HOW THE SMART GRID PROMOTES A GREENER FUTURE.

A smarter electric grid can engage renewables at scale, enable the market for electric transportation and usher in a new age of sustainability.

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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 nations electricity grid to improve its reliability and efficiency. As part of this effort, DOE is also responsible for increasing awareness of our nations 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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The nation's electricity consumption is estimated to increase by 41% by 2030.

THE SMART GRID: LESSENING THE NEED FOR MORE.

A century-old, trillion-dollar machine that has served our nation exceedingly well works tirelessly in our midst. Hidden in plain sight, its approximate dimensions are nevertheless difficult to ignore: 1 million megawatts of generating capacity, 200,000 miles of high voltage transmission lines and 5.5 million miles of distribution lines.[1]

America's electrical grid, hailed as the most significant engineering achievement of the 20th century, has fueled our nation's prosperity almost since the days of Edison. It continues to keep our lights on, our businesses productive and our citizens comfortable. And it responds to our split-second demands 99.97% of the time.[2]

Yet because the grid was never built to respond to today's environmental challenges, it is frankly failing on this score.

Failing to respond to the stresses of climate change. 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.[3]

Failing to respond to issues of sustainability. The nation's electricity consumption is estimated to increase by 41% by 2030. The production of electricity from fossil-fuel power plants is forecast to increase during the same period from 71% to 74%, requiring investment in new plants. In fact, 319 new fossil-fuel generators are scheduled to be online by 2011.[4]

THE SMART GRID: WHAT IT IS. WHY WE NEED IT.

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

Until now.

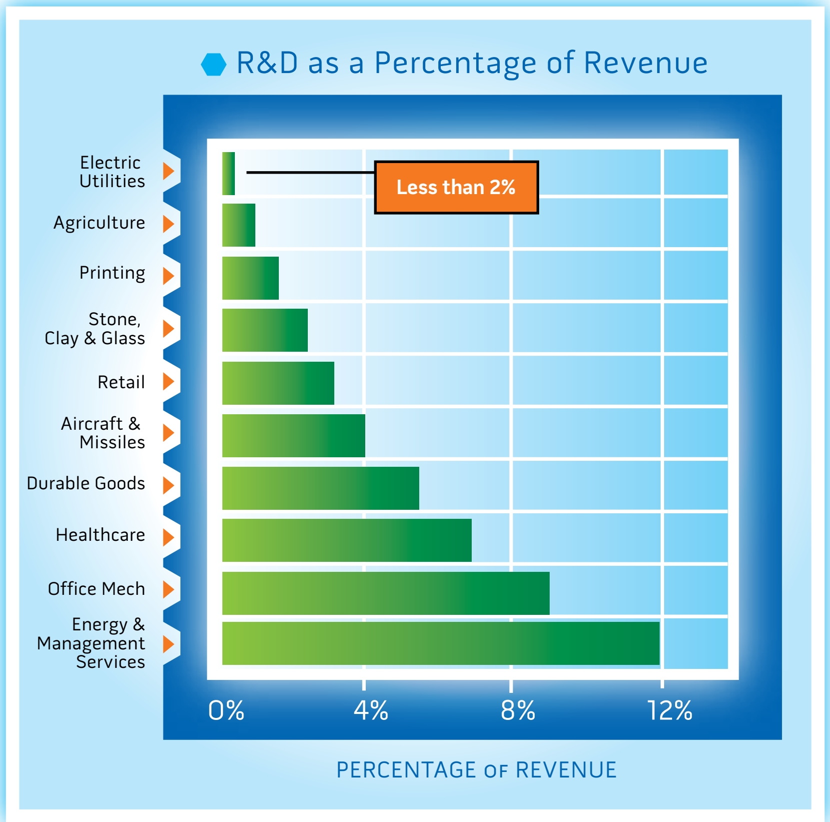
TRIPLE BOTTOM LINE DEFINED

Triple bottom line" was first used in 1989 by John Elkington, co founder of a consultancy focused on sustainability. Alternately referred to as TBL," or "3BL," triple bottom line stands for People, Planet and Profit – and the betterment of all three.

