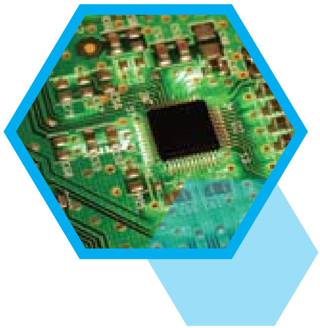
ONE *of* **SIX** SMART GRID **STAKEHOLDER BOOKS**

WHAT THE SMART GRID MEANS TO AMERICA'S FUTURE.

A smarter grid requires the participation of those who can deliver technology solutions to assist utilities and engage consumers.



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Your stake as a technology professional.

PRINTED IN THE UNITED STATES OF AMERICA.

PREFACE

The U.S. Department of Energy (DOE) is charged under the Energy Independence and Security Act of 2007 (EISA 2007) with modernizing the nation's electricity grid to improve its reliability and efficiency. As part of this effort, DOE is also responsible for increasing awareness of our nation's Smart Grid. Building upon *The Smart Grid: An Introduction*, a DOE-sponsored publication released in 2008 and available online at www.smartgrid.gov, this publication is one in a series of books designed to better acquaint discrete stakeholder groups with the promise and possibilities of the Smart Grid. Stakeholder groups include Utilities, Regulators, Policymakers, Technology Providers, Consumer Advocates and Environmental Groups.

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Nationwide, demand for electricity is expected to grow 30% by 2030. Electricity prices are forecast to increase 50% over the next 7 years.

OUR ELECTRIC GRID: **AN INFRASTRUCTURE IN SEARCH OF SOLUTIONS.**

TITLE XIII – SEC. 1301. STATEMENT OF POLICY ON MODERNIZATION OF THE 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 and achieve the goals that together define a Smart Grid.

Remember the telecommunications industry circa 1980? The phone booth was a ubiquitous feature of the American landscape, a stationary symbol of an industry legendary for its reliability. Back then, about the only way to make a phone "portable" was to pull it out of the wall. Innovation – to the extent it could be called innovation – went by the name of something called a "Princess phone." And customer choice was a matter of what weekend you chose to make that slightly cheaper long-distance call to the relatives.

Once telecommunications was transformed, significant changes occurred. Communications became digitized, markets were made, innovation encouraged and a new era of customer choice inaugurated.

The potential exists for similar transformation and opportunity in the provision of electricity embodied in a concept known as the Smart Grid. The Smart Grid is defined as the system that delivers electricity from suppliers to consumers using digital technology to save energy, reduce cost, and increase reliability and transparency. Like the telecommunications and Internet revolutions that preceded it, technology holds the key to the Smart Grid and its realization. This essential set of investments will help bring our electric grid into the 21st century using megabytes of data to move megawatts of electricity more efficiently, reliably and affordably. In the process, our nation's electric system will move from a centralized, producer-controlled network to a less centralized, more consumer-interactive model.

Far more than "smart meters," a fully functioning Smart Grid will feature sensors throughout the transmission and distribution grid to collect data, real-time two-way communications to move that data and electricity between utilities and consumers, and the computing power necessary to make that intelligence actionable and transactive. Indeed, only by bringing the tools, techniques and technologies that enabled the Internet to the utility and the electric grid is such a transformation possible.

SMARTER GRID / SMART GRID

Because it is deploying now, yet will only be fully realized over time, it is necessary to split one Smart Grid into two for the purpose of discussion: A smarter grid refers to the current state of the transformation, one in which technologies are being deployed today or in the near future. The Smart Grid is the ultimate vision – the full realization of everything it can be.

TIME IS OF THE ESSENCE

We literally cannot afford the grid as it stands. The costs of new generation and delivery infrastructure are climbing sharply. According to The Brattle Group – a consulting group that specializes in economics, finance, and regulation – investments totaling approximately $1.5 trillion will be required over the next 20 years to pay for the infrastructure alone.

Nationwide, demand for electricity is expected to grow 30% by 2030, according to the Energy Information Administration's Energy Outlook 2009.

Electricity prices are forecast to increase 50% over the next 7 years.[1]

Spiraling electricity rates and the cost of carbon (to be fully ascertained through the outcome of proposed cap-and-trade legislation) are combining to reveal the true – i.e., higher – cost of energy.

In 2007, the last year statistics were available, power plants in the United States emitted 2,500 million metric tons of carbon dioxide; total CO_2 emissions nationwide were 6,022 million metric tons, 75.9 million more than in 2006.[2]

At the same time, a sea change is occurring on the customer side of the meter. Research is incomplete as to how much control over their energy choices customers ultimately will seek to exercise. Yet their awareness has been heightened by projects large and small, from the proliferation of Advanced Metering Infrastructure (AMI) projects to high-profile developments in states such as Texas, California, Colorado and Hawaii. And if their recent telecommunications history is any guide, customers will be demanding more control rather than less. Just tell them what they're paying for and how they might be able to pay less and watch what happens. In addition, recent polls indicate that 75% of Americans support federal controls on the release of greenhouse gases in an effort to reduce global warming, 54% "strongly." Even among those who are "very" concerned about the cost impact, two-thirds support the regulation.[3]

THE SIZE OF THE OPPORTUNITY

Compared with other industries, our electrical grid has been largely bypassed by technological innovation until relatively recently, owing to the fact that historically it has been heavily regulated and modeled to keep the lights on and costs low. Partly for this reason, its modernization by means of

THE ELEMENTS OF TITLE XIII

(1) Increased use of digital information and controls technology.

(2) Optimization of grid operations and resources, with full cyber-security.

(3) Deployment and integration of distributed resources and generation, including renewable resources.

(4) Incorporation of demand response, demand-side resources, and energy-efficiency resources.

(5) Deployment of 'smart' technologies for metering, communications concerning grid operations and status, and distribution automation.

(6) Integration of 'smart' appliances and consumer devices.

(7) Deployment and integration of advanced electricity storage and peak-shaving technologies, including plug-in electric and hybrid electric vehicles, and thermal-storage air conditioning.

(8) Provision to consumers of timely information and control options.

(9) Development of standards for communication and interoperability of appliances and equipment connected to the electric grid.

(10) The lowering of unreasonable or unnecessary barriers to adoption.

information technology tools and techniques has been somewhat of a back-burner priority.

Until now.

The Smart Grid represents the creation of a near-term marketplace in the tens of billions of dollars. According to the Electric Power Research Institute (EPRI) and the Pacific Northwest National Laboratory (PNNL), the total market size is approximately $200 billion spread over 10-15 years.

Technological assistance is needed anywhere performance can be enhanced, efficiencies gained or innovation enabled. Notable among potential technology applications is the charging of electric vehicles, which share many of the same characteristics as cell phones. Distributed energy storage at scale – sometimes called community energy storage – will require the networking of thousands of energy storage devices, i.e. batteries, similar to networking computers.

MOVING OPPORTUNITY FORWARD

Consider this a prospectus on the potential of our present and future grid. In the following pages, you'll see how DOE is working with utilities to develop a Smart Grid Maturity Model, state and federal regulators to further a deeper understanding of Smart Grid issues and implementation strategies, and standards groups to develop interoperability standards and protocols.

You'll learn about the barriers and opportunities relative to Smart Grid adoption; you'll discover how some utilities have already taken significant steps or put projects in place; you'll see how consensus is being achieved as various stakeholders align behind the need for a Smart Grid, if not exactly agreeing on the steps needed to get there.

Where are we on the Smart Grid adoption curve? Consider the fact that Intel is already getting its "smart chips" into appliances all over the world.

Translation: Your company has little time to lose.

DON'T I KNOW YOU FROM SOMEWHERE?

