3
% spend for labor	30%
Average annual labor cost per Full Time Equivalent employee	$75,000

Exhibit 8: Key Assumptions

We reviewed Duke Energy's regulatory filing in Indiana to determine the total projected labor costs. Their five-year capital cost estimate is $435 million or 870,000 meters, along with a total employee labor expense of $125 million, which represents close to 30% of the total cost projection.

To derive a national projection, we rounded the Duke Energy Indiana population to one million meters, increased the implementation cost to $500 million and then used a 30% ratio of labor to total cost, as a proxy consistent with the filing.

3.2.3 Calculation

There are an estimated 150 million meters in the U.S. This number has to be reduced by 10-15% to account for the deployments already underway in California and Texas and other utilities that are already in AMI deployment, and where many of the jobs are already being created. So we used 128 million meters as a remaining population. To facilitate the simplicity of the calculations, we also assumed that there would be approximately 128 Smart Grid projects at 1 million meters per project. We then used the $500 million dollar projected projects cost times 150 to get the estimated $64 billion Smart Grid spend.

We could project a "potential" Smart Grid jobs impact assuming that every eligible utility in the U.S. moved to full deployment immediately. However, we realize that some reduced percentage of implementation exists based on local power system economics, regulatory perspectives, public/private utility ownership, and the level of Smart Grid incentives. Additionally, there will be some limitations on the ability of the utilities and their suppliers to find and train some of the more demanding positions created by Smart Grid. We therefore used an estimate of the percentage of potential Smart Grid projects that start in each of the four years 2009-2012 (as shown in Exhibit 8) of 30%, 40%, 25%, and 5%, respectively. We also used the Duke Energy projected budget over a three to five year deployment period as a proxy for how labor and other costs are dispersed over time. The Duke filing has 30% of the total budget planned as utility labor; at an average cost of $75,000 per Full Time Equivalent (FTE), which we can then translate the budgeted spend over time into FTEs over time. This yields the utility direct labor jobs created as shown in the table on page 3-3. The projects started per year and the Smart Grid spending is shown in Exhibit 9.

Note: All figures in $M, except column one

No. of Programs Started	Budget	2009	2010	2011	2012	2013	2014	2015	2016
38	$19,200	$2,880	$4,800	$5,760	$2,880	$2,880			
51	$25,600		$3,840	$6,400	$7,680	$3,840	$3,840		
32	$16,000			$2,400	$4,000	$4,800	$2,400	$2,400	
6	$3,200				$480	$800	$960	$480	$480
Annual Spend	**$64,000**	**$2,880**	**$8,640**	**$14,560**	**$15,040**	**$12,320**	**$7,200**	**$2,880**	**$480**

Exhibit 9: Projected U.S. Smart Grid Projects and Spending

In addition, once a Smart Grid system is deployed, there will be several thousand utility jobs needed to maintain the Smart Gird. We estimated this number as just under 5,800 new positions. The on-going number is not expected to be higher due to the operational efficiencies gained.

3.3 Contract Utility Employee Job Estimate

3.3.1 Overview

Filings show that utilities generally subcontract the installation of meters and some of the communications equipment used for the infrastructure. Based on estimates of time and effort to complete these tasks we have projected the total number of jobs created. These jobs persist over a five-year deployment as a temporary condition, and then dissipate over time as the deployments ramp downward.

3.3.2 Methodology

A similar methodology to the utility jobs creation is used to extrapolate the 40 jobs per million meters to the 123 million meters to be installed going forward. This yields 19,000 contractor positions.

3.4 Supply Chain Job Estimate

3.4.1 Overview

Relevant Smart Grid sectors, as illustrated in Exhibit 10, outline the categories of vendors involved in supporting two-way communications on utility T&D lines and infrastructure. The illustration includes designers and manufacturers of intelligent devices capable of communicating information from customer premises or from the T&D circuits with utilities. A brief description of each sector is provided in the following paragraphs.

Exhibit 10: Relevant Smart Grid Sectors

In-home energy devices are energy management tools for customer use and control of consumption. These devices could include displays (e.g., energy usage, current kWh rate), showing programmable communicating thermostats and pre-payment terminals, as examples.

AMI meters measure time-differentiated energy consumption, and because of embedded two-way communications, facilitate customer participation in demand response programs, register customer generated energy (as in solar, wind, PHEV), measured and fed back to the electric grid (also known as net metering), signal power quality information to utilities, and provide other information that increases utility operational efficiencies.

Communications equipment transmits meter and other data between customer premises and the utility or retail energy provider, using a variety of technologies.

Distribution Automation includes two-way, intelligent communicating equipment (e.g., reclosers, circuit breakers, regulators) that enhance utility reliability and operational effectiveness.

A Meter Data Management (MDM) system is defined as the central repository for data that can be accessed by a large number of utility groups and systems. Data collected through the AMI communications backbone may be shared across the utility enterprise:

Back-office utility systems perform specific functions of collecting, storing, analyzing, and reporting information useful to the utility to improve system reliability, prepare accurate billing, enhance interaction with the customer service department, alert, manage and mitigate interruption because of outages. Examples of back-office systems include customer information systems (CIS), outage management systems (OMS), net metering applications (NMA), field work force management, asset management systems, etc.

3.4.2 Methodology

To facilitate the estimation of national jobs impact on applicable Smart Grid suppliers to utilities, the Duke Energy filing was rounded to one million meters.

If Smart Grid implementation were to take place nationally with all utilities participating concurrently, the number of jobs needed to supply the country with equipment would number 117,000. The useful life of this equipment may be as much as 10 to 15 years, after which there would be a need for replacement. Assuming manufacturing efficiencies over time, and accounting for equipment upgrades and failures more than 90,000 positions on an on-going basis would be needed. There would additionally be export market opportunities, which are not factored into this estimate.

In-home devices were not included in the Duke Energy regulatory filing. Because the vision of a Smart Grid includes customer communication, including demand response, price signaling and other data exchanges between customers and utilities, in-home devices were added. The assumption was that there were would be a minimum of two in-home devices per meter. Because of their longer useful life, there were no on-going jobs calculated for in-home devices. Those devices were identified in 3.4.1 as programmable communicating thermostats and in-home energy displays.

Naturally, there are other jobs that are supported or created by direct utility (Tier 1) supplier demand in the form of raw materials or sub-components, shipping, design, packaging, independent testing and consulting firms. This paper estimates the additional jobs created at the suppliers (Tier 2) of the direct suppliers in a consistent manner below.

Capital equipment expenditures of $686 million were calculated for a 1-million meter project, where 51% was derived from in-home devices. Meters and communications accounted for 39% and 10% for Distribution Automation and IT hardware.

For the categories of communications, IT and Distribution Automation, assumptions were that 24.5 cents of each dollar spent supported domestic jobs, where the blended cost of those jobs was estimated at $100,000 each include wages/ salaries, taxes and benefits for each full-time equivalent (FTE) position. Forty FTEs were estimated for each 1 million meters produced, and nearly 11 cents of each dollar spent for in-home displays was for domestic manufacturing related positions.

We assume that of the 75 cents of each dollar spent on purchased goods and imports; a similar 25% is spent on domestic jobs; i.e. (0.25 * 0.75) or another 75% of the tier 1 jobs created in tier 2 and upstream suppliers, or 79,250 additional jobs.

	Supply Chain Impact	
	Deployment	On-Going
In-home Devices (x2)	49,300	
AMI Meters	5,100	6,500
Communications Equipment	38,700	52,200
Distribution Automation Hardware	18,800	24,100
MDM Hardware	1,300	1,700
Back Office Hardware	4,500	6,100
Total Jobs	117,700	90,600

Exhibit 11: Jobs Needed to Support Smart Grid by Direct Suppliers

3.5 Related Industry Job Estimate

3.5.1 Overview

Utility and ESCO New Smart Grid Business Model Job Creation

Data collected from several existing competitive retailers and demand aggregators indicate an employee to customer ratio ranges from approximately 1:2, in the case of aggregators that are focused on large, complex Commercial and Industrial (C&I) customers, to 1:4,000, in the case of large utility affiliates serving major shares of residential customers in a large area. We believe that in a Smart Grid future the resulting Energy Services Company (ESCO) job situation will be a blend of the two models, but that employee customer ratios will decrease below these levels, due to better use of technology and Internet-based customer interaction, as well as due to competitive pressures. If we use a ratio of 5,000 residential customers to one employee and 500 C&I customers to one employee as conservative long term figures, we can project that utility and independent customer service employment in this new world would approach 50,000 positions as explained below.

Utility Share of Distributed Renewables Installation, Servicing, Operations

Other studies have projected from 100,000 to 300,000 new jobs to be created in the manufacturing, installation, servicing, and operations of renewable energy sources. While admittedly this is a "double count" to include any share of this figure in the Smart Grid job creation estimate, it is important to realize that long term utility employment may decrease slightly due to Smart Grid deployment; but new utility business activities would result in a net increase in utility employment. Utility shares of the ESCO job category above will be significant, especially in still-regulated jurisdictions. Utilities will also share in the business and job growth of renewables sales, installation, and service either directly or via contractors. Estimating this figure scientifically will require further work. Anecdotally, we observe that published employment advertising already is a sign that utilities with aggressive rooftop solar programs (e.g., SCE, PG&E). If we were to make a guess that the installation, servicing, and operations job content of the 100,000 renewables-derived jobs (low end of the scale) were 40% of the total, and that utilities will somehow be involved in 50% of that new market; then there are another 20,000 utility jobs to be created. These jobs are not included in the Smart Grids totals. The point of this discussion is that the utility sector is actually poised to *grow,* not to decrease, as a result of Smart Grid.

3.5.2 Methodology and Calculation

We use the same 128 million new meter figure for consistency. Twenty percent of these serve C&I customers and, at 2 meters / customer industry average, this yields 12.8 million customers. At 1 job per 500 C&I customers this would generate 25,600 positions.

The 122 million residential customers, at a typical industry ratio of 1 job per 5,000, would generate 25,800 positions.

These estimates are very conservative, given the potential for a new kind of consumer experience to generate jobs. The U.S. experience with the cellular and cable industries suggest that new job creation will be much larger. The far-from-concluded experience with the Internet suggests that the entire energy landscape will change as a result of Smart Grid and create additional businesses and jobs that cannot be foreseen today.

3.6 Broad Industry Job Estimates

Accelerated deployment of a Smart Grid would provide an incentive for accelerated development and deployment of new technologies, such as plug-in hybrid electric vehicles (PHEVs), smart appliances, home automation hardware and software, and distributed renewable energy resources (e.g., rooftop photovoltaic systems, small wind turbines, geothermal heat pumps).

By enabling accelerated deployment of these technologies, an investment in the Smart Grid has the potential to create additional jobs in these sectors. As these are emerging technologies in a sector of the economy with significant entrepreneurial activity, it is difficult to assess just how many jobs could be created in these sectors. One proxy for identifying the level of economic growth that could be anticipated is the interest from venture capital groups like Goldman Sachs and Kleiner Perkins Caufield & Byers (KPCB) and the commitment of funding from technology powerhouse Google.

In June 2007, Google announced the launch of the RechargeIT initiative to accelerate adoption of PHEVs. Google awarded $1 million in grants and promised another $10 million to fund development, adoption and commercialization of PHEVs and vehicle-to-grid technology.[7] In July 2008, Google awarded $5.8 million to ActaCell, to advance commercialization of its lithium-ion battery, and $2.5 million to Aptera, for market integration of its all-electric Typ-1 supercar.[8]

VentureBeat, an online portal that tracks venture capital funding, reported in May 2008 that funding in the Smart Grid space was "hot and heavy," with well over half a dozen large fundings in the months preceding the article.[9] Among the companies receiving funding were Optimal Technologies ($25 million from Goldman Sachs), a start-up company with technology to manage electricity allocation on local utility grids, and SmartSynch ($20 million from Credit Suisse), a company that supplies major meter manufactures with internal communication technology for their smart meters. In October 2008, KPCB announced that it was investing $75 million through its Green Growth Fund in Silver Spring Networks, a Smart Grid solution provider with technology to help consumers manage their energy use more efficiently.[10]

In addition to increasing venture capital investment in the "clean" technology sector, and Smart Grid in particular, electric utilities are investing in distributed renewable generation, for which the deployment of a Smart Grid is an enabling factor. In March 2008, Southern California Edison (SCE) announced an $875 million program to install 250 MW of solar photovoltaic (PV) systems

[7] Google Launches RechargeIT Plug-In Hybrid Car Initiative and Unveils Solar Installation, June 18, 2007. www.google.com, retrieved December 18, 2008.
[8] Google RechargeIT Fund Recipients Announced. July 24, 2008. www.pcmag.com, retrieved December 18, 2008.
[9] Smart grid investments come hot and heavy – SmartSynch gets another $20M for talkative electrical meters. May 22, 2008. http://venturebeat.com, retrieved December 18, 2008.
[10] Venture capital for smart grid technology expansion, October 9, 2008. www.metering.com, retrieved December 18, 2008.

on commercial rooftops throughout their service territory.[11] The 1 to 2 MW utility-owned PV systems will be installed on unused commercial rooftops and connected directly to the distribution system to meet the energy needs of the fastest growing areas in the region. The SCE program is intended to drive down the current cost of solar photovoltaic systems and to help California meet goals set forth in the Renewable Portfolio Standard and the California Solar Initiative ("Million Solar Roofs").

The SCE program has been a model for other electric utilities trying to achieve goals for renewable and distributed energy, including Duke Energy, which has proposed a $50 million program to install 16 MW of solar PV systems at up to 850 North Carolina sites, including homes, schools, and commercial and industrial facilities.[12] Smart Grid technologies, including smart meters with net metering capabilities, greatly facilitate the increasing penetration of distributed renewable energy technologies, which creates jobs for solar system manufacturers and installers.

[11] Application of Southern California Edison Company (U 338-E) for Authority to Implement and Recover in Rates the Cost of its Proposed Solar Photovoltaic (PV) Program (Application number A0803015). Filed with CPUC on March 27, 2008.
[12] Carr, Housley. Duke Energy plans to invest $100 million in solar projects to expand renewable portfolio. Global Power Report, June 12, 2008.

4. Summary and Recommendations

The GridWise Alliance endorses the Obama-Biden plan for Smart Grid incentives which would compensate qualifying Smart Grid projects for up to 25% of the initial investment cost. By reducing the utility investment by 25% this will make the cost benefit analysis that much more favorable.

