WHAT THE SMART GRID MEANS TO AMERICANS.

A smarter electrical grid can save us energy, protect consumers, safeguard our environment and ultimately save money for all Americans.

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Your stake as a consumer advocate.

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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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Our nation's grid, which has performed brilliantly for more than a century in powering our nation's past prosperity, is ill-equipped on several fronts to meet our collective future.

WHAT IS THE SMART GRID?: **WHY DO WE NEED IT?**

As a consumer advocate, you've probably heard the term "Smart Grid" a time or two. If and when you get a spare moment, you'll probably even get around to researching it in depth.

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 ultimate goals that together define a Smart Grid.

We submit that for a key stakeholder like you and the people you represent, that time is now.

Like the telecom and Internet revolutions that preceded it, technology holds the key to realizing the Smart Grid. The Smart Grid and the technologies embodied within it are an essential set of investments that 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.

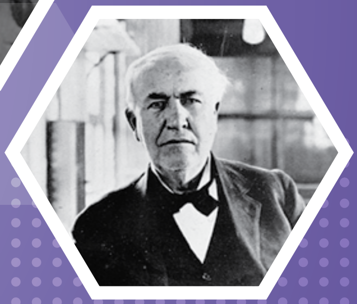
Far more than "smart meter," a fully-functioning Smart Grid will feature sensors throughout the transmission and distribution grid to collect data, real-time two-way communications to move that data and electricity between utilities and consumers, and the computing power necessary to make that intelligence 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.

HERE'S WHY WE NEED THE SMART GRID

Our nation's grid, which has performed brilliantly for more than a century in powering our nation's past prosperity, is ill-equipped on several fronts to meet our collective future. Consider the grid's declining reliability factor, recognized as long as a decade ago. The second half of the 1990s saw 41% more outages affecting 50,000 or more consumers than in the first half of the decade. It remains victim to outages and interruptions that cost Americans $150 billion annually – or $500 for each one of us.[1]

WE'RE RUNNING OUT OF TIME

Over the next seven years, electricity prices are forecast to increase 50%[2], redefining everyone's idea of 'affordability.' Spiraling electricity rates and the cost of carbon



DON'T I KNOW YOU FROM SOMEWHERE?

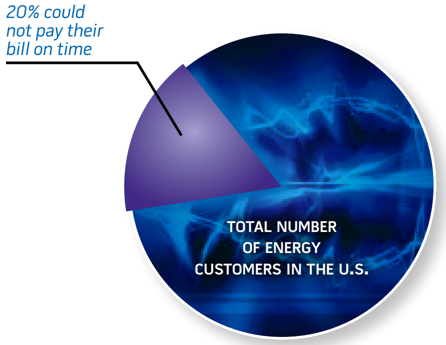
To give you an idea of the current state of grid modernization, consider this: If Alexander Graham Bell were confronted with today's telephony – cell phones, texting, etc. – he would most likely be amazed. Thomas Edison, meanwhile, would feel quite at home in the largely non-digital, electromechanical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

(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.

Nationwide, demand for electricity is expected to grow 30% by 2030.[3] To support growth of such magnitude, investments totaling approximately $1.5 trillion will be required over the next 20 years to pay for infrastructure alone according to The Brattle Group – a consulting group that specializes in economics, finance, and regulation. This is occurring in an industry where investments and R&D have traditionally lagged far behind other industries. In transmission alone, investments actually decreased nearly 50% in the last quarter of the 20th century.

YOUR ROLE JUST GOT BIGGER

During the winter of 2007/08, 20% of Americans fell behind in their energy payments and an astonishing 8.7 million American consumers were disconnected from utility services.[4] If we were to maintain the "status quo," percentages such as these would only increase. But an Act of Congress, as well as the imprimatur of the Administration, are working to change things. As you will see in the following pages, by spurring transitioning to a smarter grid – some of which is happening now – and ultimately the Smart Grid, electricity will be more affordable and our environment better protected. Throughout the transformation to a Smart Grid, you'll be charged with ensuring fairness, cost-effectiveness and appropriate customer protections. This book is designed to inform your perspective going forward.



A QUESTION OF FAIRNESS?

Historically, the electrical grid has been heavily regulated and modeled to keep costs low. Partly for this reason, its modernization by means of IT tools and techniques has been until relatively recently a back-burner priority. Given the number of choices technology has made available to businesses and consumers by Internet and telecom companies, you might even say it hardly seems fair.