To give you an idea of the current state of grid modernization, consider this: If Alexander Graham Bell were confronted with today's telephony – cell phones, texting, etc. – he would most likely be amazed. Thomas Edison, meanwhile, would feel quite at home in the largely non-digital, electromechanical landscape that is today's grid.

With real-time data made possible by Smart Grid technologies, utilities will be able to more effectively utilize assets under normal and adverse conditions.

THE SMART GRID: **OPERATIONAL BENEFITS.**

Realizing the Smart Grid will require, to greater or lesser degrees, smart sensors and controls, a broadly accepted communications platform, advanced tools for planning and operation and dynamic pricing. It will also require clear standards for interconnection, performance and metrics. Constantly communicating, proactive and virtually self-aware, the Smart Grid has been described as a complex ecosystem.

THE HIGHLIGHTS...

The Smart Grid will increase the overall use and value of existing production and transmission capacity; incorporate greater levels of renewable energy; reduce carbon emissions by increasing the efficiency of the system and of loads; gain functionality out of increasing energy intensity; improve power quality to correspond to new digital demands; and do it all with the highest levels of security.

It is a fitting characterization.

When viewed relative to "the grid we have now," transformation to this smarter grid will give rise to enhancements that promise to positively affect every aspect of electricity generation, delivery and consumption, as most recently detailed by the Modern Grid Strategy and the Electricity Advisory Committee.

OPTIMIZING ASSET UTILIZATION AND EFFICIENT OPERATION

In 2005, excluding fuel and purchased power, investor-owned utilities spent $40 billion to operate and maintain the power system.[4] With real-time data made possible by Smart Grid technologies, utilities will be able to more effectively use assets under normal and adverse conditions. Among the benefits: A reduction in failure-related maintenance and outage costs and a longer service life among some of the assets. Overall and over time, integrated communications technologies will lessen the need for new and costly hard assets.

ENHANCING RELIABILITY

The Smart Grid will dramatically reduce the cost of power disturbances. Communications and control technologies applied to the grid will be able to isolate faults and rapidly restore service. Decision-support systems will "know" when there is the need to quickly reduce load or redirect power and respond autonomously to adverse conditions.

The Smart Grid will also be able to "call for help," enlisting support from distributed energy resources to help balance system needs.

POINT OF CLARIFICATION: WHAT THE SMART GRID ISN'T

It's only natural to confuse the terms Smart Grid and smart meters. The general news media do it all the time. But smart metering and the physical meter itself are just examples of a single enabling technology that makes two-way communication possible.

In combination, such functionality will strengthen the transmission and distribution system, increase operational flexibility and greatly reduce the risk of a failure that might affect the entire grid.

IMPROVING POWER QUALITY

Power quality events – dips in voltage lasting less than 100 milliseconds – can have the same effect on an industrial process as a more general outage that lasts minutes. A single such event can cost commercial facilities such as banks and data centers millions of dollars.

According to the EPRI, by 2011, fully 16% of our nation's electric load will require digital-quality power. (And digital equipment is far more sensitive than analog ever was, requiring tighter tolerances for voltage and frequency fluctuation.) The Smart Grid will help limit the impact of power-quality events. Transmission-side Smart Grid components will work to reduce voltage sags and swells. On the distribution level, disturbed sources could be removed and replaced with clean backup power supplies.

Broad-based power-quality improvements will reduce losses to American businesses across the board, from scrapped materials in industrial processes to the number of lost customers in a retail environment.

REDUCING WIDESPREAD OUTAGES

A $10-billion event

According to the "Final Report on the August 14, 2003 Blackout in the United States and Canada," that was the estimated price tag for our nation's last massive blackout, which left more than 28 million people in Michigan, New York and Ohio living without power for up to 4 days. Already, "lessons learned" from this event have resulted in a smarter grid and the institution of enforceable reliability standards.

That said, the Smart Grid will be able to employ multiple technologies to ensure that such a scenario is not repeated. Improved interfaces and decision-support tools will enable system operators to monitor the status of the grid at a glance – detecting threats against it – and identify, relieve and/or replace failing equipment even before a breakdown can occur. In some cases, power-stabilization software will be able to address an event and "heal" faster than humans can even react to the event. Even grid-friendly appliances will play a role, responding to demand-response signals to adjust load.

REDUCING VULNERABILITY TO MAN-MADE EVENTS AND NATURAL DISASTERS

Overlaying the entire electrical network, the Smart Grid's integrated communications infrastructure will provide detection and

10/28

10 BILLION
Dollars
28 MILLION
People

TECH HIGHLIGHT: SUPERCONDUCTING CABLE TECHNOLOGY

According to the U.S. Department of Energy, more than 7% of the electricity transported across the wires is lost in transmission and distribution because of resistance in current copper technologies. Superconducting cable technologies, roughly half the size of conventional copper technologies, will be capable of carrying 3-5 times more power, making them particularly useful and economically viable where space and rights-of-way are at a premium.

mitigation of both cyber and physical threats. Its ability to support a wide variety of generation options also reduces the effects of an attack at any one point on the system. Indeed, its strength is in its diversity. For example, whether natural or man-made, a diversity of distributed energy resources offers grid operators a variety of options in response to an emergency. Similarly, resource diversity within a geographic region offers additional means to restore the grid, and a diversity of fuels increases the likelihood that adequate power will be available.

IMPROVING PUBLIC AND WORKER SAFETY

According to the American Public Power Association, utility work is among the most dangerous occupations, resulting in 1000 fatalities and 7000 flash burns annually. Rapid identification of problems and hazards made possible by improved monitoring and decision-support systems will be able to predict equipment failure before it occurs to save lives and reduce injuries. Clearly, it is easier to service equipment routinely than during an outage event. Reducing failures also leads to reducing outages, which means traffic lights, elevators, etc., continue to function for the benefit of the public's safety.

IMPROVED ECONOMICS

Efficiencies ushered in by the Smart Grid should mitigate some of the rising costs of electricity. Real-time price signals will allow consumers to participate based on current supply and demand pricing scenarios. Communication among these buyers and sellers should reduce grid congestion and unplanned outages, as well as determine the real price for electricity at various times throughout the day. The reach of market efficiencies is also improved. Consider that analyst group LECG recently determined that the organized wholesale electricity markets of PJM and the New York Independent System Operator (ISO) have already reduced average wholesale electric rates between $430 million and $1.3 billion a year.

MORE ROBUST MARKETS

The Smart Grid will encourage new market participants, enabling a variety of new load management, distributed generation, energy storage and demand-response options and opportunities. These contributions are reinforcing the Smart Grid's economic advantages by allowing demand to act as a supply resource, allowing utilities to defer some large capital investments in power plants, substations and transmission and distribution lines. As a result, tens of billions of dollars will

BENEFITS FOR COMMERCIAL AND INDUSTRIAL CUSTOMERS

Electric motors consume approximately 65% of industrial electricity, understandable because they power virtually every process necessary for moving things from compressed air to conveyor belts. Variable-speed drives can reduce a motor's energy consumption by up to 60% compared with fixed drives and can be enabled to respond to a utility's price signals. Imagine the impact that such communication can have on manufacturing specifically and society in general.

be saved over a 20-year period, according to the Pacific Northwest National Laboratory. By increasing the grid's robustness and efficiency, options such as these will work to reduce peak prices and demand, leading to cost savings and downward pressure on rates for all stakeholders.

Demand response is already illuminating the promise of the Smart Grid through its greater enablement in certain regions of the country. Demand response is a means by which demand will be dynamically and continuously balanced with supply-side resources to produce the least costly electricity system. Distributed energy resources (DER) may accelerate consumer usage of small generation and storage devices through connections with the grid and two-way flows of electricity and communications.