In conclusion, Smart Grid incentives should focus on achieving the benefits of Smart Grid as outlined in Section 2 and reported in several DOE and other industry reports. The Grid Modernization Commission can be a vehicle for achieving best practices and comprehensive benefits from Smart Grid projects. Smart Grid investments have the potential to accomplish numerous benefits for the industry and the nation, including:

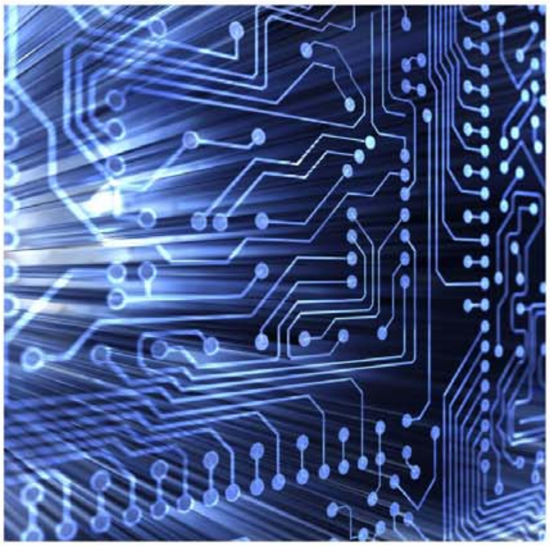
- Generate 280,000 new positions, many of which are high-value.
- Spur development of a domestic Smart Grid supplier's industry, which will create 140,000 ongoing high-value jobs.
- Position the U.S. as a global supplier of Smart Grid technologies, given the parallel rising interest in international Smart Grid efforts.

EAC

ELECTRICITY ADVISORY COMMITTEE

Smart Grid:
Enabler of the New Energy Economy

A Report by
The Electricity Advisory Committee
December 2008



ELECTRICITY ADVISORY COMMITTEE

ELECTRICITY ADVISORY COMMITTEE MISSION

The mission of the Electricity Advisory Committee is to provide advice to the U.S. Department of Energy in implementing the Energy Policy Act of 2005, executing the Energy Independence and Security Act of 2007, and modernizing the nation's electricity delivery infrastructure.

ELECTRICITY ADVISORY COMMITTEE GOALS

The goals of the Electricity Advisory Committee are to provide advice on:

- Electricity policy issues pertaining to the U.S. Department of Energy
- Recommendations concerning U.S. Department of Energy electricity programs and initiatives
- Issues related to current and future capacity of the electricity delivery system (generation, transmission, and distribution, both regionally and nationally)
- Coordination between the U.S. Department of Energy, state, and regional officials and the private sector on matters affecting electricity supply, demand, and reliability
- Coordination between federal, state, and utility industry authorities that are required to cope with supply disruptions or other emergencies related to electricity generation, transmission, and distribution

PURPOSE OF REPORT

The purpose of the Report is to address barriers and opportunities to deploying Smart Grid technologies to enhance the Nation's electric power delivery system to meet the challenges of the 21st century. The Report focuses on specific actions the U.S. Department of Energy can take to implement Smart Grid technologies.

Electronic copies of this report are available at: http://www.oe.energy.gov/eac.htm

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Smart Grid:
Enabler of the New Energy Economy

December 2008

More information about the EAC is available at:
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Letter from the Chair

December 2008

On behalf of the members of the Electricity Advisory Committee (EAC), I am pleased to provide the U.S. Department of Energy (DOE) with this report, ***Smart Grid: Enabler of the New Energy Economy***. This report recommends policies that the U.S. Department of Energy should adopt to ensure that a successful Smart Grid program is funded and implemented in the months ahead.

The recommendations herein were developed through a process carried out in 2008 by the Electricity Advisory Committee. The members of the Electricity Advisory Committee represent a broad cross-section of experts in the electric power arena, including representatives from industry, academia, and state government. I want to thank and recognize ***Guido Bartels***, General Manager of Global Energy and Utilities at IBM, Chairman of the GridWise Alliance, and Chair of the EAC Smart Grid Subcommittee, for his leadership in developing this report. I also want to thank those members of the EAC who served on the Subcommittee. Thanks also go to ***Kevin Kolevar***, Assistant Secretary for Electricity Delivery and Energy Reliability, U.S. Department of Energy and to ***David Meyer***, Senior Policy Advisor, DOE Office of Electricity Delivery and Energy Reliability and Designated Federal Officer of the Electricity Advisory Committee.

The members of the Electricity Advisory Committee recognize the vital role that DOE can play in helping modernize the nation's electric grid. These recommendations are intended to provide options for DOE to consider as it develops and deploys policies and programs to help ensure a twenty-first century electric power system.

Sincerely,

Linda G Stuntz

Linda Stuntz, Chair
Electricity Advisory Committee

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Special thanks to ***Peggy Welsh***, Senior Consultant at Energetics Incorporated, and to ***Amanda Warner***, Energy Policy Analyst at Energetics Incorporated, for their tireless support of the Electricity Advisory Committee.

Table of Contents

Executive Summary

At the request of the U.S. Department of Energy (DOE), the Electricity Advisory Committee (EAC) puts forward this report on the nation's goal to transform its electric power delivery system (the energy grid) into a more intelligent, resilient, reliable, self-balancing, and interactive network that enables enhanced economic growth, environmental stewardship, operational efficiencies, energy security, and consumer choice. In this report, EAC offers DOE recommendations on how to transform the nation's grid to meet that goal.

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.

This report discusses both the opportunities and challenges the nation faces in its quest to bring the grid into the twenty-first century. Numerous pressures on the electric power delivery system are converging, forcing the system to evolve. These pressures include:

- Rising costs of capital, raw materials, and labor
- Aging infrastructure and workforce
- Continuing national security concerns
- Need for and viability of energy efficiency caused by the expansion of the global economy
- Rising energy costs with viable options
- Increasing awareness of environmental issues, including global warming
- Regulatory pressures
- Social pressures
- Calls for energy efficiency
- Growing demand for energy
- Rising consumer expectations
- Rapid innovations in technology

A Smart Grid is capable of addressing these challenges.

There are many working definitions of a Smart Grid and many examples of initiatives under way that could be considered Smart Grid projects. However, for the purposes of this report, a Smart Grid is defined as a broad range of solutions that optimize the energy value chain. To provide examples, this report highlights four utilities deploying various Smart Grid projects that are approved and funded by the relevant regulatory body.

The report substantiates the benefits of moving to a more intelligent grid, not only for utilities and grid operators, but also for consumers and society as a whole. Studies have shown that the potential economic and environmental payoffs of transforming the current electric power delivery system into a Smart Grid are numerous. From an economic perspective, a Smart Grid can enable reduced overall energy consumption through consumer education and participation in energy efficiency and demand response / load management programs. Shifting electricity usage to less expensive off-peak hours can allow for better utilization of equipment and better use of capacity. From an environmental standpoint, a Smart Grid can reduce carbon emissions by maximizing demand response / load management, minimizing use of peak generation, and replacing traditional forms of generation with renewable sources of generation. A Smart Grid also holds the promise of enhanced reliability and security of the nation's power system.

Fundamentally, the challenges faced by the energy sector emanate from transitioning an existing and operational energy model toward a Smart Grid. These challenges include increasing customer awareness and participation, allocating costs appropriately and fairly among stakeholders, developing and executing business case models, identifying and implementing best practices and standards throughout the industry, and establishing a coordinated strategy that capitalizes on using smarter technology to evolve to a Smart Grid.

This report outlines critical steps that DOE can take to help overcome these challenges and fulfill its pivotal and much-needed leadership role in developing a coordinated, cost-effective national Smart Grid strategy. The EAC offers the following recommendations to DOE:

1. Create a Smart Grid Program office within DOE. This office should do the following:
   - Act as a clearinghouse of global Smart Grid information via web-based self-service tools.
   - Provide information on, at a minimum, worldwide best practices, effective Smart Grid business models, available technologies, and effective regulatory models.
   - Develop and make available educational materials to utility regulators, utilities, consumer advocates, and other stakeholders.
   - Provide or support coordination of Smart Grid activities among diverse organizations, if appropriate.
   - Drive standards-based work once the National Institute of Standards and Technology (NIST) completes its development of a framework, as authorized in Section 1305 in the Energy Independence and Security Act of 2007 (EISA 2007).
2. Develop a roadmap by December 2009 for the achievement of a coordinated nationwide cost-effective deployment of Smart Grid technologies. The key elements of this roadmap should include:
   - A description of the essential components under a Smart Grid
   - A prioritization for the development of these components
   - Identification of Smart Grid subsectors that particularly need further investment
   - A timetable for Smart Grid investments necessary by utilities and other stakeholders throughout the United States
   - Identification of the areas in the electric grid that need to be able to interact seamlessly
   - Identification of appropriate standards to facilitate the rapid deployment and utilization of Smart Grid technologies
3. Request that Congress appropriate the funds needed for the Smart Grid Regional Demonstration Initiative and the Smart Grid Investment Matching Grant Program authorized under EISA 2007. Also, request that Congress provide NIST with the funds to coordinate the development of a framework as defined in Section 1305 of EISA 2007.
4. Develop, manage, conduct, and communicate appropriate R&D and deployment projects to identify and prove next steps, consistent with the roadmap, and direct the Smart Grid Regional Demonstration Initiative and Matching Grant Program as authorized in EISA 2007 and referenced above.
5. Conduct a focused education campaign. This DOE campaign should focus on educating consumers on the cost of energy and how those costs can be better managed.
6. Establish a Smart Grid engineer and technician development program that encourages students to pursue Smart Grid-related technical degrees.
   - Define appropriate university training for these new-generation engineers leveraging the existing land-grant universities in every state for assistance in disseminating information.
   - Create a workforce training program to ensure that working technicians have the skills needed to work with Smart Grid technologies.
7. Work with Congress, industry, state regulators, and other stakeholders to create incentives and standards that will drive a market for Smart Grid-ready controllable devices beyond the meter.

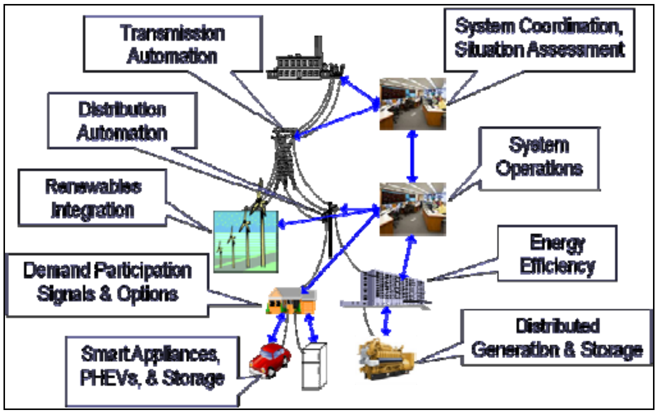
Chapter 1
Defining a Smart Grid

Though there has been much debate over the exact definition, a Smart Grid actually comprises a broad range of technology solutions that optimize the energy value chain. Depending on where and how a specific utility operates across that chain, it can benefit from deploying certain parts of a Smart Grid solution set.

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."[1] In the soon-to-be-published *Smart Grid System Report*,[2] 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."

Figure 1-1 from the DOE Smart Grid System Report[3] shows the many Smart Grid components. For a more detailed description, Table B-1 in appendix B defines Smart Grid elements as written in Title XIII of the 2007 Energy Independence and Security Act (EISA 2007).[4] Table B-2 in appendix B is a representative, though not comprehensive, list of Smart Grid technologies and Smart Grid elements as they relate to Title XIII.

Figure 1-1. DOE Smart Grid Components



Source: U.S. Department of Energy 2008.[5]

Many utilities are in the process of determining the first phases of their Smart Grid plan. Several utilities have received regulator funding and authorization for scale deployments of key elements of Smart Grid, including the examples below. Many of these utilities begin with automatic metering systems. In addition,

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[1] U.S. Department of Energy, *The Smart Grid: An Introduction* (Washington, DC: U.S. Department of Energy, 2008), http://www.oe.energy.gov/1165.htm.
[2] U.S. Department of Energy, *Smart Grid System Report* (Washington, DC: U.S. Department of Energy, 2008).
[3] Ibid.
[4] *Energy Independence and Security Act of 2007*, HR 6, 110th Cong., *Congressional Record 153* (December 19, 2007): Doc. 110–140.
[5] U.S. Department of Energy, *Smart Grid System Report* (Washington, DC: U.S. Department of Energy, 2008).

numerous Smart Grid pilots of varying scale and scope are already testing technology and consumer acceptance. By proving the value of other elements of a Smart Grid, these pilots are helping make the Smart Grid a reality. Some of the other elements include outage and work management systems, substation automation, and remote monitoring of equipment. All of these elements can take advantage of communications systems put in place for automatic metering systems.

1.1 Austin Energy

Austin Energy's Smart Grid initiative initially started out as an enterprise architecture program, followed by an effort to redefine the company's business process using service-oriented architecture (SOA). Austin went on to enable consumer choice through different demand response / load management, distributed generation, and renewable energy programs.[6] These programs saved Austin Energy operational costs, allowing the utility to fund investment in new technologies at no extra cost to consumers. Technology deployment as of August 2008 included 130,000 smart meters and 70,000 smart thermostats. Plans call for an additional 270,000 smart meters and 70,000 smart thermostats, along with 10,000 new transmission and distribution grid sensors, by January–February 2009. At that point, 100% of Austin Energy's consumer base will be served by Smart Grid technologies.

1.2 Southern California Edison

In September 2008, the California Public Utilities Commission (CPUC) approved $1.63 billion in funding from ratepayers for Southern California Edison's (SCE's) smart metering program, Edison SmartConnect. SCE will install 5.3 million new smart meters for its residential and small-business customers from 2009 until 2012. SCE has also designed and deployed its own neighborhood electricity circuit, known as Avanti, which delivers power to 1,400 customers. "Much like a household electrical circuit, utility distribution circuits are individual segments of larger power grids that are controlled with on-off switches and protected by circuit breakers. They carry power from neighborhood substations to homes and businesses," SCE said. "During the past five years the company has invested $5 billion in infrastructure expansion to keep pace with a growing service area and to retire aging components. SCE plans to invest $9 billion during the next five years."[7] In addition, SCE is pursuing several grid-connected electro-drive technologies for airports, ports, truck stops, and plug-in electric vehicles.

1.3 Oncor and CenterPoint

The Public Utilities Commission of Texas (PUCT) approved Oncor's advanced metering system (AMS) plan in August 2008.[8] The plan calls for the installation of more than 3 million advanced meters across Oncor's service territory by the end of 2012, a comprehensive consumer education program, and a provision to ensure that the benefits of AMS are available to qualified low-income consumers. The monthly surcharge for residential consumers will be $2.21 and will range from $2.41 to $5.18 for other consumer classes. Oncor also plans to deploy in-home displays as part of its AMS initiative. Through a separate project, Oncor is installing the world's largest clusters of Static Var Compensators (SVCs).[9] SVCs are advanced technology devices that provide high-speed voltage support and significantly increase transmission capacity and efficiency by allowing alternating current (AC) lines to be loaded more heavily without reliability risks. This reduces the need to run generation plants in close proximity to system loads, thereby limiting air pollutants. SVCs will also help control and rapidly respond to changes in grid conditions, and can accommodate wind power and other forms of remote generation. The PUCT also approved a plan by CenterPoint Energy to deploy 127,000 advanced meters in the Houston area.[10] There is currently an active case at the PUCT, Docket No. 35639, to address deployment of advanced meters to the remaining customers in the Houston area.