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.

SECTION **02**

A smarter grid gets that way by giving consumers the power to participate and choose.

THE SMART GRID: ***OPPORTUNITIES IN BRIEF.***

Realizing the Smart Grid will require, to greater or lesser degrees, smart sensors and controls, broadly accepted communications platforms, advanced tools for planning and operation and dynamic pricing.

It will also require clear standards for interconnection and metrics. Constantly communicating, proactive and virtually self-aware, the Smart Grid has been described as a complex ecosystem.

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 DOE's Modern Grid Strategy and the Electricity Advisory Committee.

HERE'S HOW THE SMART GRID DELIVERS:

Benefit: Enabling active participation by consumers.

A smarter grid gets that way by giving consumers the power to participate and choose. Two-way communication will create a dialog between utilities and consumers enabling consumers to see what electricity they use, when they use it, and how much it costs. For the first time, many will be able to manage their energy costs proactively, whether that means investing in intelligent, energy-saving end-use devices or selling energy back to the utility for revenue or as a means of exercising environmental stewardship.

From the utility perspective, "customer participation" will enable utilities to enlist consumer demand as another resource, offsetting the need for additional power generation. With help from customers, utilities will be able to help balance supply and demand and ensure reliability by modifying the way they use and purchase electricity. For the first time, residential customers will have the same types of demand-response options as many commercial and industrial customers enjoy today.

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.

Smart Grid technology was on display during 2008's Hurricane Gustav, when Entergy's use of Phasor Measurement Units (PMUs) "islanded" an area without power to prevent a far wider incidence of outages. By having the PMUs' global positioning system (GPS) time-synchronized and taking frequency measurements at 30 samples/second, Entergy was able to monitor real-time changes of the island, an advantage not possible with supervisory control and data acquisition (SCADA) data.

Benefit: Optimizing asset utilization and efficient operation.

The Smart Grid will be able to exploit proven technologies to optimize the use of its assets – power plants, distribution substations and other critical infrastructure. Such improvements will result in more power flowing through existing assets as well as giving utilities more precise insight into the need for additional power plants. Operational improvements will range from improved load factors to lower system losses. The result: A net reduction in utility costs, and maximization of efficiencies throughout the system.

Benefit: Anticipating and responding to system disturbances.

By performing continuous self-assessments, the Smart Grid will be able to prevent disruptions rather than simply react to them and act faster than operators ever could in resolving fast-moving problems.

Benefit: Accommodating all generation and storage options.

Central to the success of the Smart Grid is the ability to safely and seamlessly accommodate a wide variety of generation, from massive centralized plants to small solar panels and everything in between. "Everything in between" refers to the growing roster of distributed energy resources (DER) which include:

- *Distributed generation (DG) – small, widely dispersed plants, generally in close proximity to load*
- *Renewables – wind, solar, biomass, etc.*
- *Energy storage – in essence, giant "batteries" and "capacitors"*
- *Demand response (DR) – decreasing demand instead of increasing supply in response to peak loads*

Opportunities for grid-connected distributed generation are substantial. With the progression of Smart Grid adoption, DER is envisioned to increase rapidly all along the value chain, from suppliers to marketers to customers. The upshot: A grid that is less expensive, more reliable and environmentally friendlier.

Benefit: Providing power quality for the digital economy.

It is a fact of modern life that our economy grows relentlessly more digital by the minute. Check out your nearest server farm, brokerage operation or high-definition television. According to the Electric Power Research Institute (EPRI), by 2011, fully 16% of our

As numerous studies indicate, the societal case for Smart Grid adoption is fundamental, lasting and real.

- *Over 20 years, $46 billion to $117 billion could be saved in the avoided cost of construction of power plants, transmission lines and substations.[5]*
- *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]*

nation's electric load will require digital-quality power. And there's no turning back. The Smart Grid will be able to supply varying grades of power quality with a variety of pricing options. It will also detect and correct poor power quality before its effects become significant, dramatically reducing customer losses due to power quality issues – currently estimated at $25 billion per year – and increasing overall quality control of the grid.[9]

Benefit: Enabling new products, services and markets.

In overlaying intelligence across the national grid, Smart Grid principles and technologies support the creation of well-integrated electricity markets compared to the somewhat Balkanized markets of today. The certainty and vibrancy inherent in such markets will attract new market participants – brokers, aggregators and the like – and open the door to new ideas, products and services.

Benefit: Operating resiliently against attack and natural disaster.