MORE ENVIRONMENTALLY FRIENDLY

In enabling the deployment of all forms of generation and storage, the Smart Grid will encourage greater use of distributed energy resources, including maximizing the use of existing combined heat and power (CHP) units. Residing primarily at large commercial and industrial sites, existing CHP units – the CO_2 emissions profile of which are substantially lower than fossil-fueled power plants – represented 83.5 gigawatts (GW) of installed capacity in place as of 2005. DOE estimates suggest that additional opportunities could be as high as 130 GW.[5]

In being able to access a wider diversity of fuels, the Smart Grid will be able to generate more energy from carbon-free sources such as centralized hydro, wind, solar and nuclear power. In addition, it will be able to better take into account the intermittency of renewables.

Through the use of low-emission DER sources, the Smart Grid will enable states to more rapidly approach their Renewable Portfolio Standards (RPS) goals.

REDUCTION IN ELECTRICAL LOSSES

Electrical generation is required to "cover" system losses; that is, for the system to work, power is required to provide the energy consumed by line loss and inefficient equipment. Smart Grid components and other efficiency improvements engineer this waste out of the system. With more generation alternatives at its disposal, the Smart Grid will be able to utilize many more near load centers and minimize transmission losses.

ON MAKING THE SMART GRID BUSINESS CASE

The Smart Grid increases opportunities for consumer choice while reducing the cost of delivered electricity. It makes firm the promise of clean, renewable energies such as wind and solar available at meaningful scale. It allows for the connection of an entire portfolio of resources. And it enables communication among all parties.

Yet it's important to remember that the Smart Grid is a journey rather than a destination. Through modernization efforts, a smarter grid will evolve into the fully integrated Smart Grid over time. And, much like every major modernization effort in history, it will face hurdles.

Consider the business case for investing in the Smart Grid. Utilities such as Austin Energy have proven the cost-effectiveness of multi-dimensional Smart Grid investment. Currently, however, business cases for investing in the Smart Grid processes and technologies are often incomplete when viewed strictly with regard to near-term cost-effectiveness.

Invariably, it is easier to demonstrate the value of the end point than it is to make a sound business case for the intermediate steps to get there. Societal benefits, often necessary to make investments in modern grid principles compelling, are normally not included in utility business cases. Yet credit for those very societal benefits in terms of incentives and methods for reducing investment risks might stimulate the deployment of modern grid processes and technologies.

As study after study indicates, the societal case for Smart Grid adoption is fundamental, lasting and real:

Increasing energy efficiency, renewable energy and distributed generation would save an estimated $36 billion annually by 2025.[6]

Distributed generation can significantly reduce transmission-congestion costs, currently estimated at $4.8 billion annually.[7]

Smart appliances costing $600 million can provide as much reserve capacity to the grid as power plants worth $6 billion.[8]

Over 20 years, $46 billion to $117 billion could be saved in the avoided cost of construction of power plants, transmission lines and substations.[9]

Realizing the Smart Grid will require the best solutions that technology providers and integrators have to offer.

INNOVATION CALLING: KEY SMART GRID TECHNOLOGIES.

Where precisely do Smart Grid opportunities reside in terms of technology design, engineering and development? The following have been categorized as Smart Grid Key Technology Areas by DOE.

ABOUT FACTS

In fact, FACTS (Flexible AC Transmission Systems) is somewhat of an umbrella term that encompasses several technologies designed to enhance the security, capacity and flexibility of power transmission systems. FACTS manage to increase the existing transmission network capacity while maintaining or improving the operating margins necessary for grid stability. More power reaches consumers at a lower investment cost and with less of an impact on the environment.

INTEGRATED TWO-WAY COMMUNICATION

Two-way communication makes the Smart Grid a dynamic, interactive, real-time infrastructure. An open architecture creates a plug-and-play environment that securely networks grid components and operators, enabling them to talk, listen and interact.

ADVANCED COMPONENTS

Advanced components play an active role in determining the electrical behavior of the grid, applying the latest research in materials, superconductivity, energy storage, power electronics and microelectronics to produce higher power densities, greater reliability and power quality.

Examples include:

- *Next-generation FACTS/PQ (power quality) devices*
- *Advanced distributed generation and energy storage*
- *Plug-in hybrid electric vehicles (PHEVs)*
- *Fault current limiters*
- *Superconducting transmission cables*
- *Microgrids*
- *Advanced switches and conductors*
- *Solid-state transformers*

Improved interfaces and decision support will enable grid operators and managers to make more accurate and timely decisions at all levels of the grid, including the consumer level, while also enabling more advanced operator training.

ADVANCED CONTROL METHODS

Advanced control methods monitor power system components, enabling rapid diagnosis and timely, appropriate responses to any event. They also support market pricing, enhance asset management and efficient operations, and involve a broad application of computer-based algorithms.

Examples include:

- *Data collection and monitoring of all essential grid components*
- *Data analysis to diagnose and provide solutions from both deterministic and predictive perspectives*
- *"Diagnosis" and subsequent appropriate action processed autonomously or through operators (depending on timing and complexity)*
- *Provision of information and solutions to human operators*
- *Integration with enterprise-wide processes and technologies*

SENSING AND MEASUREMENT TECHNOLOGIES

Sensing and measurement technologies enhance power system measurements and facilitate the transformation of data into information to evaluate the health of equipment, support advanced protective relaying, enable consumer choice and help relieve congestion.

Examples include:

- *Smart meters*
- *Ubiquitous system operating parameters*
- *Asset condition monitors*
- *Wide-area monitoring systems (WAMS)*
- *Advanced system protection*
- *Dynamic rating of transmission lines*

IMPROVED INTERFACES AND DECISION SUPPORT

Improved interfaces and decision support will enable grid operators and managers to make more accurate and timely decisions at all levels of the grid, including the consumer level, while enabling more advanced operator training. Improved interfaces will better relay and display real-time data to facilitate:

- *Data reduction*
- *Visualization*
- *Speed of comprehension*
- *Decision support*
- *System operator training*

APPLICATIONS OF SMART GRID TECHNOLOGY

Consumer energy management within the Smart Grid will necessarily include some form of AMI, including but not limited to "smart meters." On the customer side of the meter, this will enable electricity service providers to signal homeowners and businesses when power is expensive and/or in tight supply,

either by special indicators or displayed through Web browsers. Another level of implementation would allow the utility to automatically reduce the customer's electricity consumption when power is expensive or scarce. This will be managed through communication between the smart meter and the customer's equipment or appliances.

The Smart Grid will make it easier to realize benefits from distributed generation, such as rooftop solar panels, and to implement "net metering," a ratemaking approach that allows operators of distributed generators to sell surplus power to utilities. The Smart Grid will also manage the connection of millions of plug-in electric vehicles into the power grid (see Section 7, "Smart Grid & the Environment: Enabling a cleaner energy future").

On the transmission side, monitoring and reliability of the Smart Grid will include real-time monitoring of grid conditions; improved automated diagnosis of grid disturbances; automated responses to grid failures to isolate disturbed zones and prevent or limit cascading blackouts; the plug-and-play ability to connect new generating plants to the grid, reducing the need for time-consuming interconnection studies and physical upgrades; and enhanced ability to manage large amounts of wind and solar power. Some analysts believe that deployment of the Smart Grid is essential to the large-scale use of wind and solar energy. (Again, see Section 7.)

TECHNOLOGIES IN ACTION: CITY OF FORT COLLINS, COLORADO

The city and its city-owned Fort Collins Utility support a wide variety of clean energy initiatives, including the establishment of a Zero Energy District within the city (known as FortZED).