Like the telecom and Internet revolutions that preceded it, technology holds the key to the Smart Grid and its realization. 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, more environmentally responsive 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 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.

That transformation will also produce equally important environmental benefits.



Research and development in the grid has lagged far behind other industries.

THE SMART GRID REPRESENTS OUR NATION'S SINGLE BEST CHANCE TO BUILD SUSTAINABILITY INTO THE ELECTRIC SYSTEM.

Slowing the advance of climate change requires a mission, vision and game plan equal to the challenge. Such key components are resident in the Smart Grid. As you'll see in the following pages, revitalizing the grid will synergize efficiency programs, demand response, renewable energy sources and distributed generation to a degree previously unattainable. It will enable citizens to exercise control over how and when they use energy, incent utilities to save energy as well as generate electricity, and motivate businesses to attain sustainability's triple bottom line.

Only with a comprehensive set of Smart Grid policies and technologies can renewables be integrated at high penetration at the scale and speed we need to address climate change.

Only with two-way communication between energy service provider and customer – one of the Smart Grid's bedrock principles – can plug-in electric vehicles (PEVs) ever assist in sustaining a more reliable, flexible and balanced grid.

Only a smarter grid will enable us to measure and verify what has never been measured and verified – remediating system inefficiencies and allowing us to conserve more energy as a result.

Only with a smarter grid in place can consumers step forward, exercise their brand of environmental stewardship, and help us all use less energy.

THE GOOD NEWS: WE'RE NOT AT SQUARE ONE.

Across the country, utilities are already integrating new technologies into both their transmission and distribution systems to make them more efficient. Technology providers have developed "shelf-ready" solutions available to be deployed today. Regulators are actively collaborating on innovative approaches to Smart-Grid ratemaking. And research indicates that residential consumers are willing to pay more to lessen the generation of greenhouse gases.

As an environmentalist, your participation is critical to ensure the ultimate creation of a Smart Grid that makes good on our environmental promises, safeguards future generations and reasserts environmental leadership to the rest of the world.

A JOURNEY RATHER THAN A DESTINATION

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 full realization of everything it can be.

Transformation to a smarter grid will lead to enhancements that will positively affect every aspect of generation, delivery and consumption.

KNOWLEDGE EMPOWERED: BENEFITS OF A MODERNIZED ELECTRIC GRID.

Smart Grid will require, to greater or lesser degrees, real-time pricing, smart sensors and controls, broadly accepted communications platforms, and advanced tools for planning and operation. It will also require clear standards for interconnection metrics. Constantly communicating, proactive and virtually self-aware, the Smart Grid has been described as something of an 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: 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,

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]*

INSIGHT IS 20/20

According to a study by Cambridge Energy Research Associates (CERA), the cost of building a U.S. power plant has risen 130% since 2000, and 27% in the year prior to October 2007 alone. Clearly, the Smart Grid's ability to bring transparency to the decision of whether or not a new power plant is needed benefits all of us.

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: 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 power generation. With help from consumers, 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.

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: 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 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.

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: 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.

THE SMART GRID JOBS BANK

Among the Smart Grid's other "leading economic indicators" are these:

Up to 280,000 new jobs can be created directly from the deployment of Smart Grid technologies, in addition to enabling a substantial number of indirect jobs through the deployment of new technologies.[9]

The solar industry can create an estimated 440,000 gross jobs and $325 billion in economic development over the next eight years.[10]

An investment of $10 billion in 25-year solar power purchase agreements could produce 4,000 MW of energy and create 350,000 jobs.[11]

A smarter grid delivers end use conservation and efficiency. In so doing, it also positively addresses our nation s growing carbon footprint.

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.[12] This is widely attributable to the length and depth of the worldwide recession and just as widely expected to be an anomaly. Most agree that as the national and global economies improve, carbon emissions will resume their upward trend.