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[6] Austin Energy, "Austin Energy – More Than Electricity," Austin Energy, http://www.austinenergy.com (accessed November 2008).

[7] Southern California Edison, "Avanti: Circuit of the Future," Edison International, http://www.sce.com/Feature/Archive/Avanti.htm (accessed November 2008).

[8] Oncor, "Oncor," http://oncor.com (accessed November 2008).

[9] "Oncor to Use New SVC Technology for Grid Reliability," *Transmission and Distribution World*, October 7, 2008, http://tdworld.com/test_monitor_control/highlights/oncor-abb-svc-1008.

[10] "Application of CenterPoint Energy Houston Electric LLC for Approval to Implement Advanced Meter Information Network Pursuant to PURA § 39.107(i)," Docket No 35260, August 29, 2008.

Chapter 2
Value of a Smart Grid

According to the Galvin Electricity Initiative and the Electric Power Research Institute (EPRI), the economic and environmental benefits of transforming the current electric power delivery system into a Smart Grid are numerous.

A Smart Grid brings the power of networked, interactive technologies into an electricity system, giving utilities and consumers unprecedented control over energy use, improving power grid operations, and ultimately reducing costs to consumers. Table 2-3 summarizes the value of a Smart Grid deployment for the various stakeholders.

2.1 THE ECONOMIC CASE

The EPRI *Electricity Sector Framework for the Future* estimates $1.8 trillion in annual additive revenue by 2020 with a substantially more efficient and reliable grid.[11]

To elaborate, according to the Galvin Electricity Initiative, "Smart Grid technologies would reduce power disturbance costs to the U.S. economy by $49 billion per year. Smart Grids would also reduce the need for massive infrastructure investments by between $46 billion and $117 billion over the next 20 years.[12]

"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."[13] 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.[14]

In addition, efficient technologies can dramatically reduce total fuel consumption—and thereby potentially reduce fuel prices for all consumers.

Virtually the nation's entire economy depends on reliable energy. The availability of high-quality power could help determine the future of the U.S. economy. See Table 2-1 for an outline of the value of an enhanced electric power system.

Additionally, a Smart Grid creates new markets as private industry develops energy-efficient and intelligent appliances, smart meters, new sensing and communications capabilities, and passenger vehicles.

2.2 THE ENVIRONMENTAL CASE

Around the globe, countries are pursuing or considering pursuit of greenhouse gas legislation suggesting that public awareness of issues stemming from greenhouse gases has never before been at such a high level. According to the National Renewable

[11] Electric Power Research Institute, *Electricity Sector Framework for the Future Volume I: Achieving the 21st Century Transformation*, (Washington, DC: Electric Power Research Institute, 2003).

[12] Galvin Electricity Initiative, "The Case for Transformation," Galvin Electricity Initiative, http://www.galvinpower.org/resources/galvin.php?id=27.

[13] Ibid.

[14] Ibid.

Table 2-1. Value of an Enhanced Electric Power System

	2000	2025		
Parameter	**Baseline**	**Business as Usual (BAU)**	**Enhanced Electric Power System**	**Improvement of Enhanced Productivity Over BAU**
Electricity Consumption (billion kilowatt-hours [kwh])	3,800	5,800	4,900 – 5,200	10% – 15% reduction
Delivered Electricity Intensity (kwh/$GDP)	0.41	0.28	0.20	29% reduction
% Demand Reduction at Peak	6%	15%	25%	66% increase
% Load Requiring Digital Quality Power	<10%	30%	50%	66% increase
Carbon Dioxide Emissions (million metric tons of carbon)	590	900	720	20% reduction
Productivity Growth Rate (%/year)	2.9	2.5	3.2	28% increase
Real GDP (billions of dollars, 1996)	9,200	20,700	24,300	17% increase
Cost of Power Disturbances to Businesses (billions of dollars, 1996)	100	200	20	90% reduction

Source: Electric Power Research Institute 2003.[16]

Energy Laboratory (NREL), "utilities are pressured on many fronts to adopt business practices that respond to global environmental concerns. According to the FY 2008 Budget Request by [NREL], if we do nothing, U.S. carbon emissions are expected to rise from 1700 million tons of carbon per year today to 2300 [million tons of carbon] by the year 2030. In that same study, they demonstrate that utilities, through implementation of energy efficiency programs and use of renewable energy sources, could not only displace that growth, but actually have the opportunity to reduce the carbon output to below 1,000 [million tons of carbon] by 2030."[15]

Implementing Smart Grid technologies could reduce carbon emissions by:

- Leveraging demand response / load management to minimize the use of costly peaking generation, which typically uses generation that is comparatively fuel inefficient
- Facilitating increased energy efficiency through consumer education, programs leveraging usage information, and time-variable pricing
- Facilitating mitigation of renewable generation variability of output—mitigation of this variability is one of the chief obstacles to integration of large amounts of renewable energy capacity into the bulk power system
- Integrating plug-in hybrid electric vehicles (PHEVs), distributed wind and photovoltaic solar energy resources, and other forms of distributed generation

2.3 Benefits to Utilities

Implementing or building a business case for advanced metering system or infrastructure (AMS or AMI) programs is often a utility's first involvement in Smart Grid efforts. Though the terms are not synonymous, the communications technologies and devices in AMI are key enablers of Smart Grid technologies. Advanced meters can better integrate "behind-the-meter" devices such as residential energy storage units, PHEVs, distributed generation, and various mechanisms for controlling or influencing load.

In the industry push for Smart Grid upgrades, utilities are faced with the desire to enhance technology while maintaining the reliable and safe infrastructure needed to serve their consumers today. They must balance wholesale replacement of technology with the practicality of tactical upgrades. Utilities will need to be open to supporting the needs of an increasingly complex group of consumers with sophisticated business, technology, and environmental objectives.

[15] National Renewable Energy Laboratory, *Projected Benefits of Federal Energy Efficiency and Renewable Energy Programs – FY 2008* Budget Request, 2007.

[16] Electric Power Research Institute, *Electricity Sector Framework for the Future Volume I: Achieving the 21st Century Transformation* (Washington, DC: Electric Power Research Institute, 2003).

Improved Reliability

According to the Galvin Electricity Initiative, "the 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."[17]

Table 2-2 shows the average estimated cost of a one-hour power interruption.

Table 2-2. Cost of One-Hour Power Service Interruption in Various Industries

Industry	Average Cost of 1-Hour Interruption
Cellular communications	$41,000
Telephone ticket sales	$72,000
Airline reservation system	$90,000
Semiconductor manufacturer	$2,000,000
Credit card operation	$2,580,000
Brokerage operation	$6,480,000

Source: Galvin Electricity Initiative 2008.[18]

The Galvin Electricity Initiative says that "in an increasingly digital world, even the slightest disturbances in power quality and reliability cause loss of information, processes and productivity. Interruptions and disturbances measuring less than one cycle (less than 1/60th of a second) are enough to crash servers, computers, intensive care and life support machines, automated equipment and other microprocessor-based devices."

In addition, Galvin explains that the situation may worsen as the nation's electric infrastructure continues to age. "In the United States, the average power generating station was built in the 1960s using technology that is even older. The average age of a substation transformer is 42 years, but the transformers today were designed to have a maximum life of 40 years."[19]

A Smart Grid enables significant improvements in power quality and reliability. Smart meters will allow utilities to confirm more easily that meters are working properly. Two-way communications all across the grid will let utilities remotely identify, locate, isolate, and restore power outages more quickly without having to send field crews on trouble calls. In fact, a Smart Grid could eliminate up to 50% of trouble calls.[20]

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.

Deferred Capital Spending for Generation, Transmission, and Distribution Investments

By reducing peak demand, a Smart Grid can reduce the need for additional transmission lines and power plants that would otherwise be needed to meet that demand. The peak usage of the California Independent System Operator (CAISO) for 2005–2006, for example, is 50,085 megawatts (MW). However, usage exceeds 45,000 MW only 0.65% of the time annually.[21] This means that California must build peaking plants, additional transmission lines, distribution lines, and possibly even additional baseload power plants to generate enough supply to meet demand that occurs less than 1% of the time. The ability to reduce peak demand via Smart Grid-enabled consumer demand response / load management can defer or reduce the need to build resources that would be unused much of the time. A Smart Grid can also defer capital investments by prolonging the life of existing assets through enhanced asset management methodologies that

[17] Galvin Electricity Initiative, "Fact Sheet: The Electric Power System is Unreliable," Galvin Electricity Initiative, http://www.galvinpower.org/resources/galvin.php?id=26.
[18] Ibid.
[19] Ibid.
[20] Tom Standish, "Visions of the Smart Grid: Deconstructing the traditional utility to build the virtual utility," (Washington DC: U.S. Department of Energy 2008 Smart Grid Implementation Workshop, June 19, 2008), Keynote address.
[21] Jim Detmers, "CAISO Operational Needs from Demand Response Resources," (California Independent System Operator, November 2006), Powerpoint slides, http://www.caiso.com/18a1/18a1ec276b6a0.pdf.

exploit additional condition monitoring and diagnostic information about system components.

Reduced Operations and Maintenance Costs

Smart Grid technologies allow for remote and automated disconnections and reconnections, which eliminate unneeded field trips, reduce consumer outage and high-bill calls, and ultimately reduce operations and maintenance (O&M) costs. Reduced costs can also result from near real-time remote asset monitoring, enabling utilities to move from time-based maintenance practices to equipment-condition-based maintenance. Using enhanced information about grid assets from Smart Grid monitoring technologies, grid operators can reduce the risk of overloading problematic equipment—especially transmission power transformers. These multi-million dollar assets have an expected life of 40 years, but a significant percent of the U.S. power transformer fleet is approaching or already past this age. Simply keeping the transformers in service risks increased failure rates and even greater outage costs, as well as larger disruptions or more severe damage to system equipment. However, doing so is often a necessity, as the cost of replacing transformers has increased rapidly, along with the prices for copper and ferromagnetic steel. Today, multi-function sensors are available that can continuously monitor a number of physical parameters for signs of incipient failure (e.g., insulation breakdown, loosening of fasteners that hold windings in place). Information from these devices, together with sophisticated analysis of fault conditions from power circuit breakers that protect the transformers, can help determine when the equipment needs maintenance, repairs, and eventually replacement.

Increased Efficiency of Power Delivery

Up to a 30% reduction in distribution losses is possible from optimal power factor performance and system balancing.[22] Today, this problem is managed to some extent by controlled or automated capacitor banks on distribution circuits and in substations. Control of these devices can be greatly improved with better real-time information. Almost all higher efficiency appliances, heating, ventilation, and cooling (HVAC) systems, consumer electronics, lighting, and other load devices are changing from being "resistive" (e.g., incandescent light bulbs) or "rotating" (as in motors) to "inverter based." The transition of load from "resistive" to "inverter based" means that the overall system performance, especially with respect to power factor and reactive power needs, changes dramatically over time. Smart Grid technologies offer utilities increased monitoring of rapid power changes and help them adapt control schemes and deploy capacitors and other power-factor control devices—including power electronics-based devices in substations—to compensate.

Integration of Renewable Energy and Distributed Resources

Smart Grid technologies will allow the grid to better adapt to the dynamics of renewable energy and distributed generation, helping utilities and consumers more easily access these resources and reap the benefits. Today's grid was designed to move power from centralized supply sources to fixed, predictable loads; this makes it challenging for the grid to accept input from many distributed energy resources across the grid. And because resources such as solar and wind power are intermittent, the grid will require integrated monitoring and control, as well as integration with substation automation, to control differing energy flows and plan for standby capacity to supplement intermittent generation. Smart Grid capabilities will make it easier to control bi-directional power flows and monitor, control, and support these distributed resources.

Improved System Security

Utilities are increasingly employing digital devices in substations to improve protection, enable substation automation, and increase reliability and control. However, these remotely accessible and programmable devices can introduce cyber security concerns. While the North American Electric Reliability Corporation (NERC) has developed Critical Infrastructure Protection standards to address these issues, Smart Grid technology and capabilities will offer better integration of these devices, increased use of sensors, and added layers of control. Smart Grid technologies, however, can bring their own cyber security concerns, which will require comprehensive, built-in security during implementation. Smart Grid technologies can do the following:

[22] Xcel Energy, *Xcel Energy Smart Grid: A White Paper* (Minneapolis, MN: Xcel Energy, 2008) http://birdcam.xcelenergy.com/sgc/media/pdf/SmartGridWhitePaper.pdf.

- Bring higher levels of investment and greater penetration of information technology (IT) into the grid, allowing utilities to address cyber security issues more effectively.
- Increase the robustness of the grid to withstand component failures, whether due to natural events, age/condition of assets, or hostile causes.
- Allow grid components and IT systems in time to detect intrusion attempts and provide real-time notification to cyber security organizations.

2.4 Benefits to Consumers

A 2007 survey conducted by IBM of 1,900 energy consumers revealed that growing reliability concerns, fears over environmental sustainability, and increasing costs of energy bills have created a demand from consumers for more control over their energy consumption decisions.[23] As Smart Grid projects enable a more participatory network comprising intelligent network-connected devices, distributed generation, and energy management tools, consumers will be able to better plan and manage their energy consumption.[24] Additional benefits are outlined below.

Consumption Management

Smart Grid technologies offer consumers the knowledge and ability to manage their own consumption habits through in-home or building automation. Advanced meters tell consumers how energy is used within their home or business, what that usage costs them, and what kind of impact that usage has on the environment. They can manage their usage interactively or set preferences that tell the utility to automatically make adjustments based on those choices. Consumers can create home area networks (HANs) of smart appliances, thermostats, security systems, and electronics that are able to communicate with the grid and relay information back to the consumer. Consumers will further be able to remotely manage these appliances. Two-way communications facilities will even allow appliances and security systems to initiate the conversation, notifying home and business owners of problems or safety alerts when they are away. These Smart Homes and Smart Buildings are convenient, efficient, and can encourage consumers to make energy-efficient decisions that result in energy savings.

Cost Savings from Peak Load Reduction

The electric power industry has long known that demand response / load management programs aimed at reducing peak load can have economic benefits for the utility and the consumer. As noted in the Electricity Advisory Committee's report, *Keeping the Lights On in the New World*, some peaking combustion turbines only run a few hours a year when load is at its highest, which in a market environment can mean that energy costs $1000 per megawatt hour (MWh) to generate. In a regulated environment, the system average costs still have to cover the annualized cost for those units, even if it does not show up as a very high spot price. Consumers that defer peak energy usage to a later hour or otherwise reduce peak consumption save the cost of generating expensive peak energy. All consumers either benefit from reduced peak prices in a market environment, or from reduced average costs in a regulated environment. Peak reduction is thus a highly leveraged win for all consumers. In the longer term, the use of demand response / load management programs as a generation resource avoids building expensive peak generation. A Smart Grid is a key enabler in achieving demand response / load management; communicating peak prices to consumers; and integrating smart appliances, consumer storage and distributed generation, and smart building controls with the goal of peak reduction.