This DOE demonstration project will integrate a wide range of renewables and demand response within utility operations. It seeks to transform the electrical distribution system by developing an integrated system of mixed distributed resources to increase the penetration of renewables – such as wind and solar – while delivering improved efficiency and reliability. To realize the potential of a "zero energy district," the project involves a mix of nearly 30 distributed generation, renewable energy and demand-response resources across five customer locations for an aggregated capacity of more than 3.5 MW. By increasing the use of renewables and distributed energy resources for

HOW ENERGY STORAGE FITS IN

The facility with which personal electronics such as cell phones and "smart phones" can store energy is a welcome fact of everyday life. When similar technologies and approaches are applied to the grid, the collective electric infrastructure will come to represent a far more reliable, secure and efficient network.

According to the Electric Advisory Committee, there are many benefits to deploying energy storage technologies into the nation's grid. Energy storage can provide:

1. A means to improve grid optimization for bulk power production

2. A way to facilitate power system balancing in systems that have variable or diurnal renewable energy sources

3. Facilitation of integration of plug-in hybrid electric vehicle (PHEV) power demands with the grid

4. A way to defer investments in transmission and distribution infrastructure to meet peak loads (especially during outage conditions) for a time

5. A resource providing ancillary services directly to grid/market operators

Types of energy storage include:

- *Thermal*
- *Flow batteries*
- *Pumped hydro*
- *Lithium-ion batteries*
- *Flywheel*
- *Compressed air*

supplying power during peak load periods, the project seeks to achieve a 20%-30% peak-load reduction on multiple distribution feeders.

Technologies being integrated include:

- *Photovoltaics (PV)*
- *Wind turbines*
- *Microturbines*
- *Dual-fuel combined heat and power (CHP) systems*
- *Backup generators*
- *Plug-in hybrid electric vehicles (PHEVs) in an ancillary-services role*
- *Fuel cells*

THE STATE OF SMART APPLIANCES

Major home-appliance manufacturers are sufficiently convinced of the commercial viability of the Smart Grid.

Whirlpool, the world's largest manufacturer and marketer of major home appliances, has announced that it plans to make all of its electronically controlled appliances Smart Grid compatible by 2015. The company will make all the electronically controlled appliances it produces – everywhere in the world – capable of receiving and responding to signals from the Smart Grid. The company mentioned that its ability to successfully deliver on this commitment in this time frame was dependent on two important public-private partnerships:

First, the development by the end of 2010 of an open, global standard for transmitting signals to and receiving signals from a home appliance; and second, appropriate policies that reward consumers, manufacturers and utilities for adding and using these new peak demand reduction capabilities.

GE's smart appliances – or demand-response appliances – include a refrigerator, range, microwave, dishwasher and washer and dryer. Currently running as a pilot program, these appliances receive a signal from the utility company's smart meter, which alerts the appliances – and the participants – when peak electrical usage and rates are in effect. In the pilot program, the signal word "eco" comes up on the display screen. The appliances are programmed to avoid energy usage during that time or operate on a lower wattage; however, participants could choose to override the program.

ONE LESS $10 MILLION SUBSTATION

DOE is funding several demonstration projects across the country. Among these is the Perfect Power project at the Illinois Institute of Technology (IIT), leveraging advanced technologies to create a replicable and more reliable microgrid. The project's goals: To promote distribution automation, encourage more local and renewable energy generation and electricity usage. Prior to embarking on this demonstration project, local utility Exelon had planned on building a third $10 million substation to serve IIT's growing needs. That will no longer be necessary. Not only will this project eliminate the substation's cost, but also the carbon dioxide it would have generated.

NIST is matching its expertise with DOE's domain expertise to formulate a Smart Grid Roadmap, set to be released by the end of 2009.

SECURITY & STANDARDS: **GETTING TO CERTAINTY.**

Present and future architects of the Smart Grid look for regulatory certainty before they can confidently enter the marketplace with their respective tools, technologies and deployment plans. Meanwhile, many regulators are seeking evidence of mature interoperability and security standards before they can convey such certainty.

Historically, in industries from telecommunications to computers, standards follow markets rather than lead them. That said, standards in both areas are evolving with all deliberate speed.

A status report:

SMART GRID SECURITY: SAFETY BUILT IN

The grid as we know it was engineered, designed and built during a time when "security" referred to the continuing operation of the grid itself rather than determined efforts by terrorists and others to harm it.

Times have certainly changed. Today, the integrity of the grid is itself an issue of national security. At issue are not only attacks *on* the power system, i.e., physical attacks – but also attacks *through* the power system, or cyber attacks. According to the Government Accountability Office (GAO), cyber attacks are increasing at an alarming rate. As far back as 2002, the GAO reports, 70% of energy and power companies experienced some kind of severe cyber attack to computing or energy management systems.

Ironically, recent technological approaches to the grid, including reliance on unprotected telecommunications networks, may be adding to the security problem. In addition, the ease of accessibility to open information sources available via the Internet may also be putting the infrastructure at risk.

The Smart Grid makes security an imperative from the outset. A systems approach to electric power security will identify key vulnerabilities, assess the likelihood of threats and determine consequences of an attack. Resilience will be built into each element of the system and the overall system designed

THE GRIDWISE ALLIANCE: AN EARLY SMART GRID CHAMPION

As part of a public/private partnership with DOE, the GridWise Alliance and its affiliate GridWise Architecture Council have earned a reputation as an influential voice in support of Smart Grid technologies and implementation. The Alliance and its members advocate change locally, regionally, and nationally to promote new policies and technology solutions.

to deter, detect, respond and recover from man-made disruptions as well as those from natural disasters such as hurricanes and earthquakes. Planning for man-made threats will consider multiple points of potential failure.

According to DOE, this approach would apply risk management methods to prioritize the allocation of resources for security. Particular goals of security programs would include:

- *Identifying critical sites and systems*
- *Protecting selected sites using surveillance and barriers against physical attack*
- *Protecting systems against cyber attack using information denial (masking)*
- *Dispersing sites that are high-value targets*
- *Tolerating disruptions*
- *Integrating distributed energy sources and using automated distribution to speed recovery from attack*

KEYS TO RESISTING ATTACK

The Smart Grid must be designed – at the component level – to reduce the:

- *Threat of attack by concealing, dispersing, eliminating or reducing single-point failures*
- *Vulnerability of the grid to attack by protecting key assets from physical and cyber attack*
- *Consequences of a successful attack by focusing resources on recovery*

To succeed at this task, the Smart Grid's "system requirements" rely upon greater and more sophisticated levels of automation to provide wide-area monitoring, remote system control, and predictive tools to deal with impending disruptions before they happen. In addition, the system must be capable of enabling the autonomous operation of selected grid elements and ensuring that added equipment and control systems do not create additional opportunities for attack.

SECURITY AT THE METER

A collaborative utility task force – the Advanced Metering Infrastructure Security Task Force (AMI-SEC) – is currently partnering with DOE to develop a common set of cybersecurity requirements for advanced metering infrastructure (AMI).

THE VALUE OF A SYSTEMS APPROACH TO GRID SECURITY

A systems approach involving government and industry encourages balanced investment, which ensures that costs for security requirements will be allocated across the Smart Grid. Federal, state and local policies and regulations should be developed to allow utilities and others in the electricity industry to recoup reasonable costs for security upgrades that are part of the overall system design.

INTEROPERABILITY STANDARDS: NIST AND THE ROADMAP

Many within the grid community argue that waiting for standards is the only way to ensure cost-effective implementation. Others hold that the only standard required is the size of the plug for Smart Grid appliances. Still others maintain that waiting for standards might have retarded the growth of personal computing to the extent that we'd still be playing Pong.

Clearly, there are technologies that can and are being implemented within utilities in anticipation of the Smart Grid, among them a wide array of smart sensors. And as long as open, technology-neutral standards are observed, private industry is free to develop standards on its own. However, the National Institute of Standards and Technology (NIST) will draw the Interoperability Roadmap.