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

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.

From a behavioral perspective, there is a measurable conservation effect when using demand response, approximately 6% in the residential sector.[13] Awareness on the part of consumers to manage peak load by virtue of a feedback mechanism incites greater attention to consumption patterns and results in savings.

ENABLING CARBON SAVINGS

The full exploitation of renewable energy sources such as wind and 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. The Smart 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.

KNOCKING SO_X OFF… AND OTHER BENEFITS

Beyond CO_2, the Smart Grid's ability to make demand response more pervasive and distribution generation more robust also addresses NO_x and SO_x emissions as a collateral benefit. What's more, improved power quality made possible by the Smart Grid, most notably in terms of reduced harmonics and momentary voltage excursions, can reduce electrical losses as well as equipment failures. Residential and small commercial equipment such as computers and plasma TVs are particularly susceptible to power quality and voltage issues.

PV DATA POINT

Covering 4% of the world s desert area with photovoltaics could supply all of the world s electricity.

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.

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.

A SMARTER GRID IS A GREENER GRID

Smart Grid enabled distribution would reduce carbon dioxide emissions by up to 25%.[14]

The use of wind as 20% of the U.S. power supply would save 4 trillion gallons of water typically used in electricity generation between now and 2030, savings all the more significant due to increasing stress on our nation's water supply.[15]

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.

STATES TAKING ACTION:

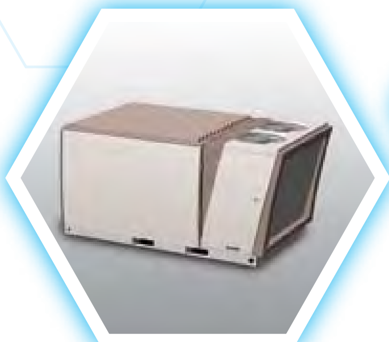
32 states and the District of Columbia have developed and adopted renewable portfolio standards, which require a pre-determined amount of a state's energy portfolio (up to 20%) to come exclusively from renewable sources by as early as 2013.

STATE	AMOUNT	YEAR	RPS ADMINISTRATOR
Arizona	*15%*	*2025*	*Arizona Corporation Commission -*
California	*33%*	*2030*	*California Energy Commission -*
Colorado	*20%*	*2020*	*Colorado Public Utilities Commission*
Connecticut	*23%*	*2020*	*Department of Public Utility Control*
District of Columbia	*20%*	*2020*	*DC Public Service Commission*
Delaware	*20%*	*2019*	*Delaware Energy Office*
Hawaii	*20%*	*2020*	*Hawaii Strategic Industries Division*
Iowa	*105 MW*	*–*	*Iowa Utilities Board*
Illinois	*25%*	*2025*	*Illinois Department of Commerce*
Massachusetts	*15%*	*2020*	*Massachusetts Division of Energy Resources*
Maryland	*20%*	*2022*	*Maryland Public Service Commission*
Maine	*40%*	*2017*	*Maine Public Utilities Commission*
Michigan	*10%*	*2015*	*Michigan Public Service Commission*
Minnesota	*25%*	*2025*	*Minnesota Department of Commerce*
Missouri	*15%*	*2021*	*Missouri Public Service Commission*
Montana	*15%*	*2015*	*Montana Public Service Commission*
New Hampshire	*23.8%*	*2025*	*New Hampshire Office of Energy and Planning*
New Jersey	*22.5%*	*2021*	*New Jersey Board of Public Utilities*
New Mexico	*20%*	*2020*	*New Mexico Public Regulation Commission*
Nevada	*20%*	*2015*	*Public Utilities Commission of Nevada*
New York	*24%*	*2013*	*New York Public Service Commission*
North Carolina	*12.5%*	*2021*	*North Carolina Utilities Commission*
*North Dakota**	*10%*	*2015*	*North Dakota Public Service Commission*
Oregon	*25%*	*2025*	*Oregon Energy Office*
Pennsylvania	*8%*	*2020*	*Pennsylvania Public Utility Commission*
Rhode Island	*16%*	*2019*	*Rhode Island Public Utilities Commission*
*South Dakota**	*10%*	*2015*	*South Dakota Public Utility Commission*
Texas	*5,880 MW*	*2015*	*Public Utility Commission of Texas*
*Utah**	*20%*	*2025*	*Utah Department of Environmental Quality*
*Vermont**	*10%*	*2013*	*Vermont Department of Public Service*
*Virginia**	*12%*	*2022*	*Virginia Department of Mines, Minerals, and Energy*
Washington	*15%*	*2020*	*Washington Secretary of State*
Wisconsin	*10%*	*2015*	*Public Service Commission of Wisconsin*