Convenience of Distributed Generation

The new energy paradigm does not just empower utility consumers to better manage their consumption, reduce demand, and help the environment; through distributed generation, it can enable them to become energy producers. Distributed generation assets are typically consumer owned and rely on a range of generation technologies that deliver electricity directly to the consumer. Onsite photovoltaic panels and small-scale wind turbines are familiar examples. Emerging distributed generation resources include geothermal, biomass, carbon-free hydrogen fuel cells, PHEVs, and batteries for energy storage. As the cost of traditional energy sources continues to rise and the cost of distributed generation technologies declines,

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[23] Michael Valocchi and others, *Plugging in the Consumer: Innovating utility business models for the future* (Somers, NY: IBM Institute for Business Value, 2007.
[24] Ibid.

these new energy resources will become more affordable. Renewable energy resources are not only environmentally friendly; they create cost-saving opportunities for consumers who are able to generate electricity in excess of their own needs and sell the surplus back to the grid.

Cost Savings through Energy Efficiency

Today's new smart metering and communication technology could enable consumers and system operators to monitor and potentially control consumption—and cost—at 15-minute intervals. Such improved awareness gives consumers incentives to reduce energy use by switching to more efficient appliances and light bulbs, adjusting thermostat temperatures, and turning off lights and other energy-consuming devices when not in use. Consumers will become more active participants in the energy market, as they will be able to more easily compare monthly bills applying different electric retailers' rates to their actual usage. Improved market transparency will allow consumers to easily seek the best retail prices and services. Based on nationwide pilot data, consumers could reduce their electricity consumption by up to 25% during peak periods.[25]

Convenience of Advanced Meters

With two-way communications between the consumer's meter and the utility, automated meter reading is much easier for consumers and utilities alike. Not only are digital smart meters more accurate, but they also will greatly reduce the number of estimated readings due to inaccessible meters. Smart Grid technologies will also allow utilities to connect and disconnect electric service remotely, making it easier and faster for consumers to start, stop, or transfer service, as well as change retail electric providers.

Reduced Industrial Consumer Costs

Commercial and industrial consumers will benefit greatly from a Smart Grid. For example, electric motors account for about 65% of industrial electricity usage. This is because motors power virtually every moving process necessary for power generation, oil and mining extraction, compression and pumping for heating and cooling buildings, as well as moving conveyors in discrete and process manufacturing like pharmaceuticals and automobiles.[26] Small improvements in motor efficiency can therefore generate significant savings in energy costs. Only a small percentage of large motors are controlled by variable speed drives as opposed to traditional fixed drives which run at full speed all the time. A U.S. motor challenge study indicated that 85 billion kilowatt hours (kWh) per year could be saved using variable drives and high-efficiency motors. A variable speed drive can reduce a motor's energy consumption by as much as 60%. Further, a variable speed drive can be enabled to respond automatically to pricing signals from the utility; this could have a major impact on a firm's total consumption requirements and costs, as well as energy-efficiency benefits for society at large.[27]

Enhanced Business Consumer Service

According to EPRI,[28] a Smart Grid will allow automatic monitoring and proactive maintenance of end-use equipment, which can be an avenue for energy savings and reduced carbon emissions. Equipment is sometimes not properly commissioned when it is first installed or replaced. With the two-way communications of a Smart Grid infrastructure in place, a utility could monitor the performance of major consumer equipment through advanced interval metering and on-premise energy management control systems. The utility would thus be able to advise the consumer on the condition of specific facilities. EPRI estimates that this could lead to an annual energy savings potential of 2.2 billion–8.8 billion kWh, depending on the level of market penetration.[29]

Research from Energy Insights, an IDC Company, indicates that consumers are interested in the opportunities offered by a Smart Grid. Results from the 2007 Energy Insights *National Residential Online Panel In-Home Display Survey* found that most people surveyed are interested in having such a unit to provide direct feedback on their energy use. About 70% expressed high interest, with an additional 20% expressing moderate interest. Although consumers are

[25] Energy Insights, Compilation of Nationwide Pilot Data, (Framingham, MA: IDC, 2008).

[26] ABB, *Pathway for Transmission & Distribution Sector*, a report submitted to the Business Roundtable Energy Taskforce, 2006.

[27] ABB, *Pathway for Transmission & Distribution Sector*, a report submitted to the Business Roundtable Energy Task Force, 2006.

[28] Electric Power Research Institute, *The Green Grid: EPRI Report 1016905* (Palo Alto, CA: Electric Power Research Institute, 2007).

[29] Ibid.

less enthusiastic about giving their utility control over their appliances, a third said they would be more likely to sign up for a dynamic pricing program if their utility could use the in-home display to automate their appliances.[30]

Findings from Energy Insights' *2008 National Residential Online Panel Real-Time Pricing (RTP) Survey* show that a large group of consumers is interested in RTP.[31] Results from Ameren's Energy-Smart Pricing Plan (ESPP) pilot in Illinois and its subsequent Power Smart Pricing program also prove that consumers can and will respond to price signals; in fact, participants significantly reduced both their peak demand and energy consumption.[32]

[30] Energy Insights, *National Residential Online Panel In-Home Display Survey* (Framingham, MA: IDC, 2007).
[31] Energy Insights, *2008 National Residential Online Panel Real-Time Pricing (RTP) Survey* (Framingham, MA: IDC, 2008).
[32] Ibid.

Table 2-3. Smart Grid Benefits Matrix

Potential and Real Benefits to be Realized by Building and Implementing a Smart Grid						
Benefit	**Stakeholder**					
	Utility	**Independent Generator**	**Residential**	**Commercial**	**Industrial**	**Future Generations**
System Reliability and Economics						
Smart Grid technologies allow faster diagnosis of distribution outages and automated restoration of undamaged portions of the grid, reducing overall outage times with major economic benefits.	X		X	X	X	
Smart Grid's automated diagnostic and self-healing capability prolongs the life of the electric infrastructure.	X					X
Distributed generation is supported because the grid has the ability to dynamically manage all sources of power on the grid.	X	X	X	X	X	X
Price-sensitive peak shaving defers the need for grid expansion and retrofit.	X					
Price-sensitive peak shaving reduces the need for peaking generation capacity investments.	X		X	X	X	
Smart Grid technologies may allow better utilization of transmission paths, improving long distance energy transfers.	X	X				
Positive Environmental Impact						
Smart Grid can reduce distribution losses, thus reducing power generation demands.	X		X	X	X	X
Grid integration of high levels of renewable resources as called for in many state RPS standards will require Smart Grid to manage extensive distributed generation and storage resources.	X	X	X	X	X	X
A high penetration of PHEV will require Smart Grid to manage grid support of vehicle charging. Potential use of PHEV as Vehicle to Grid will absolutely require Smart Grid technologies.	X		X			X
A Smart Grid enables intelligent appliances to provide feedback through the system, sense grid stress, and reduce their power use during peak demand periods.	X		X			
Advanced metering technology can be used to help measure electricity use and calculate the resulting carbon footprint.			X	X	X	X
Increased efficiency of power delivery						
Direct operating costs are reduced through the use of advanced metering technology (AMR/AMI) such as connects/disconnects, vehicle fleet operations and maintenance, meter reads, employee insurance compensation insurance, etc.	X					
Smart Grid technologies, such as synchrophasors, offer the promise of reducing transmission congestion.	X	X	X	X	X	
Economic Development						
Standards and protocols supporting interoperability will promote product innovation and business opportunities that support the Smart Grid concept.	X	X	X	X	X	X
Consumer Choice						
Provide consumers with information on their electric usage so they can make smart energy choices.			X	X	X	X
Real-time pricing offers consumers a "choice" of cost and convenience trade-offs that are superior to hierarchical demand management programs.			X	X	X	
Integration of building automation systems offers efficiency gains, grid expansion deferral, and peak shaving.	X			X		

Source: Table created for *Smart Grid: Enabler of the New Energy Economy* by EAC Smart Grid Subcommittee 2008

Chapter 3
Challenges and Opportunities

"The biggest impediment to the smart electric grid transition is neither technical nor economic," said Kurt Yeager, Executive Director of the Galvin Electricity Initiative and President Emeritus of the Electric Power Research Institute (EPRI), in testimony before the House Committee on Energy and Commerce on May 3, 2007. "Instead, the transition is limited today by obsolete regulatory barriers and disincentives that echo from an earlier era."[33] Those regulatory barriers and other challenges to a Smart Grid are discussed in detail below.

3.1 Regulatory Challenges

The nation's electric power delivery system is much like the telecommunications network of the past—dated and increasingly costly for consumers. Three decades ago, one phone company was the monopoly provider of services across much of the United States, and it was illegal to plug other companies' telephones and devices into that company's network. Today, telecommunications choices and services are much greater thanks to legislation and technological advances that broke up the monopoly and later opened the door to competition in the telecommunications industry. The Energy Independence and Security Act of 2007 (EISA 2007), with its support for Smart Grid research and investment, is an important step forward in achieving similar results for the power industry, although more government involvement is needed to remove obstacles to further innovation.[34]

State public utility commissions (PUCs) are responsible for ensuring that electric utilities under their jurisdiction provide safe and reliable service at a reasonable price. PUCs analyze and determine if proposed utility infrastructure investments, like the deployment of Smart Grid technologies, are prudent investments. Investments are often evaluated based upon actual and realizable benefits, and while future benefits may be considered, they must be evaluated appropriately. The state-by-state PUC approval process could create a patchwork approach, as different Smart Grid improvements could be adopted by neighboring states or even utilities within one state. PUCs also need to develop unique rate structures using Smart Grid technology by creating special time-of-use rates, whether hourly, critical peak pricing, or some other modification from the existing approaches.

As technology advances and as the nation approaches the building of a Smart Grid, consumers and utilities will have a greater opportunity to control their electric consumption in response to price and system conditions.

[33] Kurt E. Yeager, "Facilitating the Transition to a Smart Electric Grid," (Galvin Electricity Initiative, 2007) testimonyhttp://www.galvinpower.org/files/Congressional_Testimony_5_3_07.pdf.

[34] Galvin Electricity Initiative, "Fact Sheet: The Path to Perfect Power: Policy Solutions," Galvin Electricity Initiative, http://www.galvinpower.org/files/PolicyPriorities4.pdf.

3.2 UTILITY BUSINESS MODEL

Many of today's utility business models are based upon the utility earning a negotiated return on prudent capital investments. It is not surprising, therefore, that the utilities responsible for making prudent investments focus on minimizing risk. Consequently, utilities are often slow to adopt new technologies that have not been extensively proven outside of a laboratory. In general, the existing utility business model does not provide economic rewards for cutting-edge utilities. In addition, the value of Smart Grid technologies has been difficult to quantify in a simple cost-benefit analysis due to the multi-tiered benefits they provide to the utility, the consumer, and society. Comparative financial metrics are difficult to achieve because each utility incorporating Smart Grid technologies has put a unique level of investment in a variety of technologies, as shown in the chapter 2 examples. In turn, the rewards—financial, operational, experiential, and otherwise—for first adopters are not generally recognized by other electric industry stakeholders. Existing electric rate structures create further complications. As a Smart Grid enables more conservation and distributed generation, regulators may have to address the problem of how to provide appropriate rewards to utilities for actions that will reduce total electricity sales.

3.3 LACK OF A COORDINATED STRATEGY

The efficient evolution to a Smart Grid will require a coordinated strategy that relies upon building an appropriate electric infrastructure foundation to maximize utilization of the existing system. A Smart Grid is a new integrated operational and conceptual model for utility operations. Among other things, it envisions the real-time monitoring of all utility transformers, transmission and distribution line segments, generation units, and consumer usage, along with the ability to change the performance of each monitored device. This will require significant planning for both implementing a system-wide installation of monitoring devices (including monitoring devices at the consumer level), and for installing the equipment necessary to enable parts of the system to "talk" with other components and take rerouting, self-healing, and other actions independent of system operators. Developing such an integrated system requires a multi-year, phased installation of Smart Grid devices and upgraded computer and communication capabilities; those investing in this technology likely will not realize the value until the return value of the combined benefits of these technologies are achieved.

3.4 COST

As discussed, the effort to move from using smarter technology to a Smart Grid is a significant undertaking that needs focused coordination both strategically and tactically. This undertaking also will require significant investment. Investors often face the challenges of access to capital to make these investments, as well as the lack of ability to bear the associated costs of the expenses. Utilities must grapple with making Smart Grid investments, knowing that significant utility and consumer benefits may not occur for several years. A Smart Grid is a complex, comprehensive, and integrated monitoring and operating system; it will provide publicly observable benefits only after considerable investments have been made in upgrading the infrastructure of the nation's utilities and the monitoring and control devices in the homes and businesses of consumers. Investing in equipment and personnel training, for which there are few short-term benefits, creates operating costs that may be difficult to justify without policy direction and support from government agencies.

3.5 CONSUMER IMPACTS

Intellectually, Americans can welcome a Smart Grid because it offers more efficient use of resources, while maximizing electricity services. However, in order for the typical consumer to accept and embrace the transformation to a Smart Grid, utilities and policymakers must communicate the benefits effectively to the public. Consumer benefits need to be defined and advocated by utilities and policymakers alike across all economic levels in order to overcome this hurdle.

3.6 KEY INFRASTRUCTURE ISSUES

Without question, creating a Smart Grid presents many complex technical challenges. Chief among them are the integration issues associated with the automation systems that manage the nation's transmission and distribution networks, along with the interface codes and standards required to enable a more reliable and smoothly operating electric system. One of the most important foundations of a Smart

Grid is the interoperability that enables all of the required devices, technologies, and agents (for example, energy producers, consumers, and operators) to interact beneficially in the network.

Interoperability has been defined as the ability of two or more systems or components to exchange information and to use the information that has been exchanged.[35] In the case of a Smart Grid, these systems might include outage management, distribution management, condition-based maintenance, supervisory control and data acquisition (SCADA), advanced metering infrastructure (AMI), distribution planning, load forecasting, and a variety of systems that have not been designed or built yet.

Ultimately, when a new device is added to the system, interoperability will enable it to register itself in the grid upon installation, communicate its capabilities to neighboring systems, and cause the connectivity database and control algorithms to update themselves automatically.

Evidence from other industries indicates that interoperability generates tangible cost savings and intangible benefits amounting to 0.3%–4% in cost savings or avoided construction. In the electric power industry, that could result in a net benefit of up to $12.6 billion per year.[36]

A Smart Grid will require interoperability among the many technology components involved. New solutions must also be configured to exchange information with legacy systems, including existing back office systems and other systems that need to be connected.