Ultimately, interoperability standards are needed to ensure that power electronics, communication data, and information technology will work together seamlessly, while cyber security standards protect the multi-system network against natural or human-caused disruptions.

NIST is matching its expertise with DOE's domain expertise to formulate a Smart Grid Roadmap, set to be released by the end of 2009. At the same time, the GridWise Architecture Council has begun to develop an interoperability maturity model to determine the appropriate process for developing software.

These efforts provide a starting point to bring the stakeholders together to work toward common goals and visions of what the Smart Grid needs to become.

ABOUT NIST

Founded in 1901, NIST is a non-regulatory federal agency whose mission is to promote U.S. innovation and industrial competitiveness by advancing measurement science, standards, and technology in ways that enhance economic security and improve our quality of life. NIST has created standards for everything from automated teller machines and atomic clocks to mammograms and semiconductors. The agency has been designated within EISA 2007 (Title XIII) to develop the standards framework for Smart Grid technologies.

Simply put, the purpose of the Collaborative is to get a fix on the state of Smart Grid issues, technologies and best practices.

FERC, NARUC & THE SMART GRID CLEARINGHOUSE: **DRAWING CLARITY FROM COMPLEXITY.**

DOE-sponsored Smart Grid projects of various sizes and scope are increasingly coming before regulatory commissions in jurisdictions across the country.

SMART GRID "FOR THE REST OF US"

Analogous to the Clearinghouse, the Department of Energy will also launch www.smartgrid.gov. Created for a far broader audience – a "typical" American consumer of electricity interested in the country's energy plan but possibly puzzled by its complexity – this site will keep the public informed about DOE's activities in support of the Smart Grid in an easy-to-understand manner. The site will also function as a single point of entry for the general and trade news media, providing a value-added reference point for this key outreach constituency.

Reconciling the value of the Smart Grid with the day-to-day business facing the nation's regulators is complex at best. Regulators are hard at work balancing competing priorities; keeping utility service reliable and affordable; "greening" the electricity supply; modernizing transmission; and combating climate change. Where precisely does the Smart Grid "fit" in their busy schedules and what does it mean to the ratepayers they serve?

FERC/NARUC SMART GRID COLLABORATIVE

To further their understanding with regard to the range of issues associated with the Smart Grid, federal and state regulatory officials have joined together under DOE sponsorship to form the FERC/NARUC Smart Grid Collaborative, using collaboration to draw clarity from complexity.

Most recently, at the request of the two organizations, DOE has established the Smart Grid Clearinghouse, a comprehensive website built to house "all things Smart Grid," detail and analyze best practices and enable regulators to make more informed ratemaking decisions.

The Collaborative sees the Smart Grid Clearinghouse as an additional tool for Smart Grid stakeholders to use in advancing Smart Grid concept and implementation as well as a venue for many federal and state agencies and public and private sector organizations to assess Smart Grid development and practices.

To ensure transparency and maximize "lessons learned," recipients of DOE Smart Grid Investment Grants will be required to report setbacks as well as successes on the site. Accentuating such lessons will speed knowledge transfer, facilitate best practices and hasten the progress of all Smart Grid initiatives.

The Maturity Model creates a roadmap of activities, investments, and best practices with the Smart Grid as its focus.

THE SMART GRID MATURITY MODEL: **BECAUSE ONE SIZE DOESN'T FIT ALL.**

No two electricity service providers are alike. Nor are their business plans or investment strategies. As utilities across the country consider investing in a Smart Grid, they're also searching for a reasonable degree of solid footing. Utility executives and technology providers alike want to know that making the grid smarter is good business with clear benefits.

In effect, how does a Smart Grid-curious utility "do" the Smart Grid? And how best can technology providers help them succeed?

Moving forward toward the Smart Grid can't be done without adopting a systems view. Utilities in search of a starting place need look no further than the Smart Grid Maturity Model (SGMM). The Maturity Model creates a roadmap of activities, investments and best practices with the Smart Grid as its vision. Those using the model will be able to establish an appropriate development path, communicate strategy and vision, and assess current opportunities. The Maturity Model can also serve as a strategic framework for vendors, regulators and consumers who have or desire a role in Smart Grid transformation.

Maturity models – which enable executives to review the progress a business is making in transforming or altering the way it operates – have an admirable track record of moving entire industries forward. Consider, for example, how they have transformed the software development industry.

During 2007-2009, IBM and seven utilities from four continents developed the Maturity Model and recently donated it to the Carnegie Mellon Software Engineering Institute (SEI). The SEI has developed worldwide de facto standards, such as the Capability Maturity Model Integration (CMMI) for process improvement, and led international efforts to improve network security through its globally recognized Computer Emergency Response Team (CERT) program.

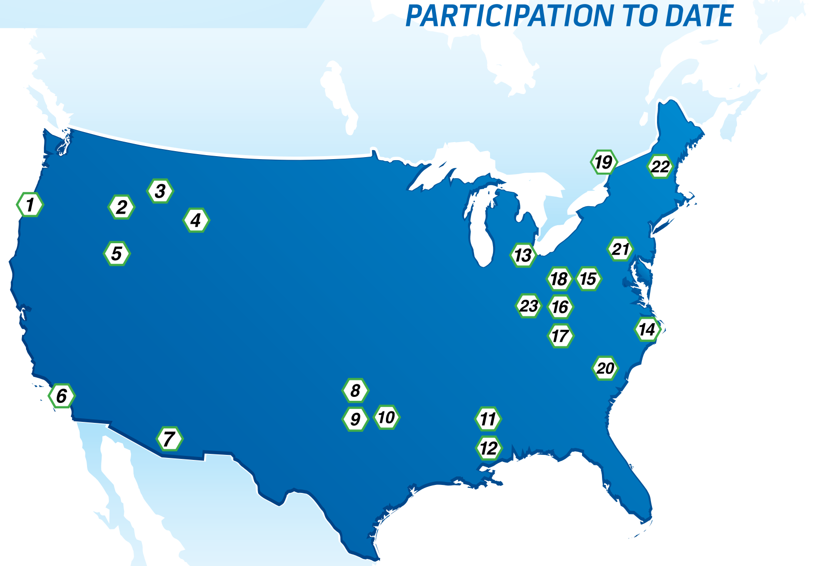
The U.S. Department of Energy is working with the SEI, enabling the Institute to serve as the independent steward of the global SGMM with primary responsibility for its ongoing governance, growth and evolution

SMART GRID MATURITY MODEL

Levels, Descriptions, Results

LEVEL	DESCRIPTION	RESULT
ONE: Exploring and Initiating	*Contemplating Smart Grid transformation. May have vision but no strategy yet. Exploring options. Evaluating business cases, technologies. Might have elements already deployed.*	Vision
TWO: Functional Investing	*Making decisions, at least at a functional level. Business cases in place, investment being made. One or more functional deployments under way with value being realized. Strategy in place.*	Strategy
THREE: Integrating Cross Functional	*Smart Grid spreads. Operational linkages established between two or more functional areas. Management ensures decisions span functional interests, resulting in cross-functional benefits.*	Systemization
FOUR: Optimizing Enterprise Wide	*Smart Grid functionality and benefits realized. Management and operational systems rely on and take full advantage of observability and integrated control across and between enterprise functions.*	Transformation
FIVE: Innovating Next Wave of Improvements	*New business, operational, environmental and societal opportunities present themselves, and the capability exists to take advantage of them.*	Perpetual Innovation

PARTICIPATION TO DATE



1. PORTLAND GEN.
2. BC HYDRO
3. EPCOR
4. MANITOBA HYDRO
5. BONNEVILLE POWER
6. SEMPRA
7. SALT RIVER PROJECT
8. COSERVE
9. AUSTIN ENERGY
10. CENTERPOINT
11. ENTERGY
12. EAST MISS. EPA
13. COMED
14. DOMINION VIR.
15. ALLEGHENY POWER
16. PEPCO
17. DUKE
18. AEP
19. HYDRO OTTAWA
20. SCANA CORP.
21. EXELON
22. VELCO
23. FIRST ENERGY

based upon stakeholder needs, user feedback and market requirements.