Today's grid is far too susceptible to disruption by means of both natural disasters and human actions or attack. The Smart Grid will address critical security issues from the outset, making security a requirement for all of its elements.

at-a-glance

Benefits *of the Smart Grid:*

- *Enabling active participation by consumers*
- *Optimizing asset utilization and efficient operation*
- *Anticipating and responding to system disturbances*
- *Accommodating all generation and storage options*
- *Providing power quality for the digital economy*
- *Enabling new products, services and markets*
- *Operating resiliently against attack and natural disaster*

To fully capitalize upon grid modernization, certain elements of the Smart Grid plan must be as thoughtful as the technologies deployed.

RATES & REGULATIONS: **POSSIBLE APPROACHES.**

Currently, the benefits of the Smart Grid are not as apparent to many stakeholders as they could or should be. Like the early days of construction of the interstate highway system, it may be difficult to envision the Smart Grid's ultimate value during its building phase. In fact, perhaps all that certain observers can see when they consider the Smart Grid is disruption of the status quo.

What is abundantly clear is that our costs are rising, our environment is suffering, our energy resources are finite – and we need a plan, disruptive or not. Try to imagine the interstate highway system without one: "Roads to Nowhere," everywhere. Or the Internet without an organizing principle. Millions might have access to e-mail, but millions more would be staring at blank screens.

To fully capitalize upon grid modernization, certain elements of the Smart Grid plan must be as thoughtful as the technologies deployed. Here, we enumerate a number of approaches towards that objective.

DYNAMIC PRICING

The typical electric bill of decades past was undecipherable to many and delivered long after the electricity was. Worse yet, that bill is still being snail-mailed today to far too many consumers of electricity, at a time when existing and emerging technologies make it possible for consumers to see the day-to-day cost of electricity. The capability of Advanced Metering Infrastructure (AMI) to facilitate two-way communication, interval metering and time-based billing make dynamic pricing an option for all classes of utility customers – including lower-income customers.

Dynamic pricing reflects hourly variations in retail power costs, furnishing customers the detail necessary to manage their utility bills in a variety of beneficial ways. Three principal categories of dynamic pricing include:

- *Real-time pricing – rates are based on hourly fluctuations in wholesale markets, which enable consumers to plan their electric use to coincide with low prices.*

DECOUPLING DEFINED

According to NARUC, decoupling "is a generic term for a rate adjustment mechanism that separates (decouples) an electric or gas utility's fixed-cost recovery from the amount of electricity or gas it sells. Under decoupling, utilities collect revenues based on the regulatory-determined revenue requirement, most often on a per customer basis. On a periodic basis revenues are 'trued-up' to the predetermined revenue requirement using an automatic rate adjustment."

- *Peak-time rebate – the traditional blended rate applies, but customers can realize healthy rebates for reducing load during peak periods.*

- *Critical-peak pricing – prices can increase by 500% during peak periods, limited to a small number of hours per year. Customers agreeing to reduce usage in such hours will pay slightly lower rates for the remainder of the year.*

Especially in the prevailing economy, customers may want to avail themselves of as many tools and choices as possible to control their usage and energy bills. According to its adherents, dynamic rates, judiciously structured and applied, stand to benefit every consumer of electricity. Consider a working family out of the house for most of the day with the kids at school. The family's ability to save money by participating in demand-response efforts during the afternoon peak can be very beneficial to them.

With dynamic rates, there are also savings to the system and ratepayers as a whole every time peak demand is reduced because the utility doesn't have to buy expensive power at 2 in the afternoon on July 15 or fire up that expensive peaking plant.

INCENTIVIZING UTILITIES

The pros and cons of retail rate reform with respect to the Smart Grid include a number of hot topics. For example, historically a utility's rate of return has been based on the amount of power it generates and energy it sells. Absent in this model is the incentive for any party to conserve energy, which effectively leaves a utility's incentive to engage in demand response, energy efficiency and distributed generation out of the conversation. One way being proposed to redress this issue is decoupling.

Decoupling lowers a utility's rate of return because that utility is assuming less risk. In fact, since it now has certainty, it lowers the revenue requirements overall that customers otherwise would have to pay. If the utility over-recovers, it refunds the surplus to customers in the same way that if it under-recovered, it would require customers to pay a surcharge. Decoupling also brings a degree of transparency to rate cases among all parties – utilities, regulators and consumer advocates.