The past 20 years have seen tremendous progress in collaborative efforts across the industry to address issues associated with interoperability. The various members in the GridWise Alliance, GridWise Architecture Council, and other organizations including the American National Standards Institute, the Electric Power Research Institute, the International Electrotechnical Commission, the Institute of Electrical and Electronics Engineers, and the National Rural Electric Cooperative Association have created a knowledge base to draw upon and an initial set of standards and models the industry can implement. Common Information Model (CIM), IntelliGrid Architecture, MultiSpeak, Telecontrol Application Service Element 2 (TASE-2), Utility Communications Architecture (UCA) and the GridWise Architecture Council concepts all contain valuable knowledge to assist utilities and integrators in achieving interoperability. Industry support for continued development in several areas could significantly improve the potential state of interoperability, thereby improving the cost-benefit ratio of deploying a Smart Grid.[37]

3.7 SECURITY

The vision of a Smart Grid typically boasts enhanced system security. Indeed, the report *A Systems View of the Modern Grid*, published by the U.S. Department of Energy (DOE) and the National Energy Technology Laboratory (NETL) in January 2007, includes "resists attack" as one of seven principal characteristics of the future Smart Grid.[38] The DOE report goes on to list the following design features and functions:

- Identification of threats and vulnerabilities
- Protecting the network
- Inclusion of security risk in system planning

Expected benefits include:

- Reduced system vulnerability to physical or cyber attack
- Minimal consequences of any disruption, including its extent, duration, or economic impact
- Using security-related improvements to also help optimize reliability, communications, computing, decision-making support and self-healing

However, many of the technologies being deployed to support Smart Grid projects—such as smart meters, sensors, and advanced communications networks—can themselves increase the vulnerability of the grid to cyber attacks. Accordingly, it is essential that Smart Grid deployment leverage the benefits of increased threat awareness while mitigating against

[35] GridWise Architecture Council, "GridWise Architecture Council," http://www.gridwiseac.org (accessed November 2008).
[36] Rick Drummond, "Why Interoperable Grid Software will Pay for Itself," *Smart Grid Newsletter*, June 20, 2007, http://www.smartgridnews.com/artman/publish/article_210.html.

[37] Subramanian V. Vadari, Wade P. Malcolm, and Mark Lauby, "Resolving Intelligent Network Interoperability Challenges" (Accenture and NERC, 2007).
[38] National Energy Technology Laboratory, *A Systems View of the Modern Grid*, (Washington DC, National Energy Technology Laboratory, 2007), http://www.netl.doe.gov/moderngrid/docs/ASystemsViewoftheModernGrid_Final_v2_0.pdf.

heightened security concerns. It will be a difficult task, but one that can be addressed by being aware of the risks and leveraging security best practices from other industries.

3.8 Credit Crisis Impacts

The 2008 global financial crisis has dealt a major blow to business and consumers alike. In September 2008, MidAmerican Energy Holdings proposed acquiring Constellation Energy Group, Inc. (Constellation) for $4.7 billion after Constellation's stock plunged 60% over the preceding three days on fears about the company's exposure to bankrupt Lehman Brothers and its overall liquidity situation. Two weeks later, Reliant Energy (Reliant), after its stock nose-dived on news that it was losing a credit arrangement with Merrill Lynch and was raising $1 billion in new, more expensive capital, announced that it had formed a special committee to review strategic alternatives.

Despite media attention to the precarious financial situation of Constellation and Reliant, the majority of U.S. investor-owned utilities are vertically integrated and dominated by their regulated operations. These companies have little or no credit risk from trading or hedging activities and are unlikely to fall victim to the problems that beset Constellation and Reliant. Nonetheless, some analysts believe that technology spending will slow in the near term as utility chief information officers conserve cash by freezing or slowing down all external spending, primarily due to the tight commercial paper market which has made short-term cash difficult and costly to raise.[39] Over the next one to two years, the credit crisis will probably make the cost of capital more expensive, even for utilities with good credit ratings. At the same time, state utility regulators are becoming increasingly reticent to approve large capital expenditures, given the existing risks associated with the rising costs of labor and materials, the uncertainty surrounding the cost of carbon regulation in an inevitable mandatory carbon cap-and-trade program in the United States (at least for fossil fuel plants), and the unknown impact of a recession on demand growth. The credit crisis means that utilities in some jurisdictions may delay raising capital to build new large power plants and transmission lines, which can cost billions of dollars.

Despite this expected slowdown in spending for large capital projects, energy demand will continue to grow (albeit at a slower rate) and state utility regulators will continue to enforce renewable-energy, CO_2-reduction, and energy-efficiency goals. This situation will make distributed energy, demand response / load management programs, and energy-efficient technology investments more attractive, particularly in light of the Emergency Economic Stabilization Act of 2008. Tucked into the $700 billion rescue legislation is a measure allowing utilities to quickly write off investments in smart meters or other Smart Grid equipment. Worth $915 million over 10 years, the tax treatment in this legislation allows companies to depreciate investments over 10 years instead of 20 years, in essence taking bigger deductions each year. As a result, spending on renewable energy, distributed energy, smart metering, and Smart Grid-related technologies is likely to increase over the next one to two years.[40]

3.9 Conclusion

A Smart Grid presents opportunities for utilities and consumers to benefit from efficient management of energy and advanced equipment and devices. It offers significant opportunities to wisely manage the nation's fuel resources by potentially reducing the national need for additional generation sources, better integrating renewable and non-renewable generation sources into the grid's operations, reducing outages and cascading problems, and enabling consumers to better manage their energy consumption. DOE has the opportunity to address many of these challenges and accelerate the deployment schedule so that the nation can achieve the many benefits a Smart Grid offers.

[39] Rick Nicholson and others, *Impact of the Financial Crisis on Technology Spending in the Utility Industry* (Framingham, MA: Energy Insights, October 17, 2008).

[40] Ibid.

Chapter 4 Recommendations

Considering the importance of a Smart Grid, the Electricity Advisory Committee (EAC) finds that it is in the best interest of the nation to accelerate the cost-effective deployment of Smart Grid technologies. A Smart Grid can be a mechanism for achieving the nation's goals in the areas of energy security, climate change, grid reliability, economic growth, and national competitiveness.

At the same time, there are serious challenges to the timely development of a Smart Grid. Accordingly, the EAC offers the following recommendations to the U.S. Department of Energy (DOE):

1. Create a Smart Grid Program office within DOE. This office should do the following:
   - Act as a clearinghouse of global Smart Grid information via web-based self-service tools.
   - Provide information on, at a minimum, worldwide best practices, effective Smart Grid business models, available technologies, and effective regulatory models.
   - Develop and make available educational materials to utility regulators, utilities, consumer advocates, and other stakeholders.
   - Provide or support coordination of Smart Grid activities among diverse organizations, if appropriate.
   - Drive standards-based work once the National Institute of Standards and Technology (NIST) completes its development of a framework, as authorized in Section 1305 in the Energy Independence and Security Act of 2007 (EISA 2007).
2. Develop a roadmap by December 2009 for the achievement of a coordinated nationwide cost-effective deployment of Smart Grid technologies. The key elements of this roadmap should include:
   - A description of the essential components under a Smart Grid
   - A prioritization for the development of these components
   - Identification of Smart Grid subsectors that particularly need further investment
   - A timetable for Smart Grid investments necessary by utilities and other stakeholders throughout the United States
   - Identification of the areas in the electric grid that need to be able to interact seamlessly
   - Identification of appropriate standards to facilitate the rapid deployment and utilization of Smart Grid technologies
3. Request that Congress appropriate the funds needed for the Smart Grid Regional Demonstration Initiative and the Smart Grid Investment Matching Grant Program authorized under EISA 2007. Also, request that Congress provide NIST with the funds to coordinate the development of a framework as defined in Section 1305 of EISA 2007.
4. Develop, manage, conduct, and communicate appropriate R&D and deployment projects to identify and prove next steps, consistent with the roadmap, and direct the Smart Grid Regional Demonstration Initiative and Matching Grant Program as authorized in EISA 2007 and referenced above.
5. Conduct a focused education campaign. This DOE campaign should focus on educating

consumers on the cost of energy and how those costs can be better managed.

6. Establish a Smart Grid engineer and technician development program that encourages students to pursue Smart Grid-related technical degrees.
   - Define appropriate university training for these new generation engineers leveraging the existing land-grant universities in every state for assistance in disseminating information.
   - Create a workforce training program to ensure that working technicians have the skills needed to work with Smart Grid technologies.

7. Work with Congress, industry, state regulators, and other stakeholders to create incentives and standards that will drive a market for Smart Grid-ready controllable devices beyond the meter.

Appendix A
Acronyms

AC	alternating current
AMI	advanced metering infrastructure
AMR	automatic meter reading
AMS	advanced metering system
CAISO	California Independent System Operator
CIM	Common Information Model
CPUC	California Public Utilities Commission
DG	distributed generation
DOE	U.S. Department of Energy
DR	demand response
EAC	Electricity Advisory Committee
EPRI	Electric Power Research Institute
ESPP	Energy-Smart Pricing Plan
FACTS	flexible alternating current transmission systems
FLISR	Fault location, isolation, and service restoration
GPS	global positioning system
HAN	home area network
HVAC	heating, ventilation, and cooling
HVDC	high-voltage direct current
IED	intelligent electronic device
ISO	independent system operator
IT	information technology
kWh	kilowatt hour
MW	megawatts
MWh	megawatt hour
NERC	North American Electric Reliability Corporation
NETL	National Energy Technology Laboratory
NIST	National Institute of Standards and Technology
NREL	National Renewable Energy Laboratory
O&M	operations and maintenance
OMS	outage management system
PHEV	plug-in hybrid electric vehicle
PUC	public utility commission
PUCT	Public Utilities Commission of Texas
RTP	real-time pricing
SCADA	supervisory control and data acquisition
SCE	Southern California Edison
SG	Smart Grid
SOA	service-oriented architecture
SVC	Static Var Compensator

T&D	transmission and distribution
TASE-2	Telecontrol Application Service Element 2
Tx	load tap changer
UCA	Utility Communications Architecture
WAM	wide-area measurement

Appendix B
Energy Independence and Security Act of 2007 Smart Grid Sections

Table B-1. Energy Independence and Security Act Title XIII Smart Grid Technologies

Title XIII Section	Description of Title XIII
SEC. 1304. Smart Grid Technology Research, Development, and Demonstration	
1304.(a).1	To develop advanced techniques for measuring peak load reductions and energy-efficiency savings from smart metering, demand response / load management, distributed generation, and electricity storage systems
1304.(a).2	To investigate means for demand response / load management, distributed generation, and storage to provide ancillary services
1304.(a).3	To conduct research to advance the use of wide-area measurement and control networks, including data mining, visualization, advanced computing, and secure and dependable communications in a highly-distributed environment
1304.(a).4	To test new reliability technologies, including those concerning communications network capabilities, in a grid control room environment against a representative set of local outage and wide area blackout scenarios
1304.(a).5	To identify communications network capacity needed to implement advanced technologies
1304.(a).6	To investigate the feasibility of a transition to time-of-use and real-time electricity pricing
1304.(a).7	To develop algorithms for use in electric transmission system software applications
1304.(a).8	To promote the use of underutilized electricity generation capacity in any substitution of electricity for liquid fuels in the transportation system of the United States
1304.(a).9	In consultation with the Federal Energy Regulatory Commission, to propose interconnection protocols to enable electric utilities to access electricity stored in vehicles to help meet peak demand loads
1304.(b).1	The Secretary shall establish a Smart Grid regional demonstration initiative (referred to in this subsection as the `Initiative') composed of demonstration projects specifically focused on advanced technologies for use in power grid sensing, communications, analysis, and power flow control. The Secretary shall seek to leverage existing Smart Grid deployments
SEC. 1306. Federal Matching Fund for Smart Grid Investment Costs	
1306.(b).1	In the case of appliances covered for purposes of establishing energy conservation standards under part B of title III of the Energy Policy and Conservation Act of 1975 (42 U.S.C. 6291 et seq.), the documented expenditures incurred by a manufacturer of such appliances associated with purchasing or designing, creating the ability to manufacture, and manufacturing and installing for one calendar year, internal devices that allow the appliance to engage in Smart Grid functions

Title XIII Section	Description of Title XIII
1306.(b).2	In the case of specialized electricity-using equipment, including motors and drivers, installed in industrial or commercial applications, the documented expenditures incurred by its owner or its manufacturer of installing devices or modifying that equipment to engage in Smart Grid functions
1306.(b).3	In the case of transmission and distribution equipment fitted with monitoring and communications devices to enable Smart Grid functions, the documented expenditures incurred by the electric utility to purchase and install such monitoring and communications devices
1306.(b).4	In the case of metering devices, sensors, control devices, and other devices integrated with and attached to an electric utility system or retail distributor or marketer of electricity that are capable of engaging in Smart Grid functions, the documented expenditures incurred by the electric utility, distributor, or marketer and its consumers to purchase and install such devices
1306.(b).5	In the case of software that enables devices or computers to engage in Smart Grid functions, the documented purchase costs of the software
1306.(b).6	In the case of entities that operate or coordinate operations of regional electric grids, the documented expenditures for purchasing and installing such equipment that allows Smart Grid functions to operate and be combined or coordinated among multiple electric utilities and between that region and other regions
1306.(b).7	In the case of persons or entities other than electric utilities owning and operating a distributed electricity generator, the documented expenditures of enabling that generator to be monitored, controlled, or otherwise integrated into grid operations and electricity flows on the grid utilizing Smart Grid functions
1306.(b).8	In the case of electric or hybrid-electric vehicles, the documented expenses for devices that allow the vehicle to engage in Smart Grid functions (but not the costs of electricity storage for the vehicle)
1306.(b).9	The documented expenditures related to purchasing and implementing Smart Grid functions in such other cases as the Secretary shall identify. In making such grants, the Secretary shall seek to reward innovation and early adaptation, even if success is not complete, rather than deployment of proven and commercially viable technologies
Smart Grid Functions—The Term "Smart Grid Functions" Means Any of the Following:	
1306.(d).1	The ability to develop, store, send and receive digital information concerning electricity use, costs, prices, time of use, nature of use, storage, or other information relevant to device, grid, or utility operations, to or from or by means of the electric utility system, through one or a combination of devices and technologies
1306.(d).2	The ability to develop, store, send and receive digital information concerning electricity use, costs, prices, time of use, nature of use, storage, or other information relevant to device, grid, or utility operations to or from a computer or other control device
1306.(d).3	The ability to measure or monitor electricity use as a function of time of day, power quality characteristics such as voltage level, current, cycles per second, or source or type of generation and to store, synthesize or report that information by digital means
1306.(d).4	The ability to sense and localize disruptions or changes in power flows on the grid and communicate such information instantaneously and automatically for purposes of enabling automatic protective responses to sustain reliability and security of grid operations
1306.(d).5	The ability to detect, prevent, communicate with regard to, respond to, or recover from system security threats, including cyber-security threats and terrorism, using digital information, media, and devices
1306.(d).6	The ability of any appliance or machine to respond to such signals, measurements, or communications automatically or in a manner programmed by its owner or operator without independent human intervention
1306.(d).7	The ability to use digital information to operate functionalities on the electric utility grid that were previously electro-mechanical or manual
1306.(d).8	The ability to use digital controls to manage and modify electricity demand, enable congestion management, assist in voltage control, provide operating reserves, and provide frequency regulation
1306.(d).9	Such other functions as the Secretary may identify as being necessary or useful to the operation of a Smart Grid

Source: Table created for *Smart Grid: Enabler of the New Energy Economy* by ABB 2008.[41]

[41] *Energy Independence and Security Act of 2007*, HR 6, 110th Cong., *Congressional Record 153* (December 19, 2007): Doc. 110–140.