To support widespread adoption and use, the SEI will ensure availability of the model and supporting materials and services for the user community, including a suite of offerings on how to use the tool and "train the trainer" sessions.

It is important to note that the Smart Grid Maturity Model is not a means of comparing one utility with another; rather, the intent is strictly one of self-assessment. The first step for utilities is taking the Smart Grid Maturity Model survey by contacting customer-relations@sei.cmu.edu. The survey offers insights into a utility's current position relative to adoption and development of the business plan necessary to set milestones toward achieving the benefits of the Smart Grid – for both residential and business customers.

A smarter grid delivers end-use conservation and efficiency thanks to its ability to establish more focused and persistent consumer participation.

SMART GRID & THE ENVIRONMENT: **ENABLING A CLEANER ENERGY FUTURE.**

In 2008, emissions of carbon dioxide from fuel burning in the United States were down 2.8%, the biggest annual drop since the 1980s.[10] This is widely attributable to the length and depth of the worldwide recession and just as widely expected to be an anomaly. Most agree, as the national and global economies improve, carbon emissions will resume their upward trend.

Thanks to its ability to establish more focused and persistent use of demand response controls, a smarter grid delivers end-use conservation and efficiency. In so doing, it also positively addresses our nation's growing carbon footprint.

ENABLING CARBON SAVINGS

The full exploitation of renewable energy sources such as wind and PV solar is critical to managing our collective carbon footprint. However, when viewed against the limitations of the current grid, both technologies face barriers to full-scale deployment. A smarter grid enables grid operators to see further into the system and allows them the flexibility to better manage the intermittency of renewables. This in turn surmounts a significant barrier – enabling wind and solar to be deployed rapidly – and in larger percentages.

OPTIMIZING WIND

Although possessing myriad attributes, renewables also increase the complexity of operating the grid. A smarter grid enables operators to manage against this complexity.

The Smart Grid can lower the net cost for wind power by regulating fluctuations with demand response. Combining demand response, energy storage and distributed and centralized generation assets can manage these fluctuations (i.e., when the wind doesn't blow) to lower the cost of integrating wind into the system. Overall, the Smart Grid can optimize the penetration of renewables into our nation's electrical system.

CAP & TRADE & SMART GRID

Congress is working on proposed legislation that would limit greenhouse gas emissions and turn them into a commodity that can be bought and sold (i.e., cap and trade). Accurate accounting of actual carbon footprints made possible by a smarter grid offers solid verification, thereby capturing the value and enhancing the tradability of carbon offsets.

A smarter grid can optimize wind resources in conjunction with demand response controls, dealing with the intermittency of such resources by actively managing "holes in the wind."

OPTIMIZING SOLAR

A PV array on every roof would be a welcome sight. However, although existing distribution grids are capable of safely supporting high penetrations of PV solar energy, placing excess power back onto the grid may also pose problems. Smart Grid control systems can help the grid rise to this challenge.

SMART GRID & ELECTRIC VEHICLES: DRIVING TOWARD A CLEANER PLANET

The Smart Grid's single biggest potential for delivering carbon savings is in providing cost-effective and increasingly clean energy for plug-in electric vehicles (PEVs), including plug-in hybrid electric vehicles (PHEVs).

Here's how they work. PEVs can be plugged into a standard household electrical outlet to recharge their batteries. Capable of travelling up to 40 miles in electric-only mode, the majority of PEVs operating on battery power would meet the daily needs of most drivers, according to Edison Electric Institute (EEI). Compared with a current hybrid, a PEV with an electric-only range of 20 miles could reduce fuel use by about one-third according to a report by the American Council for an Energy-Efficient Economy (ACEEE). EPRI estimates that the same PEV could reduce fuel consumption by about 60% compared with non-hybrid vehicles.

Although the vehicles will be producing the savings rather than the Smart Grid, only Smart Grid technologies will allow us to tap their fundamental potential. Consider the following ramifications:

The idle production capacity of today's grid – potential that is not now being used – could supply 73% of the energy needs of today's cars, SUVs, pickup trucks, and vans with existing power plants.[11]

On average, PHEVs will produce just one-third of the greenhouse gases (GHGs) emitted by conventional, gasoline-fueled vehicles – tailpipe to tailpipe. According to a joint study by EPRI and the Natural Resources Defense Council (NRDC), PEVs have the potential to reduce cumulative U.S. GHG emissions by as much as 10.3 billion tons from 2010 to 2050. They could reduce national oil consumption by as much as four million barrels per day in 2050 according to that same EPRI/NRDC study.

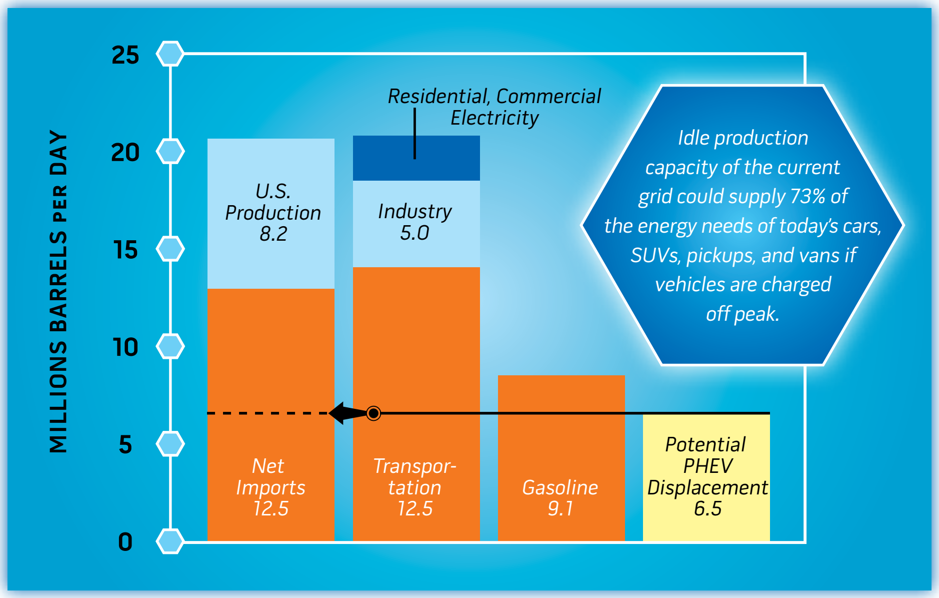
At scale, PHEV deployment will cut GHG emissions including CO_2.

Furthermore, by enabling the sale of more electricity over the same infrastructure, the Smart Grid has the potential to lower electric rates. These benefits accrue, however, only if these vehicles are charged strictly off-peak. Charging PEVs on-peak would only further stress the grid.

In terms of carbon emissions, the nation's vehicles produce roughly the same carbon emissions as the nation's coal-based power plants. By moving their emissions from millions of tailpipes to far fewer smokestacks, the Smart Grid could dramatically reduce the size and complexity of the industry's ongoing "clean-up detail." That is, rather than wondering how to handle hundreds of millions of four-wheeled emitters, Smart-Grid functionality enables us to shift focus to challenges ranging from carbon management to the use of more renewable sources of electricity.