Some believe that such an incentive to save energy may make it more likely to subscribe to demand-response, energy-efficiency and distributed-generation programs that haven't "paid off" in the past.

Other stakeholders maintain that decoupling is not the answer, that it guarantees earnings to a utility rather than gives it the opportunity to earn. In response, decoupling advocates argue that it is precisely in removing this risk or uncertainty that enables utilities to take advantage of saving energy rather than generating even more of it.

DYNAMIC IDAHO

The Idaho Public Utilities Commission is actively gauging the effectiveness of dynamic pricing strategies. The state's time-variant pricing programs include Energy Watch, a simplified critical peak pricing program that rewards customers for reducing demand during summertime "Energy Watch events"; and a Time-of-Day program for customers who shift consumption of electricity from daytime hours to the late evening and weekends. Among the Commission's findings are that customers substantially reduced load during Energy Watch events.

The state is also one of the "early adopters" of decoupling. A three-year pilot has been instituted and is currently deployed by the Idaho Power company. For a map of current decoupling activity by state, visit the website of the Institute of Electric Efficiency (IEE).

EFFICIENCY ORGANIZATIONS: AN ALTERNATIVE APPROACH TO RETAIL RATE REFORM

NARUC holds the position that taking utilities out of the efficiency business and having that function played by a State, quasi-State, or private sector entity is a proven alternative to removing disincentives to their promoting efficiency. In fact, numerous examples exist of successful efficiency programs being delivered by non-utility providers. Examples of such organizations include Efficiency Vermont and the New York State Energy Research and Development Authority (NYSERDA).

NET METERING

Net metering programs serve as an important incentive for consumer investment in distributed energy generation, enabling customers to use generation on their premises to offset their consumption by allowing their electric meters to turn backwards when they generate electricity in excess of their demand. In some states, this offset means that customers receive retail bill credits for the electricity they generate themselves, rather than buy from the system.

THESE APPROACHES ARE NOT SELF-EVIDENT

It will require significant educational outreach to ensure that consumers and utilities alike understand the potential benefits that can be gained from decoupling, dynamic pricing, net metering and similar concepts as they apply to the Smart Grid. DOE is charged with raising their awareness. This book is just one of the many resources you have at your disposal; others are noted in the Resources section.

On approaches like these and others, stakeholders can and will "agree to disagree." However, merely discussing issues such as net metering can result in various constituencies moving beyond conflict to consensus to create forward momentum toward realizing the Smart Grid.

Visit naruc.org for more information.

Visit dsireusa.org to learn more about renewable-energy and energy-efficiency incentives for each state.

HOW NET METERING WORKS IN PENNSYLVANIA

Properly designed regulations & policies like net metering can further the development of the Smart Grid.

In Pennsylvania, investor-owned utilities must offer net metering to residential customers that generate electricity with systems up to 50 kilowatts (kW) in capacity; nonresidential customers with systems up to three megawatts (MW) in capacity; and customers with systems greater than 3 MW but no more than 5 MW who make their systems available to the grid during emergencies. It is available when any portion of the electricity generated is used to offset on-site consumption.

Systems eligible for net metering include those that generate electricity using photovoltaics (PV), solar-thermal energy, wind energy, hydropower, geothermal energy, biomass energy, fuel cells, combined heat and power (CHP), municipal solid waste, waste coal, coal-mine methane, other forms of distributed generation (DG) and certain demand-side management technologies.

Net metering is achieved using a single, bi-directional meter – i.e., two-way communication – that can measure and record the flow of electricity in both directions at the same rate. Net excess generation is carried forward and credited to the customer's next bill at the full retail rate, which includes the generation, transmission and distribution components.

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.

A smarter grid delivers end-use conservation and efficiency thanks to its ability to establish more focused and pervasive consumer participation. From a behavioral perspective, there is measurable energy savings when consumers participate, approximately 6% in the residential sector. Awareness on the part of consumers to manage peak load by virtue of a feedback mechanism may incite greater attention to consumption patterns and results in savings.

Proving that timing is everything, a smarter grid can capture carbon savings from peak load shifting – even if energy is not being saved. When peak load is reduced by means of demand response, many peaking plants – and the carbon they emit – are kept on the sidelines.

THE SMART GRID & PLUG-IN ELECTRIC VEHICLES

The Smart Grid's single biggest potential in 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). 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. The idle production capacity of today's grid could supply 73% of the energy needs of today's cars, SUVs, pickup trucks, and vans with existing power plants.[11] Additional benefits include the potential to displace 52% of net oil imports (or 6.7 million barrels per day) and to reduce CO_2 emissions by 27%.[12]

Widespread adoption of PHEVs 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.