Table B-2. Smart Grid Technologies and Their Applicability under Title XIII

Technologies	Total checks	1304.(a).1 Sensors, Measuring	1304.(a).2 DR, DG, storage -> ancillary services	1304.(a).3 Wide-area measurement (WAM), control network, data mining, visualization,	1304.(a).4 Reliability technologies	1304.(a).5 Communication network cap	1304.(a).6 Transition to time-of-use and real-time pricing	1304.(a).7 Algorithms for transmission system software	1304.(a).8 Electric vehicle	1304.(a).9 Electricity stored in vehicles	1304.(b).1 Regional demo	1306.(b).1 Appliances to engage in Smart Grid (SG) functions	1306.(b).2 Motor and drive	1306.(b).3 T&D equipment fitted with smarts	1306.(b).4 Metering, sensors, control devices --> SG	1306.(b).5 Software enables devices and computer --> SG	1306.(b).6 Regional grid operations	1306.(b).7 Distributed generation (DG)	1306.(b).8 Electric or hybrid vehicles	1306.(b).9 Smarts by secretary	1306.(d).1 Metering	1306.(d).2 Communication	1306.(d).3 Reporting	1306.(d).4 Fault location, isolation, and restoration service (FLISR)	1306.(d).5 Security	1306.(d).6 Automatic control	1306.(d).7 Digitizing	1306.(d).8 Use digital control to manage grid	1306.(d).9 Catch all
		Title XIII Sections																											
		R&D and Demonstrations (50% match)										Investment Match (20% match)									Smart Grid Functions								
		18	9	26	34	2	12	10	2	1	0	6	1	11	29	27	9	4	2	1	15	11	16	27	3	27	15	26	1
Smart Grid Technologies																													
Enables Active Participation by Consumers																													
Smart meters	5	X					X								X						X	X							
Advanced metering infrastructure	7	X					X					X			X						X	X						X	
Upgrade existing automatic meter reading (AMR; one-way) technology to advanced metering infrastructure (AMI; two-ways)	7	X					X					X			X						X	X						X	
Programmable communicating thermostat	2						X																			X			
Smart Home software --> enable home owners to self-manage	3											X				X										X			
Home automation network interfaced with utility Smart Grid system	7	X					X								X						X	X	X			X			
Building/facility energy management system interfaced with market pricing signal and/or utility Smart Grid system	10	X	X				X								X	X					X	X	X			X		X	
Accommodates All Generation and Storage Options																													
Virtual utilities (integrated DG with load management)	5		X				X										X	X								X			
Plug-in hybrid electric vehicles	3								X	X									X										
Solar/wind generation	2		X															X											
Distributed energy resource management system (software to optimize DG and renewable energy operations)	5		X													X		X								X		X	
Energy storage devices/systems	2		X															X											
Enables New Products, Services, and Markets																													
Real-time/time-of-use pricing options design and research	2						X										X												
New market system (applying intelligent network feedbacks and consumer responses)	8			X	X		X	X							X		X										X	X	

Technologies		Title XIII Sections																											
		R&D and Demonstrations (50% match)										Investment Match (20% match)									Smart Grid Functions								
		1304.(a).1	1304.(a).2	1304.(a).3	1304.(a).4	1304.(a).5	1304.(a).6	1304.(a).7	1304.(a).8	1304.(a).9	1304.(b).1	1306.(b).1	1306.(b).2	1306.(b).3	1306.(b).4	1306.(b).5	1306.(b).6	1306.(b).7	1306.(b).8	1306.(b).9	1306.(d).1	1306.(d).2	1306.(d).3	1306.(d).4	1306.(d).5	1306.(d).6	1306.(d).7	1306.(d).8	1306.(d).9
	Total checks	Sensors, Measuring	DR, DG, storage -> ancillary services	Wide-area measurement (WAM), control network, data mining, visualization,	Reliability technologies	Communication network cap	Transition to time-of-use and real-time pricing	Algorithms for transmission system software	Electric vehicle	Electricity stored in vehicles	Regional demo	Appliances to engage in Smart Grid (SG) functions	Motor and drive	T&D equipment fitted with smarts	Metering, sensors, control devices --> SG	Software enables devices and computer --> SG	Regional grid operations	Distributed generation (DG)	Electric or hybrid vehicles	Smarts by secretary	Metering	Communication	Reporting	Fault location, isolation, and restoration service (FLISR)	Security	Automatic control	Digitizing	Use digital control to manage grid	Catch all
		18	**9**	**26**	**34**	**2**	**12**	**10**	**2**	**1**	**0**	**6**	**1**	**11**	**29**	**27**	**9**	**4**	**2**	**1**	**15**	**11**	**16**	**27**	**3**	**27**	**15**	**26**	**1**
Smart Grid Technologies																													
Demand response / load management program	7		X				X					X					X				X	X				X			
Appliances interface with utility Smart Grid system	1											X																	
Motor and drives interface with utility Smart Grid system	1												X																
Provides Power Quality for the Range of Needs in a Digital Economy																													
Smart sensors (sensors with communication and local smarts)	7	X												X	X						X	X		X			X		
Intelligent electronic devices (IEDs)	11	X												X	X	X					X	X	X	X		X	X	X	
Smart switches capable of communications	6			X										X	X									X		X	X		
Smart reclosers with communications capability	7			X	X									X	X									X		X	X		
Intelligent assets with built-in communications (smart transformer, breakers)	3													X												X	X		
Load tap changer on load tap changer (Tx) (voltage controls with communication cap)	8			X	X									X	X									X		X	X	X	
Add-on to distribution automation utilizing existing AMI communication infrastructure	6			X	X									X										X		X	X		
Smart feeder automation (microprocessor based with communication capability)	9	X		X	X			X							X	X								X		X	X		
Upgrade and replace existing electro-mechanical control system with microprocessor-based control system with communication capability	6				X									X	X									X		X	X		
Interconnection protocols (electric vehicles, storage)	4		X						X										X							X			
System interoperability adoption project	2																										X	X	
Optimizes Asset Utilization and Operating Efficiency																													
Condition-based monitoring/maintenance	3				X																		X					X	
Computerized maintenance management	5				X			X								X							X				X		
Advanced asset management software	4				X											X							X	X					

Technologies	Total checks	Title XIII Sections																											
		R&D and Demonstrations (50% match)										Investment Match (20% match)									Smart Grid Functions								
		1304.(a).1	1304.(a).2	1304.(a).3	1304.(a).4	1304.(a).5	1304.(a).6	1304.(a).7	1304.(a).8	1304.(a).9	1304.(b).1	1306.(b).1	1306.(b).2	1306.(b).3	1306.(b).4	1306.(b).5	1306.(b).6	1306.(b).7	1306.(b).8	1306.(b).9	1306.(d).1	1306.(d).2	1306.(d).3	1306.(d).4	1306.(d).5	1306.(d).6	1306.(d).7	1306.(d).8	1306.(d).9
		Sensors, Measuring	DR, DG, storage -> ancillary services	Wide-area measurement (WAM), control network, data mining, visualization,	Reliability technologies	Communication network cap	Transition to time-of-use and real-time pricing	Algorithms for transmission system software	Electric vehicle	Electricity stored in vehicles	Regional demo	Appliances to engage in Smart Grid (SG) functions	Motor and drive	T&D equipment fitted with smarts	Metering, sensors, control devices --> SG	Software enables devices and computer --> SG	Regional grid operations	Distributed generation (DG)	Electric or hybrid vehicles	Smarts by secretary	Metering	Communication	Reporting	Fault location, isolation, and restoration service (FLISR)	Security	Automatic control	Digitizing	Use digital control to manage grid	Catch all
		18	9	26	34	2	12	10	2	1	0	6	1	11	29	27	9	4	2	1	15	11	16	27	3	27	15	26	1
Smart Grid Technologies																													
Advanced outage avoidance and management	9			X	X			X								X	X						X	X	X	X			
Dynamic line rating to improve system reliability	9			X	X			X							X	X	X						X	X				X	
Transformer load management	6			X	X			X								X							X					X	
Grid simulator and modeler—a sandbox for what-if learning	7			X	X			X								X	X						X					X	
Flexible power flow control (FACTS, SVC, HVDC) to improve power grid performance under disturbances	8	X		X	X										X	X	X									X		X	
Process re-engineering using intelligent system	3				X															X									X
Addresses and Responds to System Disturbances in a Self-Healing Manner																													
Operation Centers																													
Optimized Volt/Var management system (algorithm with communication and controls)	7			X	X										X	X								X		X		X	
Integrated outage management system (OMS) and AMI	4			X	X											X								X					
Integrated OMS and work management system	3				X											X								X					
Outage damage assessment for restoration	6			X	X			X								X							X	X					
Distribution state estimator	5			X	X											X							X	X					
Fault location and analysis	5			X	X											X							X	X					
Fault management (reconfiguration and restoration)	4			X	X											X								X					
Wide area monitoring system (a system monitoring center with GPS-synchronized phasor measurement units)	13	X		X	X	X		X							X	X	X				X	X	X		X			X	
Load management	5		X	X											X											X		X	
Substation Automation																													
Substation automation solution with 61850 interoperable protocol	8			X		X									X	X					X	X				X		X	
Station equipment condition and reliability monitoring (with communication)	7			X	X										X	X					X		X					X	

Technologies	Total checks	Title XIII Sections																											
		R&D and Demonstrations (50% match)										Investment Match (20% match)									Smart Grid Functions								
		1304.(a).1	1304.(a).2	1304.(a).3	1304.(a).4	1304.(a).5	1304.(a).6	1304.(a).7	1304.(a).8	1304.(a).9	1304.(b).1	1306.(b).1	1306.(b).2	1306.(b).3	1306.(b).4	1306.(b).5	1306.(b).6	1306.(b).7	1306.(b).8	1306.(b).9	1306.(d).1	1306.(d).2	1306.(d).3	1306.(d).4	1306.(d).5	1306.(d).6	1306.(d).7	1306.(d).8	1306.(d).9
		Sensors, Measuring	DR, DG, storage -> ancillary services	Wide-area measurement (WAM), control network, data mining, visualization,	Reliability technologies	Communication network cap	Transition to time-of-use and real-time pricing	Algorithms for transmission system software	Electric vehicle	Electricity stored in vehicles	Regional demo	Appliances to engage in Smart Grid (SG) functions	Motor and drive	T&D equipment fitted with smarts	Metering, sensors, control devices --> SG	Software enables devices and computer --> SG	Regional grid operations	Distributed generation (DG)	Electric or hybrid vehicles	Smarts by secretary	Metering	Communication	Reporting	Fault location, isolation, and restoration service (FLISR)	Security	Automatic control	Digitizing	Use digital control to manage grid	Catch all
		18	9	26	34	2	12	10	2	1	0	6	1	11	29	27	9	4	2	1	15	11	16	27	3	27	15	26	1
Smart Grid Technologies																													
Fault indicators/recorders	5	X												X							X			X			X		
Feeder and Distribution Automation																													
Smart feeder automation (microprocessor based with communication capability)	10	X		X	X										X	X					X	X		X		X		X	
Feeder condition monitoring to improve reliability	6	X		X	X										X						X		X						
Automated adaptive relaying	6	X			X										X									X		X		X	
Feeder load transfer load/switch for demand response / load management	9	X	X	X			X								X	X					X					X		X	
Automated feeder reconfiguration for loss reduction, overload relief	7	X		X	X										X									X		X		X	
Feeder fault detection and diagnostics	7	X		X	X										X	X								X				X	
Feeder equipment failure detection	5	X			X										X									X				X	
Voltage regulator with communication capability	7				X									X	X									X		X	X	X	
Capacitor control with communication capability	7				X									X	X									X		X	X	X	
Operates Resiliently Against Physical and Cyber Attacks and Natural Disasters																													
Cyber-security and data integrity	4				X							X				X									X				
Weather prediction and storm damage forecast and OMS	4				X			X								X								X					

Source: Table created for *Smart Grid: Enabler of the New Energy Economy* by ABB 2008.

Electricity Advisory Committee
http://www.oe.energy.gov/eac.htm

Smart Grid and the Consumer

The Benefits of Smart Grid to the Consumer:

- **Increases information to consumer**
  - Two way communications between utilities and consumers benefits both parties.
    - *Consumers*: In-home energy usage displays will allow consumers to monitor their electricity usage, when they use it, and how much it costs. Consumer programs will accommodate the highly involved, technologically aware user as well as the technophobe.
    - *Utilities*: "Customer participation" will help energy providers balance peak loads, which will increase reliability and decrease cost.
  - Smarter appliances are being developed that will soon be available in the market.
    - Consumers will 'communicate' with their home appliances to enable efficient energy management.
    - Intelligent appliances will be able to communicate with the grid as well – $600 million in smart appliances can offset as much reserve capacity as $6 billion worth of power plants(1).
  - Industry groups are researching consumer needs, priorities, and expectations.
    - GridWise Alliance Consumer Engagement SubGroup
    - Smart Grid Consumer Collaborative

- **Allows for consumer participation and choice**
  - Consumers will be able to choose when and how they use their energy.
    - Advanced Metering Infrastructure (AMI) will provide consumers with the tools to use power at off-peak times resulting in a lower rate per kilowatt hour(2).
    - Consumers can increase the benefits by easily changing energy use habits like switching to energy efficient lighting, raising the temperature of their thermostats and refrigerators and running wash cycles late at night or early in the morning.
  - Baltimore Gas & Electric PEAKRewards Program from 2009(3) shows positive response from consumers.
    - Customers responded emphatically to pricing signals, thereby reducing consumption by 1/4 to 1/3.
    - More than 98% reduced their bills, in all socio-demographic groups.
    - Customer satisfaction of the program was 92% - 99%.
  - Still...more consumer-friendly smart grid education is needed.
    - 79% of U.S. consumers polled in a March 2010 survey by GE said they are not familiar with the term "smart grid."
    - Only 4% said they have heard of a smart grid and have a good understanding of what it is.
    - 80% of those familiar with smart grid wish they knew more about how it affects them(4).

- **Reduces cost**
  - A smarter electric system will reduce costs at each level of the grid.
    - *Generation*: Command, control, and communications technologies will enable more efficient energy production and lessen the need for additional peaking power plants—those plants built to handle peak demands thats are used primarily when energy costs are highest(5).
    - *Transmission and Distribution*: Distributed generation, which allows for greater variety of energy options including renewables, can increase grid efficiency by reducing line loss and power shortages due to lack of transmission capacity. Costs of transmission inefficiencies to residential and commercial customers are estimated at $4.8 billion annually(1).
    - *Consumption*: More empowered consumers will have access to the information and tools to reduce their monthly bills.