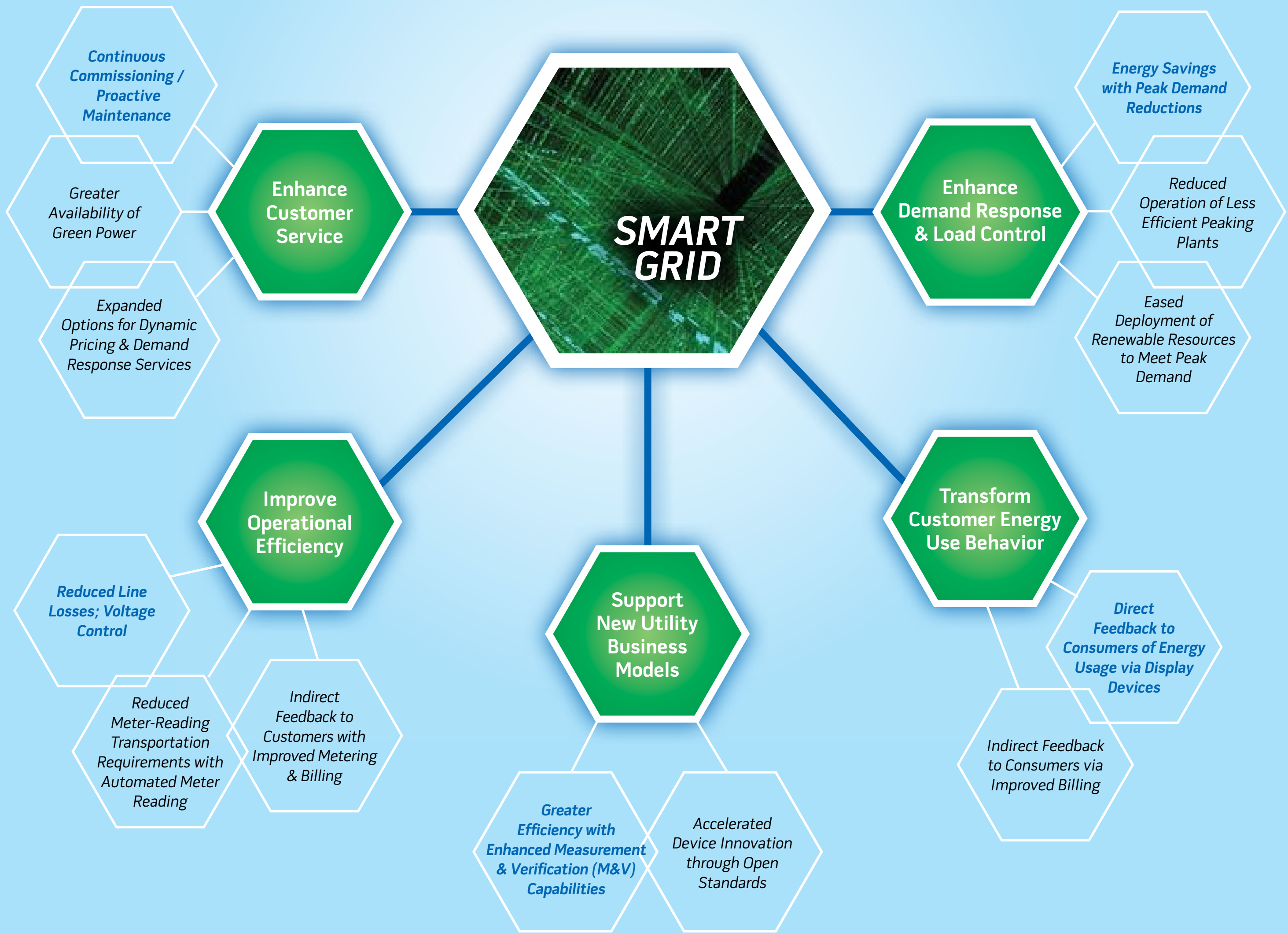
At scale, PHEV deployment will cut GHG emissions including CO_2. In the process, it will work toward improving the general health of the United States as well as lessening our dependence on foreign oil. The first models are scheduled to roll off assembly lines in 2010.

POTENTIAL IMPACTS OF HIGH PENETRATION OF PLUG-IN HYBRID ELECTRIC VEHICLES ON THE US POWER GRID



On average, PHEVs will produce just one-third of the greenhouse gases (GHGs) emitted by conventional, gasoline-fueled vehicles – tailpipe to tailpipe.

SUMMARY OF ENERGY-SAVING AND CARBON-REDUCTION MECHANISMS ENABLED BY THE SMART GRID



As the owners of the infrastructure, utilities and other service providers are keenly aware of their sizable carbon footprints. Recently, in EPRI's Green Grid Whitepaper, the Institute identified ways in which utilities can reduce carbon through the use of Smart Grid approaches and technologies.

America is counting on you to be one of the architects of the Smart Grid.

NEXT STEPS: GETTING TO SOLUTIONS.

Certain veteran observers within the technology space maintain that the Smart Grid represents an opportunity to technology providers larger than the Internet. Without a doubt, opportunities abound.

Consider that the greatest source of outages occurs between the substation and the home, where to date little intelligence has been applied. The economic implications of smartening this distance are significant in terms of engaging demand response alone, not to mention increasing two-way economic activity and potentially accommodating new market participants.

Consider too the opportunities in unlocking the potential of energy storage, which the Smart Grid can bring to bear at scale. Amazingly, the grid is the only business that has never had the benefit of storage to balance out the intermittency of market supply, in effect operating with no inventory. Many view storage as the ultimate facilitator of the Smart Grid.

Although the level of "Smart-Grid readiness" varies among key stakeholder groups such as utilities, regulators, consumer advocates and others, it is clear that the Smart Grid can and must move forward.

GETTING TO WIN-WIN

A smarter grid will become the Smart Grid over time. Like any other successful transformation, its progress will be measured in fits and starts. For example, although many important steps toward a smarter grid have already been taken, or are happening now, estimates for full Smart Grid adoption range from 5 to 15 years. One technology expert maintains that in a decade, we'll be shocked at the progress we've made.

As a technology or service provider, you should use this time to your advantage. Recognize that technology won't work in isolation. You – and it – must work with other Smart Grid and legacy technologies. Depending on your technology, you must be prepared to interface with and understand the issues of utilities, consumers and technology integrators. In short, take the time to understand your audiences. Ensuring that your technology adds value for generators and consumers of electricity in the most efficient and economical manner possible is the way for everyone to win.

As a technology or service provider, you should use this time to your advantage. Recognize that technology won't work in isolation. You – and it – must work with other Smart Grid and legacy technologies.

As another industry expert observes, there is no silver bullet for the Smart Grid, no single technology that will get us there. There is instead silver buckshot, a plethora of better ideas and technologies that will further the Smart Grid journey to its ultimate destination.

The time is now.

With customer demand pushing uncomfortably close to available generation, there's never been a better time to move toward full-scale Smart Grid adoption, particularly considering that $4.5 billion in stimulus funds under the American Recovery and Reinvestment Act of 2009 (ARRA) have already been disbursed toward its realization. The nation is counting on you to be one of its architects, helping to build a cleaner, more responsive, more reliable grid – a grid open to technological advancements we can't even foresee today. Your near-term agenda in creating a modernized electric infrastructure includes working with regulators to develop rules that support innovation and allow access to customers; encouraging market design that compensates consumers as they move from passive energy consumers to active providers; and helping to build a network ensuring that all stakeholders benefit over time...and as soon as possible. In the process, our nation will re-assert its global competitiveness and your technologies and systems will be replicated around the world.

TODAY's GRID. AND TOMORROW's.