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.

Widespread adoption of PHEVs will cut greenhouse gases (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.

ENABLING CARBON SAVINGS

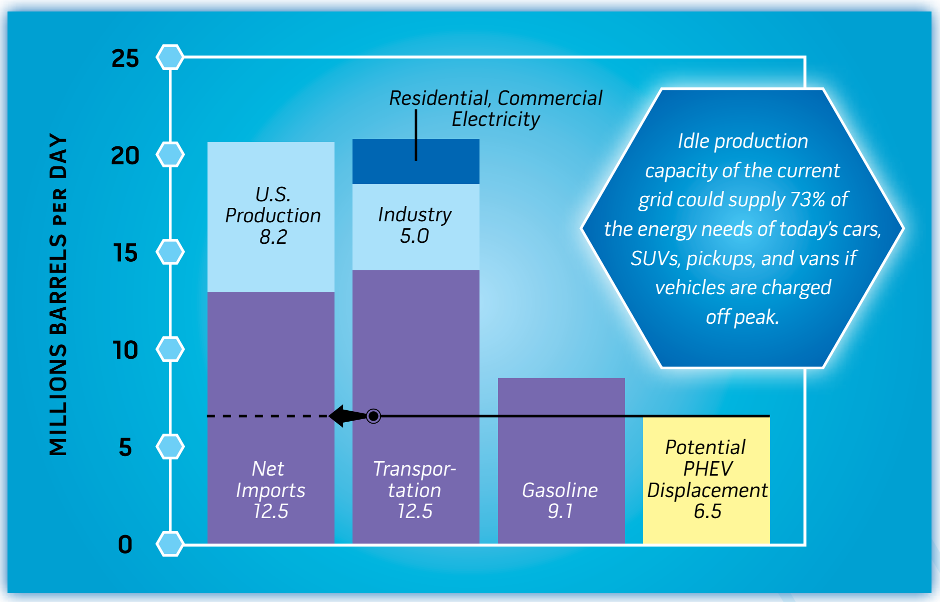
The full exploitation of renewable energy sources such as wind and PV solar is critical to managing our collective carbon footprint. However, when viewed against the limitations of the current grid, both technologies face barriers to full-scale deployment. A smarter grid enables grid operators to see 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, you will be

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



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.

better able to manage these fluctuations (i.e., when the wind doesn't blow) to lower the cost of integrating wind into the system.

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."