- There is a need for consumer awareness of system-wide benefits
    - The majority of savings will occur outside the home as utilities and energy generators reduce costs. There will be a need to increase public awareness on how this will positively affect end-users.

- **Provides environmental value**
    - A smart grid will enable the integration of energy produced from renewable sources.
    - Studies show that majority of Americans value a cleaner planet.
        - In a 2009 Oracle study, 80% of general population respondents noted that preserving the environment was important to them[(6)].
        - An April 2010, Gallup Poll, found that 61% of Americans are either active or sympathetic to the greener environment movement[(7)].
    - In a 2009 Pacific Northwest National Laboratory Study, it was found that smart grid technologies and communications advancements on the national electricity grid will reduce CO2 emissions by 12% directly and 6% indirectly[(8)].

- **Engages consumers in their energy usage though technology**
    - Utilities will communicate with their customers on the usage and implications of smart grid technologies.
        - 70 percent of the 5,000 respondents in a 2008 IBM study expressed willingness to experiment with how they interact with energy providers and would take advantage of partnerships different from traditional utility-customer relationship[(9)].
            - Customer service representatives will be asked to become well versed in their utility's smart grid activities to answer customer inquiries.
    - Smart Grid technologies must be made simple enough for all users.
        - In 2009, Steven Chu, Secretary, Department of Energy, stated that a 3-step, simple energy management tool is essential to wide-spread consumer adoption.
        - Today's teenagers – the next generation of energy customers – will have constant connectivity to all parts of their lives. Enabling the effortless management of their energy use through technological tools will be vital.

Resources:

1. Department of Energy; Consumer Advocates, Smart Grid Stakeholder Books; 2009
2. Department of Energy; The Smart Grid: An Introduction; 2008
3. Baltimore Gas & Electric; Smart Grid: Powering Our Future, Delivering Value to Consumers; 2009
4. GE Energy; Americans Feel a Smart Grid Will Help Reduce Power Outages, Personal Energy Usage; 2010
5. GridWise Alliance; And Then There Was...Light; 2008
6. Oracle; Turning Information Into Power Moving Toward the Smart Grid; 2009
7. Gallup; On 40th Earth Day, Image of Green Movement Still Positive; 2010
8. Pacific Northwest National Laboratory; The Smart Grid: An Estimation of the Energy and CO2 Benefits; 2009
9. Global Utility Consumer Survey; Lighting the Way: Understanding the Smart Energy Consumer; 2008
10. GridWise Alliance, www.gridwise.org

GWA Principles on Interoperability and Cybersecurity

PREAMBLE:

The electricity industry is essential to all sectors of our nation's economic life, more so now than ever before. From smart meters to smart appliances to more intelligent control of distribution, transmission, and generation, smart grid offers the potential of improved utilization of all generation and storage resources, increased operational efficiency and reliability, and enhanced opportunity for customers to make choices about energy use. A more interconnected, automated, and information-rich electric delivery system also provides an opportunity to deliver a safe and reliable interoperation of a complex electric grid, and to mitigate threats to the grid from accidental and intentional harm. The GridWise Alliance believes that with sound planning; thorough design; and smart execution, safe; secure; and reliable smart grid can be achieved. The key principles endorsed by the Alliance for interoperability and cybersecurity are outlined below.

PRINCIPLES:

Interoperability:

1. **GridWise Alliance endorses the key principles of interoperability expressed by the GridWise Architecture Council's (GWAC) Interoperability Constitution White Paper.**

   The GWAC Interoperability Constitution focuses on key principles in five areas, summarized as follows:

   Business – Interoperability approaches should enable the interchange of information necessary to facilitate effective business transactions.

   Usability – Interoperability approaches should empower customers to choose an electric commercial program on the basis of well-understood parameters.

   Information Technology – Interoperability strategies must be based on industry best practices, be practical, scalable, and broad enough to meet a range of business needs, and capable of evolving as technology evolves.

   Regulatory – Interoperability approaches must be understandable by and provide an effective framework for applicable regulatory bodies.

   Governance – Interoperability standards must leverage existing work, encourage the development of new standards to fill any gaps, and be capable of being corrected, updated, and clarified based on industry feedback and agreement as the needs of the grid grow and change.

   The complete GWAC Interoperability Constitution White Paper should be referenced for details regarding each of the areas of principle (www.gridwiseac.org).

2. **GridWise Alliance believes that interoperability is critical to enabling interconnection and reliability of operation in smart grid, both now and in the future.** As smart grid evolves and interconnects more points in the network, interoperability is an essential factor in driving innovation, increasing business value and enabling greater functionality.

3. **GridWise Alliance believes that interoperability-related standards need to be established to ensure consistent compliance and security review.** GridWise Alliance members support the process being coordinated by NIST, along with standards development underway at various standards organizations, to create the necessary standards framework for a secure and interoperable smart grid.

4. **GridWise Alliance believes that in order to fully enable smart grid, new equipment is needed to make the most effective use of increased information, communication, and control capabilities.** Interoperability-related standards are key to enabling manufacturers to develop and market new grid management technologies that can integrate with other new, as well as existing devices. As smart grid evolves, on-going development and maintenance of industry standards is required to ensure interoperability.

5. **GridWise Alliance believes that smart grid stakeholders should use appropriate system and energy usage information in ways that enable coordinated grid response, reconfiguration and self-healing.** Interoperable smart grids will require access to a variety of information sources for optimal, safe, and reliable operations.

6. **Gridwise Alliance believes that open standards and protocols are critical to foster innovation.** The US should avoid mandating specific technologies that could hinder technological development and global competitiveness. Clear and open standards will help to ensure that all innovative and compliant smart grid technologies will be able to interoperate within the system. A well-supported framework for conformity testing and certification of smart grid technologies will be key to successful implementation.

Cybersecurity:

1. **GridWise Alliance believes that dialog and coordination among all stakeholders is essential to developing a secure and interoperable smart grid.** Ongoing dialog and coordination is essential to developing a secure and interoperable smart grid. GridWise Alliance members support the process being coordinated by NIST along with standards development underway at various standards organizations as an appropriate means to achieve the necessary framework of standards for a secure and interoperable smart grid. Additionally, GridWise Alliance members support the work being done at NERC and within such collaborations as the DOE Roadmap to Secure Control Systems and the DHS Industrial Control System Joint Working Group. Establishing new processes outside of the existing framework could result in competition with existing processes for resources, an increased number of gaps and conflicts, confusion regarding the direction and specifics of requirements and potentially result in less timely, less robust or inferior outcomes.

2. **GridWise Alliance believes in a risk management approach that focuses on protecting the functions of the electric power system.** All smart grid projects must consider a risk-based approach to selecting and implementing security controls that provide effective and cost-effective security commensurate with potential impacts to safe and reliable power system operations.

3. **GridWise Alliance believes that smart grid component manufacturers (hardware and software) should apply sound security processes in design and development to minimize the risk and severity of vulnerabilities in their products and services.** Smart grid components will be in service for many years and subject to threats that could not be imagined at design time. It is critical that smart grid providers plan for addressing security requirements throughout the lifecycle of the system.

4. **GridWise Alliance believes that smart grid service providers (including utilities) have an important role to implement operational security procedures across their environment.** The interconnected nature of power systems requires that each and every smart grid service provider recognize the potential for intentional or unintentional misuse of their systems and take steps to guard against such misuse, whether by third-party adversaries or their own employees.

5. **GridWise Alliance believes that existing facility, hardware, and software features and practices should be leveraged and built upon as part of the approach to securing a smart grid.** The grid itself, to a greater extent than many other infrastructures, has additional methods of coping with events of different geographic size, severity and scope. These existing features, such as special protection features or operating modes, mobile generators and transformers, and excess capacity for large portions of the year or day, will provide a secure baseline. Enhancing that baseline further through smart grid functionality, such as anti-cascading and tie line protection, islanding capabilities, and automated "life line service", will add further security to the grid.

6. **GridWise Alliance believes that the concept of "defense in depth" should be employed in any approach to securing a smart grid. "**Defense in depth" is an industry concept that insists upon incorporating layers of security, a combination of requirements that provide a reasonable assurance of sufficient protection. In this scheme, if a single security element fails, a backup or redundant requirement provides a secondary level of protection. It is implicit that the collaboration of multiple entities is necessary to achieve this concept; the applicable use of existing legacy equipment is also equally essential.

7. **GridWise Alliance believes that measures intended to assure customer privacy, access to energy usage information, and cybersecurity access to data information must be balanced against operational and planning needs of the power system, in order to assure that the reliability, performance and integrity of the entire grid is preserved.** For example, the need for customer privacy cannot override the legitimate need for utilities to assess the different ways that new types of loads and/or power sources could impact the overall system. Access to data may be critical to help grid operators plan and operate the system safely and reliably, accounting for evolving load and distributed source characteristics and growth. Similarly, cybersecurity features, such as cryptography for data transfers, cannot be allowed to create latencies that would interfere with the intended and necessary operational use of the data. All measures added for privacy and/or cybersecurity must be viewed in the context of their own relative risk to the system, such as added complexity, performance and reliability impacts, or outages required for cybersecurity upgrades. Addressing cyber security concerns and physically securing the power system from other threats must be considered equally important.

GridWise Alliance
Senate Energy and Climate Priorities

The following are priorities that our coalition believes would move smart grid forward, enabling the grid to become more reliable, efficient, and clean.

AUTHORIZATION PROVISIONS

CLEAN ENERGY DEPLOYMENT ADMINISTRATION
GridWise Alliance supports the CEDA provision that will include smart grid investments as part of the technologies applicable for the financing mechanism.
[Relevant legislation: ACELA]

RENEWABLE AND EFFICIENCY STANDARD
GridWise Alliance supports including reduced line losses in the definition of energy efficiency.
[Relevant legislation: ACELA]

ELECTRIC VEHICLES
GridWise Alliance supports inclusion of smart grid interoperability and smart grid charging infrastructure in an electric vehicle provision.
[Relevant legislation: ACELA and Electric Vehicle Deployment Act S. 3495]

CONSUMER ACCESS
GridWise Alliance supports inclusion of consumer access provision in energy bill.
[Relevant legislation: Electric Consumer Right to Know Act, S. 3487]

TRANSMISSION SITING
GridWise Alliance supports inclusion of smart grid and reduced transmission line losses in transmission siting process.
[Relevant legislation: ACELA]

CLEAN ENERGY RESEARCH AND DEVELOPMENT
GridWise Alliance supports inclusion of smart grid research and development funded by climate allowances.
[Relevant legislation: America Power Act]

ENERGY STORAGE
GridWise Alliance supports enabling legislation to create a federal/state joint board, made up of federal and state regulators to address key regulatory reforms needed to jump start deployment of energy storage devices including plug in hybrid electric vehicles, fly-wheel technology and energy storage devices that support use of renewable generation on the grid.
[Legislative precedent: an existing provision in the original Federal Power Act of 1935 allows for the seating of Joint Boards made up of the Federal Energy Regulatory Commission and the states to address regulatory issues which overlap federal and state jurisdiction. In the Energy Policy Act of 2005 Congress called for the creation of a Joint Board to address a review of dispatch policies associated with electric generation. Congress could, at no cost, call for the creation of a targeted FERC/state joint board to address key impediments to the deployment of energy storage technology. Enabling legislation may be introduced soon on this topic which could then be joined with overall energy legislation.]

TAX PROVISIONS

BONUS DEPRECIATION
GridWise Alliance supports the extension of the bonus depreciation provision.
[Relevant legislative language: Extend provision in PL110-185, Section 103, SPECIAL ALLOWANCE FOR CERTAIN PROPERTY ACQUIRED DURING 2008, to expire January 1, 2011 instead of 2010.]

ACCELERATED DEPRECIATION
GridWise Alliance supports reducing applicable recovery periods for smart grid equipment, including smart grid charging infrastructure for electric vehicles to five years.
[Relevant legislation: S 2854 for extension and modification of charging infrastructure credit; Relevant legislative language for other smart grid equipment:

FIVE-YEAR APPLICABLE RECOVERY PERIOD FOR DEPRECIATION OF QUALIFIED ENERGY MANAGEMENT DEVICES.

(a) In General- Section 168(e)(3)(B) (defining 5-year property) is amended by striking `and' at the end of clause (v), by striking the period at the end of clause (vi)(III) and inserting `, and', and by inserting after clause (vi) the following new clause: (vii) any qualified energy management device.'.
(b) Definition of Qualified Energy Management Device- Section 168(i) (relating to definitions and special rules) is amended by inserting at the end the following new paragraph:
(18) QUALIFIED ENERGY MANAGEMENT DEVICE-
(A) IN GENERAL- The term `qualified energy management device' means any energy management device which is placed in service before January 1, 2012, by a taxpayer who is a supplier of electric energy or a provider of electric energy services.
(B) ENERGY MANAGEMENT DEVICE- For purposes of subparagraph (A), the term `energy management device' means any two-way communications network and associated equipment, including equipment installed on the premises of a consumer, which is used by the taxpayer--
(i) to measure and record electricity usage data on a time-differentiated basis of at least 15 minutes, and
(ii) to provide such data on demand to both consumers and the taxpayer.'.]

HOMESTAR
GridWise Alliance supports including Home Energy Management Systems (HEMS) tax credits for homeowners.
[Relevant definition for legislative language:

Home Energy Management Systems (HEMS) is a computer based system that is installed in a home and uses a combination of display technology, computer software, control equipment, sensors, and instrumentation to monitor and manage the energy use of a home.

Home Area Network (HAN): -- The term “Home Area Network” means a wireless (RF) or wired (PLC) based network that connects the HEMS device to smart meters and various smart energy devices. The HAN enable simultaneous networking of multiple sensors and embedded computing devices that monitor and adjust electricity use.]

ENERGY STORAGE
GridWise Alliance supports including energy storage tax incentives in energy bill.
[Relevant legislation: Wyden Bill, S 1091]

GridWise Alliance
Smart Grid State Regulatory & Legislative Policies

Each state has a different composition of retail customers and energy providers which will drive the functionality framework for the state. Many states have customer segments that are split roughly 1/3 residential, 1/3 commercial and 1/3 industrial (based upon sales volume). In some states however, the split can be very different: e.g., Florida's segments are split 51% residential, 41% commercial, and 8% industrial, whereas, Wyoming's segments are split 17% residential, 27% commercial, and 56% industrial.[1]

Some states have only municipalities or cooperatives providing electricity to end-users; while other states have some combination of investor-owned utilities, energy retailers, municipalities and cooperatives. State utility regulators have very specific jurisdictional authority over the load-serving entities who serve retail customers (including industrial, commercial, residential, and government segments). State regulators oversee the electric system, including power generation, transmission, and distribution to retail customers.

When considering "smart grid" improvements, state policymakers should consider functionality, applicability, and cost recovery.

A) Functional Elements

The jurisdictional scope states possess requires a robust review of the functional elements of a "smart grid" The functional elements include a broader holistic view of the "smart gird" that can be adopted by state policymakers, instead of focusing on the meter as the primary "smart grid" enabler,. States should evaluate and determine the technical functional elements, regulatory policies and technology enablers of a "smart grid" that balances the needs and interests of all stakeholders.