Today's Grid	Smart Grid
Consumers are uninformed and non-participative with power system	*Informed, involved, and active consumers; demand response and distributed energy resources*
Dominated by central generation; many obstacles exist for distributed energy resources interconnection	*Many distributed energy resources with plug-and-play convenience; focus on renewables*
Limited wholesale markets, not well integrated; limited opportunities for consumers	*Mature, well-integrated wholesale markets, growth of new electricity markets for consumers*
Focus on outages; slow response to power quality issues	*Power quality is a priority with a variety of quality/price options; rapid resolution of issues*
Little integration of operational data with asset management; business-process silos	*Greatly expanded data acquisition of grid parameters; focus on prevention, minimizing impact to consumers*
Responds to prevent further damage; focus is on protecting assets following fault	*Automatically detects and responds to problems; focus on prevention, minimizing impact to consumer*
Vulnerable to malicious acts of terror and natural disasters	*Resilient to attack and natural disasters with rapid restoration capabilities*

GLOSSARY: SMART GRID TERMS WORTH KNOWING.

ADVANCED METERING INFRASTRUCTURE (AMI): AMI is a term denoting electricity meters that measure and record usage data at a minimum, in hourly intervals, and provide usage data to both consumers and energy companies at least once daily.

CARBON DIOXIDE (CO_2): A colorless, odorless, non-poisonous gas that is a normal part of Earth's atmosphere. Carbon dioxide is a product of fossil-fuel combustion as well as other processes. It is considered a greenhouse gas as it traps heat (infrared energy) radiated by the Earth into the atmosphere and thereby contributes to the potential for global warming. The global warming potential (GWP) of other greenhouse gases is measured in relation to that of carbon dioxide, which by international scientific convention is assigned a value of one (1).

DEMAND RESPONSE: This Demand-Side Management category represents the amount of consumer load reduction at the time of system peak due to utility programs that reduce consumer load during many hours of the year. Examples include utility rebate and shared savings activities for the installation of energy efficient appliances, lighting and electrical machinery, and weatherization materials.

DISTRIBUTED GENERATOR: A generator that is located close to the particular load that it is intended to serve. General, but non-exclusive, characteristics of these generators include: an operating strategy that supports the served load; and interconnection to a distribution or sub-transmission system.

DISTRIBUTION: The delivery of energy to retail customers.

ELECTRIC POWER: The rate at which electric energy is transferred. Electric power is measured by capacity.

ELECTRIC UTILITY: Any entity that generates, transmits, or distributes electricity and recovers the cost of its generation, transmission or distribution assets and operations, either directly or indirectly. Examples of these entities include: investor-owned entities, public power districts, public utility districts, municipalities, rural electric cooperatives, and State and Federal agencies.

ENERGY EFFICIENCY, ELECTRICITY: Refers to programs that are aimed at reducing the energy used by specific end-use devices and systems, typically without affecting the services provided. These programs reduce overall electricity consumption (reported in megawatthours), often without explicit consideration for the timing of program-induced savings. Such savings are generally achieved by substituting technologically more advanced equipment to produce the same level of end-use services (e.g. lighting, heating, motor drive) with less electricity. Examples include high-efficiency appliances, efficient lighting programs, high-efficiency heating, ventilating and air conditioning (HVAC) systems or control modifications, efficient building design, advanced electric motor drives, and heat recovery systems.

FEDERAL ENERGY REGULATORY COMMISSION (FERC): The Federal agency with jurisdiction over interstate electricity sales, wholesale electric rates, hydroelectric licensing, natural gas pricing, oil pipeline rates, and gas pipeline certification. FERC is an independent regulatory agency within the Department of Energy and is the successor to the Federal Power Commission.

GREENHOUSE GASES (GHGs): Those gases, such as water vapor, carbon dioxide, nitrous oxide, methane, hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulfur hexafluoride, that are transparent to solar (short-wave) radiation but opaque to long-wave (infrared) radiation, thus preventing long-wave radiant energy from leaving Earth's atmosphere. The net effect is a trapping of absorbed radiation and a tendency to warm the planet's surface.

LOAD (ELECTRIC): The amount of electric power delivered or required at any specific point or points on a system. The requirement originates at the energy-consuming equipment of the consumers.

OFF PEAK: Period of relatively low system demand. These periods often occur in daily, weekly, and seasonal patterns; these off-peak periods differ for each individual electric utility.

ON PEAK: Periods of relatively high system demand. These periods often occur in daily, weekly, and seasonal patterns; these on-peak periods differ for each individual electric utility.

OUTAGE: The period during which a generating unit, transmission line, or other facility is out of service.

PEAK DEMAND OR PEAK LOAD: The maximum load during a specified period of time.

PEAKER PLANT OR PEAK LOAD PLANT: A plant usually housing old, low-efficiency steam units, gas turbines, diesels, or pumped-storage hydroelectric equipment normally used during the peak-load periods.

RATEMAKING AUTHORITY: A utility commission's legal authority to fix, modify, approve, or disapprove rates as determined by the powers given the commission by a State or Federal legislature.

RATE OF RETURN: The ratio of net operating income earned by a utility is calculated as a percentage of its rate base.

RATES: The authorized charges per unit or level of consumption for a specified time period for any of the classes of utility services provided to a customer.

RENEWABLE ENERGY RESOURCES: Energy resources that are naturally replenishing but flow-limited. They are virtually inexhaustible in duration but limited in the amount of energy that is available per unit of time. Renewable energy resources include: biomass, hydro, geothermal, solar, wind, ocean thermal, wave action, and tidal action.

SOLAR ENERGY: The radiant energy of the sun, which can be converted into other forms of energy, such as heat or electricity.

TIME-OF-DAY PRICING: A special electric rate feature under which the price per kilowatthour depends on the time of day.

TIME-OF-DAY RATE: The rate charged by an electric utility for service to various classes of customers. The rate reflects the different costs of providing the service at different times of the day.

TRANSMISSION (ELECTRIC): The movement or transfer of electric energy over an interconnected group of lines and associated equipment between points of supply and points at which it is transformed for delivery to consumers or is delivered to other electric systems. Transmission is considered to end when the energy is transformed for distribution to the consumer.

WIND ENERGY: Kinetic energy present in wind motion that can be converted to mechanical energy for driving pumps, mills, and electric power generators.

RESOURCES: PLACES TO GO TO LEARN MORE.

DATABASE OF STATE INCENTIVES FOR RENEWABLES & EFFICIENCY (DSIRE): *http://www.dsireusa.org*

EDISON ELECTRIC INSTITUTE (EEI): *http://www.eei.org*

ELECTRICITY ADVISORY COMMITTEE (EAC): *http://www.oe.energy.gov/eac.htm*

ENERGY FUTURE COALITION: *http://www.energyfuturecoalition.org*

EPRI INTELLIGRID: *http://intelligrid.epri.com/*

FERC/NARUC COLLABORATIVE: *http://www.naruc.org/ferc/default.cfm?c=3*

GRID WEEK: *http://www.gridweek.com*

GRIDWISE ALLIANCE: *http://www.gridwise.org*

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA): *http://www.nema.org*

NATIONAL ENERGY TECHNOLOGY LABORATORY (NETL): *http://www.netl.doe.gov/*

PACIFIC NORTHWEST NATIONAL LABORATORY (PNNL): *http://www.pnl.gov/*

PNNL GRIDWISE: *http://www.gridwise.pnl.gov/*

SMART GRID: *http://www.oe.energy.gov/smartgrid.htm*

SMART GRID MATURITY MODEL (SGMM): *http://www.sei.cmu.edu/smartgrid*

SMART GRID TASK FORCE: *http://www.oe.energy.gov/smartgrid_taskforce.htm*

ENDNOTES

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[2]EIA, http://www.eia.doe.gov/oiaf/1605/ggrpt/pdf/0573(2007).pdf

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[6]Smart Grid Benefits, DOE Modern Grid Strategy, August 2007

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[11]Pacific Northwest National Laboratory, "The Smart Grid and Its Role in a Carbon-constrained World," February 2009

www.smartgrid.gov

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