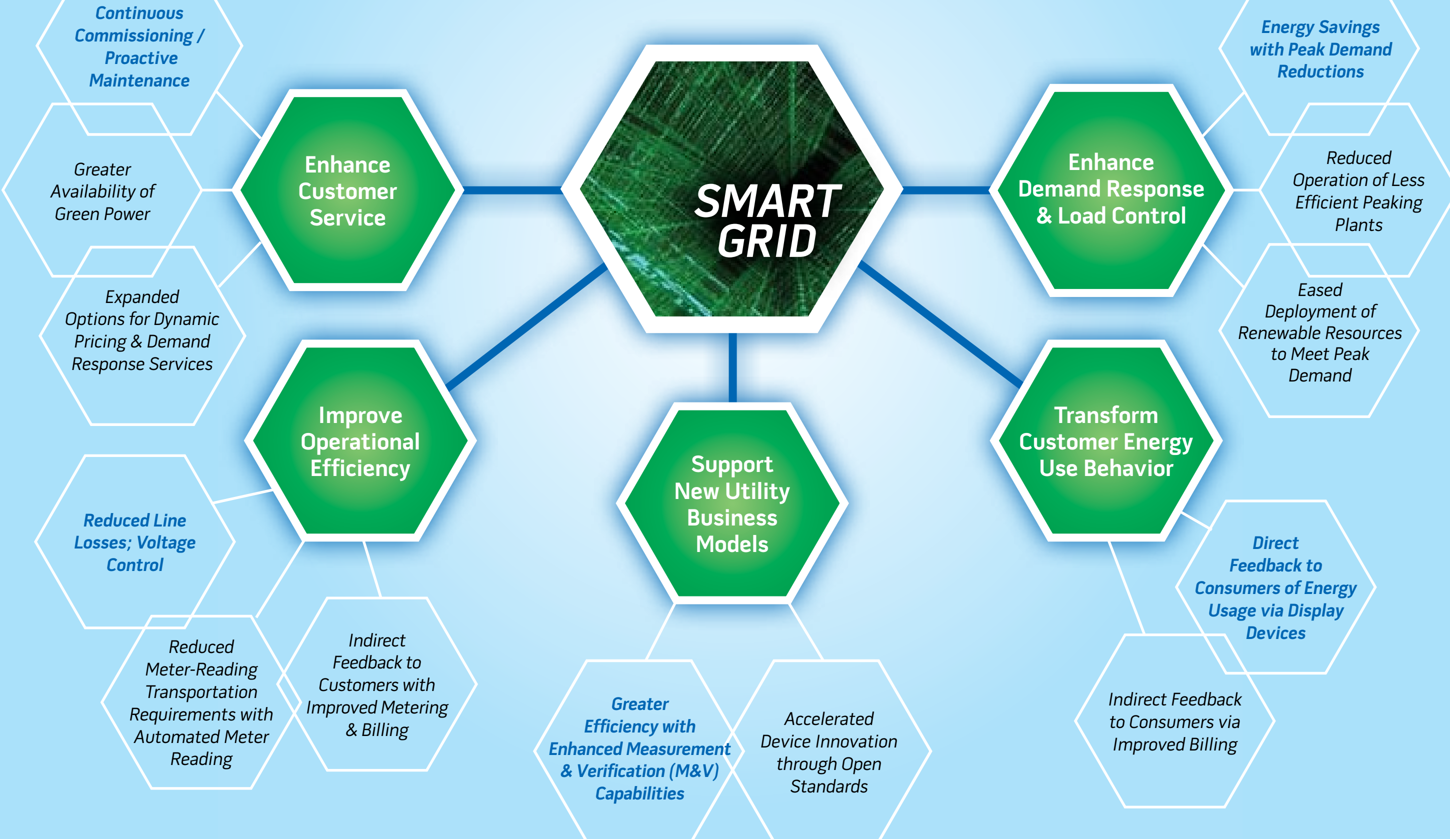
OPTIMIZING SOLAR

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

ENABLING STORAGE

The Smart Grid enables utilities to put more batteries and other forms of energy storage in more places. Stationed at thousands of points throughout the Smart Grid, they will provide additional electricity resources throughout the system.

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

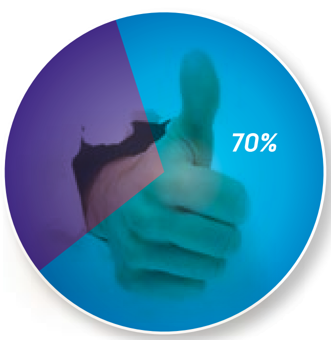


As the owners of the infrastructure, utilities and other service providers are keenly aware of their sizable carbon footprints. Recently, in EPRI's Green Grid Whitepaper, the Institute identified ways in which utilities can reduce carbon through the use of Smart Grid approaches and technologies.

Living in a world of seemingly endless customer choice, consumers have grown impatient with systems characterized by one-way communication and consumption.

CONSUMER ALERT: **THE APPETITE FOR – AND PACE OF – SMART GRID CHANGE.**

Attempting to gauge the rate of acceptance for a smarter grid reveals a fluid landscape of changing attitudes, successful Smart Grid programs and appliances that think.



7 out of 10 people expressed "high interest" in a unit that keeps them apprised of their energy use as well as dynamic pricing.

PEOPLE

What will the Smart Grid do for consumers? And how much do consumers care?

In addition to making grid operations as a whole more reliable – an extremely worthy goal in itself – the Smart Grid will empower average energy consumers to a degree unimaginable just a few years ago. Given new awareness, understanding and tools, they'll be able to make choices that save money, enhance personal convenience, improve the environment – or all three.

Until recently, the overwhelming majority of consumers considered energy a passive purchase. According to conventional wisdom, no one really wanted to think about it. And, frankly, why would they want to? Historically, the system never differentiated the true cost of electricity to the consumer, so they've been programmed not to care. Recent research, however, indicates that this perception has changed significantly. Research conducted in 2007 by Energy Insights indicates that consumers are interested in opportunities afforded them by the Smart Grid.