"Smart grid" enablers exist to:

- increase utility operating efficiency and access to various types of power production and renewable resources;

[1] 2007 data from http://www.eia.doe.gov/cneaf/electricity/epa/epa_sprdshts.html.

- increase the reliability of the transmission and distribution grids;
- and provide retail consumers sufficient data and information to make informed choices.[2]

The GridWise Alliance has worked extensively with the Department of Energy ("DOE") and strongly endorses the definition and use of the seven characteristics description of a "smart grid". Vast literature and informational resources are available at the DOE website, www.oe.energy.gov/smartgrid.htm.

GridWise Alliance recommends state policymakers develop and publish a broad set of "smart grid" approaches for each respective state. The "smart grid" design needs to establish functional elements with state-appropriate additional functionality. Functional elements provide the basis for enhancing operations and system interoperability[3], as well as choices for consumers.

A sufficiently robust design of the "smart grid" that is viewed across the value-chain, allows for customer-based applications while widely deploying a flexible infrastructure to allow the electricity grid to adapt to future needs. Discussions on specific "smart grid" designs need to include categories that encompass a variety of electric infrastructure assets, new and existing information and systems technologies, technologies that allow for open and transparent data exchanges and systems that protect cyber and physical assets. The GridWise Alliance

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[2] Of particular note, the GridWise Alliance supports the DOE enabling characteristic for consumers, which is empowerment and consumer choice. Critical to smart grid deployment is empowering consumers with knowledge and the ability to change their consumption behavior based upon the balance of consumer and electric system benefits.

Additionally, many resources and tools are available for state policy makers to assist them with evaluating their options, including the Melon document (need name and electronic site).

[3] When building "smart grid" designs, state policymakers must accommodate interoperability standards and protocols developed by the National Institute of Standards and Technology ("NIST") and the IEEE. The GridWise Alliance cautions that when state policymakers adopt these standards and protocols, policymakers resist supplemental standards and operating requirements. Due to the extensive, open, and transparent vetting process NIST and IEEE developed the standards and protocols, additional ancillary requirements potentially impact reliability improvements and efficiencies being sought across regions.

encourages state policymakers to give industry and consumers a sense of the types of technologies, equipment, and policies the state deems appropriate.

Pervasive connectivity to sensors, substations, switches and meters are critical to transforming the grid into a two-way network of both electricity and information. Robust communication networks that accomplish this task include commercial networks, private networks, and shared networks with public safety agencies. Load-serving entities, regardless of their business model, will make prudent investments and purchases in “smart grid” enabling technologies and services when regulatory rules and regulations are known in advance of the investment. Furthermore, when the state conveys its construct/expectations, then consumers will also have an unbiased resource in which to evaluate their own individual purchasing decisions.

B) Applicability

When state policymakers establish their respective “smart grid” designs, GridWise Alliance also recommends states present policies that would frame their expectations on the eligibility and applicability of “smart grid” projects. For instance, some projects may be designed for a class of customers (e.g., residential, commercial), for a geographic region (e.g., city, county, educational campus, military base), or for a service territory-wide mass market. The GridWise Alliance recommends state policymakers provide an illustrative example whereby under certain circumstances, a “pilot” project or a system-wide adoption of smart grid technologies would be deemed in the public interest.

To the extent Federal or state funding is or has been made available to spur “smart grid” investments, the GridWise Alliance encourages states avoid using the success of the award as a threshold determination that the project is viable. Non-receipt of an award is not an interpretation that a project is an inferior program. Rather, many solid and well thought-out programs do not qualify to receive awards. The GridWise Alliance believes strongly that the public interest can be served by implementing smart grid projects based on potential savings to consumers, increased reliability, enhanced security, and a cleaner, more efficient electric system.

C) Cost recovery

One of the more critical components to the “smart grid” is a clear path to cost recovery. Significant investment is needed during all phases of the “smart grid” value chain and consumers will see direct (e.g., quicker response to outages) and indirect (e.g., reliable operations of the transmission grid) benefits to these investments. State policymakers should affirm their beliefs that prudently incurred costs for the “smart grid” will result for utilities in the recovery of and on their investments in technologies, and purchases of services and capabilities. When utilities have this clear expectation, they can secure the appropriate funding to purchase new technologies, services and assets to support the “smart grid”.

Many different forms of cost-recovery mechanisms exist; however, some are more time-consuming than others. For instance, cost trackers, tariff riders, and single-issue rate cases can effectively sync cost recovery with capital investment. These types of mechanisms typically include a true-up mechanism and further reporting requirements that give regulators the ability to evaluate the justness and reasonableness of the actual investment against the projected investment. Full-scale rate cases typically take months to complete as all investments and expenses incurred by a utility are reviewed. After the full-scale rate case, utilities may still have to wait additional time before the rates and the “smart grid” program become effective. Therefore, the GridWise Alliance recommends states allow for the trackers, riders, and single-issue rate cases to advance the deployment of “smart grid” technologies expeditiously. Since the paths to a smarter grid are inherently long-term in nature, the GridWise Alliance also encourages states to explore long-term financing options such as regulatory assets (*i.e.*, allowing for deferred cost recovery) or securitization (*i.e.*, the issuance of long-term bonds against revenues collected from specific smart grid programs) which have been used by state commissions for stranded cost recovery, environmental remediation, and storm cost recovery.

Smart Grid and Workforce

We are at a perfect storm of technology advances for the electric grid, funds for training and deployment, and a need for our workforce to find stable, meaningful, and long-term jobs. Smart grid jobs could help our country to become more competitive and skilled while making our grid more stable and intelligent.

Aging Utility Workforce
A survey by the Center for Energy Workforce Development (www.cewd.org), a consortium of electric, natural gas and nuclear energy utilities, found in 2008 that within five years, the industry may need to replace 40-50% of its employees in five areas with up to 60% replacement in some areas. The five areas were: lineworkers, power plant operators, technicians, pipefitters/pipelayers, and both generation and transmission and distribution engineers. These areas comprise both craft and non-union employees.

Smart Grid Jobs Potential
A GridWise Alliance analysis of smart grid jobs potential and found that with a large stimulus investment, over 200,000 jobs could be created in the first three years alone. These employees include direct utility smart grid jobs, contractors, direct and indirect suppliers, and energy service companies.

Workforce Funding
The Recovery Act provided significant funding for workforce development. In the Department of Energy (DOE) smart grid program, $100 million was awarded smart grid training, education, and workforce development efforts at universities, community colleges, tech schools, training centers (http://www.energy.gov/news/documents/04-08-2010_SG_Workforce_Selections.pdf). The Department of Labor (DOL) green jobs program has awarded $500 million in grants, some of which gave gone to smart grid training in local settings. In addition, DOL has issued $3.5 billion in formula grants across the public workforce system to augment ongoing operations in high growth areas to help meet employers' needs. Additional information about the DOL Recovery Act Investments can be found at http://www.dol.gov/recovery/.

The Department of Education is also involved in preparing the workforce in their K-12 programs.

Resources

IEEE USA Career and Workforce Policy Committee:
http://www.ieeeusa.org/volunteers/committees/cwpc/index.html

National system of One Stop Career Centers: http://www.careeronestop.org/

State-by-state link for job listings is: http://www.careeronestop.org/JobSearch/COS_jobsites.aspx

Interagency Network of Enterprise Assistance Providers (INEAP):
https://www.ineap.nist.gov/ineap/resource.ineap?id=read&noteID=93A

Federal job openings: http://www.usa.jobs

Military transition jobs can be found at: http://www.careeronestop.org/militarytransition/

Veterans Green Jobs Academy: http://veteransgreenjobs.org/green-jobs-training/training-programs

Smart Grid program jobs at the Department of Energy: http://www.oe.energy.gov/

Department of Commerce National Institute of Standards and Technology positions:
http://www.nist.gov/hrmd/staffing/applyingforjobs.htm

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Smart Grid's U.S. Demand Reduction Capacity:
A New Way to Look at Generation

Smart grid is increasingly recognized in the United States as a key enabler of carbon reduction strategies through its ability to safely and securely integrate new, and increasingly cost-effective, technologies into the bulk power and delivery systems. Technologies such as large–scale, intermittent and lower carbon renewable generation smaller-scale distributed generation, energy storage (e.g., flywheels, batteries), as well as the use of plug-in electric vehicles all must be integrated and manageable by the utility for these technologies to become a reality.

Modernization of the electric power grid has been identified as a national policy[i] and is expected to be the required connecting backbone of our energy future. Initial smart grid projects have also demonstrated the ability for advanced electric automation to curb our existing power demand through consumer empowerment and access to more timely consumption information.

Smart grid technologies enable improved communication between consumers and their utility that can provide customers an ability to understand, in near real–time, how they are using energy and how their decisions on applying energy efficiency and demand side technologies will reduce their energy costs. The emerging track record of proven reductions in power demand from the application of smart grid technologies and systems has critical implications to our nation's supply of electric power generation and power grid reliability.

While demand response, energy efficiency, and grid optimization can be implemented individually, smart grid technologies can greatly enhance their integration to make the entire system more efficient.

Smart Demand Response

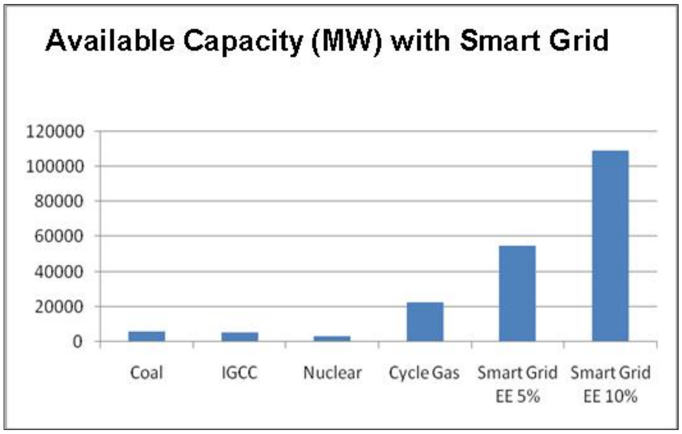
In an effort to quantify the supply-side benefits of a smarter grid, the GridWise Alliance has recently compared the cost of constructing new coal, integrated gasification combined cycle, nuclear, and combined cycle gas power plants, to the cost of reducing peak demand through the application of smart grid technologies. This analysis looks at the return on investment for developing a smarter grid to meet our growing energy needs, compared with the investment needed to build a variety of new, base-load power plants to meet those same power needs.

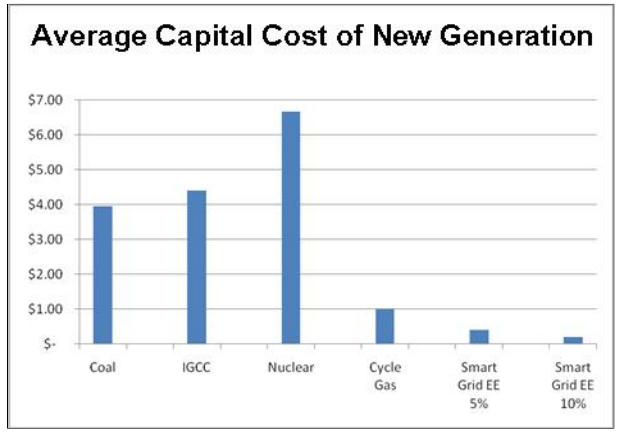
Smart grid technologies, if deployed on a national level, have been estimated to cost between $15 and $30 billion dollars. Utilities are finding, however, that investing in smart grid can greatly offset the cost of building additional generation. Baltimore Gas and Electric has determined that with $165/kW invested in energy efficiency and smart grid, they can avoid $1000/kW in costs from building a natural gas peaking plant[ii]. This is just one example of a growing number of energy efficiency and demand reduction applications that capitalizes on the economic savings potential of the smart grid.

For this analysis, two levels of peak demand reduction are considered: 5% and 10%. These reduction levels are considered against how much capacity would be made available under these two scenarios. This capacity is then compared to the various forms of new generation made available with the same investment required to build out the smart grid, approximately $22.5B.

The available capacity was then divided by the estimated average cost to deploy a smart grid to produce a per megawatt cost for the smart grid, which can be compared to the construction of new generation on a per megawatt basis. This comparison is not meant to indicate that smart grid and efficiency could replace production investment, but that the relative cost is significantly lower.

Coal[iii]	IGCC	Nuclear	Cycle Gas	Smart Grid EE 5%[iv]	Smart Grid EE 10%
$3.95	$4.40	$6.65	$1	$0.41	$0.21





These graphs compare capacity made available through smart grid and efficiency as well as the relative cost associated with investment in smart grid and power plant production. This comparison is meant to illustrate the importance of including smart grid and energy efficiency in the system planning process from both cost and capacity perspectives.

Grid Optimization

Grid optimization refers to technologies that enhance the efficiency of the electric transmission and distribution system. Typically 5 percent to 7 percent of energy is lost during transmission, distribution, and use. Grid optimization could halve those losses by managing the system to optimize distribution and lower the need for new generation.

These technologies also optimize the actual load by dynamically regulating voltage based on system conditions. These capabilities provide immediate benefits in reduced generation and carbon emissions but will also be critical in managing two-way power flow in an optimal manner as an increasing number of distributed energy sources are integrated into the electric system. **The use of a smart grid would help to mitigate these risks as it can optimize the entire electric distribution system by 3% to 5% [v]without a reliance on the customer changing behavior**.

Distribution System Demand Response

By using smart grid technologies, a utility can deliver the power that is needed when it is needed, maximizing productivity and efficiency. Reducing electrical losses with sensors and capacitors is known as VAr optimization. When voltage and VAr control are combined, efficiency is compounded**. If installed on 10% of the distribution feeders in the US, electric consumption could be reduced by 9.3 billion kWh per year, or the CO2 emissions equivalent of taking 1.1 million cars off the road**.[vi] Progress Energy in their docket in North Carolina estimates with this volt/VAr technology they can call 247 megawatts of efficiency on the distribution system without consumer demand response, avoiding the use of a peaking power plant to meet their peak demand.[vii]

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[i] Energy Independence and Security Act, 2007
[ii] BGE PeakRewards Program[SM], December 3, 2009
[iii] Lazard Levelized Cost of Energy Analysis, Version 2.0, June 2008.
[iv] Ambient Corporation projections for smart grid on demand side, 2009.

[v] Data based on California Energy Commission Public Interest Energy Research Final Project Report *'California Energy Commission on the Value of Distribution Automation'* at 75,89 (Apr. 2007) and R.W. Beck for Northwest Energy Efficiency Alliance, '*Distribution Efficiency Initiative',* at E-1, 5-2 (Dec 2007).
[vi] GE website http://www.itsyoursmartgrid.com/solutions/reducing_waste.html
[vii] Progress Energy Proposed Distribution System Demand Response Program, Docket No. E-2, Sub 926, April 29, 2008.