Although some consumers will opt for continued passivity, many will want to be involved in managing how and when they consume energy. Living in a world of seemingly endless customer choice – courtesy of the Internet, telecom and YouTube – consumers have grown impatient with systems characterized by one-way communication and consumption. Research by Energy Insights also reveals that 70% of respondents expressed "high interest" in a unit that keeps them apprised of their energy use as well as dynamic pricing.

When transmission and distribution sensors are added, 100% of Austin Energy's consumer base will be served by Smart Grid technologies.

Another key trigger for the growth of this consumer class has been growing environmental awareness. A key frustration is that members of this class don't have the tools to make these choices. Once Smart Grid technologies get this information into their hands, customers will enjoy greater levels of satisfaction and service as measured by outage minutes and have the sense that they can control their bills. More broadly, they'll be able to do their part to reduce peak, which gives rise to both environmental and economic benefits.

PLACES

Austin, Texas

Austin Energy, a utility thoroughly focused on the bottom line due to its municipal ownership, thought it was embarking on a modernization project. Instead, it went far beyond that objective, enabling consumer choice through a wide array of programs including demand response/load management, distributed generation and renewable energy programs. Programs such as these enabled the utility to fund investment in new technologies *at no extra cost to consumers*. Recent deployment included 130,000 smart meters and 70,000 smart thermostats. When transmission and distribution sensors are added, 100% of Austin Energy's consumer base will be served by Smart Grid technologies.

Olympic Peninsula, Washington

One of the first multi-dimensional DOE Smart Grid demonstration projects asked electricity customers to specify a set of simple energy preferences – and then forget about them. In the background, the utility managed energy through smart appliances and thermostats on the customer's behalf, saving customers approximately 10% on average.[13] A true measure of customer acceptance – many didn't want the project to end.

(SMART) THINGS

As for 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

"IF YOU ARE CALLING TO REPORT AN OUTAGE..."

It was voted the most significant engineering achievement of the 20th century.

Yet some of the people who run it aren't aware it's not working unless the people "left in the dark" tell them.

A father discovers his 4-year-old behind the television, intently searching for something among all the wires. Asked what she's trying to find, she replies,

"I'm looking for the mouse."

New York Times, March 31, 2008

— Tomorrow's energy consumer, demonstrating a clear preference for two-way communication.

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.

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.

THE PRIUS EFFECT

The Prius makes a strong anecdotal case for "letting the customer drive" when it comes to energy decisions. Toyota's most renowned hybrid vehicle features a dash-board monitor that constantly indicates what effect your driving habits have on your efficiency and makes visible – in real-time – the consequences of your energy usage. The resulting "Prius Effect" has been cited by various energy and computing researchers as convincing evidence that consumers will readily change their habits if exposed to feedback in real time.

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

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 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?

Moving forward toward the Smart Grid can't be done without adopting a systems view. Utilities and Policymakers alike 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 creating a smarter grid.

Maturity models – which enable executives to review the progress a business is making in transforming or altering the way it operates – have an estimable 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 based upon stakeholder needs, user feedback and market requirements.

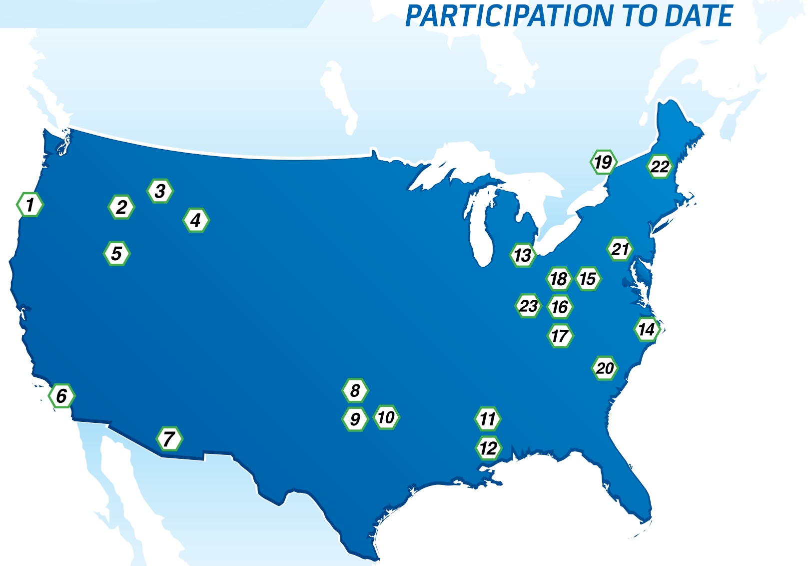
SMART GRID MATURITY MODEL
Levels, Descriptions, Results

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

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.

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

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: ***USING THE POWER OF COLLABORATION TO DRAW CLARITY FROM COMPLEXITY.***

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

In terms of generating enduring benefits to the grid and society, the Smart Grid represents seven defining and beneficial functions:

- *Accommodating all generation and storage options*
- *Enabling informed participation by customers*
- *Enabling new products, services and markets*
- *Providing the power quality for the range of needs in the 21st century*
- *Optimizing asset utilization and operating efficiently*
- *Addressing disturbances through automated prevention, containment and restoration*
- *Operating resiliently against physical and cyber events and natural disasters*

Clearly, these functions are desirable by any standard. Yet reconciling their value with the day-to-day business before 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

The Smart Grid Clearinghouse will serve as a repository for public Smart Grid information and direct its users to other pertinent sources or databases for additional public Smart Grid information.

sponsorship to form the FERC/NARUC Smart Grid Collaborative, using collaboration to draw clarity from complexity.

The Collaborative brings information to regulators so they can get a better sense of the state of Smart Grid issues, technologies and best practices. At joint meetings, regulators interact with a wide array of subject-matter experts on issues that range from AMI to interoperability standards to appropriate timing for Smart Grid deployments. Additionally, they are apprised of Smart Grid projects already at work. 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 SMART GRID CLEARINGHOUSE

The Collaborative sees the DOE-sponsored Smart Grid Clearinghouse as an additional tool for Smart Grid stakeholders to advance 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.

The Smart Grid Clearinghouse will serve as a repository for public Smart Grid information and direct its users to other pertinent sources or databases for additional public Smart Grid information. The Clearinghouse will become the preeminent resource for stakeholders interested in researching high-level Smart Grid developments and keeping abreast of updates.

In general, the Clearinghouse will be established and maintained in a timely manner that will make data from Smart Grid demonstration projects and other sources available to the public.

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.

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.

The future has a funny way of arriving while we're not looking. Moving toward Smart Grid adoption is a worthy and necessary step toward that future.

NEXT STEPS: **ACTION OR INACTION?**

What if?

What if, instead of building the Smart Grid, we do nothing?

Does a Smart Grid really matter?

IF WE DO NOTHING, an environmental study shows that 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.

The same study shows 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.[14]

IF WE DO NOTHING about engaging the consumer, we can expect to run out of both choices and time, drastically limiting our ability to meet future energy challenges.

IF WE DO NOTHING, the incidence of massive and crippling blackouts will likely increase.

IF WE DO NOTHING, rates will increase dramatically to pay not only for electricity, but also for increased transmission constraints, ever higher peak loads and the mortgages on outdated assets.

IF WE DO NOTHING, all of us will pay substantially more for electricity, to say nothing of the resulting plight of those who can least afford to pay.

NOW CONSIDER ACTION

The promise of a fully functioning Smart Grid gets closer every day as more stakeholders align behind it. For consumer advocates and the people you serve, there are legitimate questions as to its implementation. There is understandable concern relative to consumer protection in that, with the Smart Grid, the relationship between the utility and the customer may change dramatically. For instance, in permitting utilities or other

The risk a firefighter assumes when he or she runs into a burning building is compounded by the fact that the utility cannot easily cut power to the structure without manual intervention.

If nothing else changes – that needs to. A smarter grid makes it possible.

service providers access to data within the home, how do we ensure that such data is used appropriately and handled securely?

With prudent regulatory policy and utility rules, it will be easier to identify and protect those customers who can't protect themselves. Low-income customers, customers on fixed incomes, and the elderly are most at risk from extreme heat and cold when power is lost. A more reliable grid will limit the risk and duration of outages and accelerate the restoration of service.

What is lacking is effective consumer education, because the benefits of a Smart Grid have not been made clear to consumers. We hope that this book has illuminated some of those benefits and refer you to the following pages for more resources. Use them to learn more about the advancements that the Smart Grid can and will make possible for all of us.

A smarter grid will evolve into a fully integrated Smart Grid over time. But that time is not far off. Remember that "just" fifteen years ago, not many people had a cell phone. Fast-forward now to 2017, when there's general agreement that a million plug-in electric vehicles will be on the road – and potentially lessening strain on the grid.

The future has a funny way of arriving while we're not looking. Moving toward Smart Grid adoption is a worthy and necessary step toward that future.

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.

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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www.smartgrid.gov

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