*Five states, North Dakota, South Dakota, Utah, Virginia, & Vermont, have set voluntary goals for adopting renewable energy instead of portfolio standards with binding targets.

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.



THE BENEFITS OF ENERGY STORAGE

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 Electricity 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 (T&D) infrastructure to meet peak loads (especially during outage conditions) for a time

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

at-a-glance

Types of ***energy storage include:***

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

Widespread adoption of PEVs will cut GHG emissions including CO_2 and significantly reduce our dependence on foreign oil.

THE 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). Included within this vehicle class are plug-in hybrid electric vehicles (PHEVs), the next generation of hybrids.

Here's how they work. PEVs can actually be plugged in to 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 the 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 to conventional 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.[16]

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), PHEVs have the potential to reduce cumulative U.S. GHG emissions by as much as 10.3 billion tons from 2010 to 2050. PHEVs could reduce national oil consumption by as much as four million barrels of oil per day in 2050 according to that same study.

Currently, the United States imports almost 60% of its oil – 70% of which goes directly to the transportation sector. PHEVs could

PHEVs could potentially displace 52% of net oil imports (or 6.7 million barrels per day) and reduce CO_2 emissions by 27%.

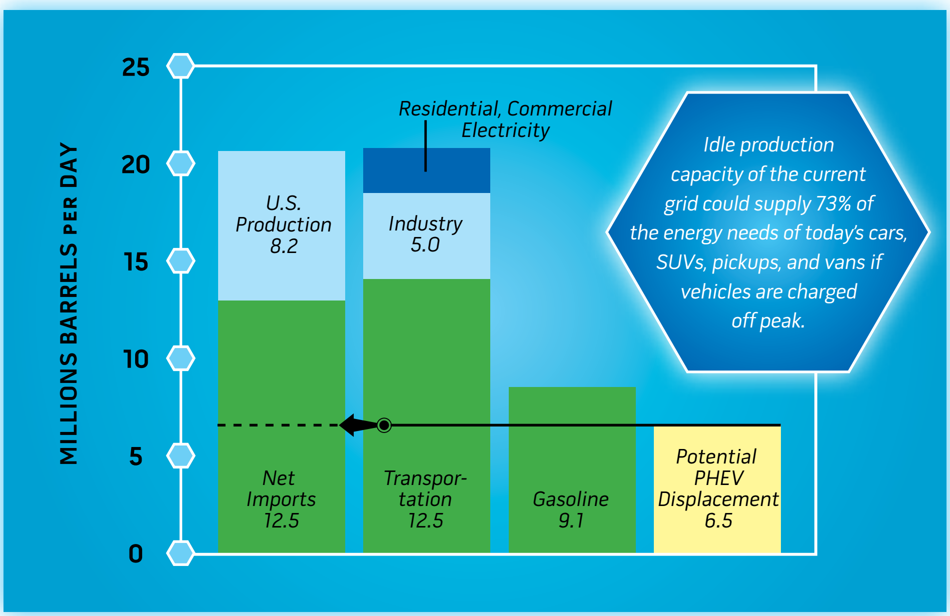
potentially displace 52% of net oil imports (or 6.7 million barrels per day) and reduce CO_2 emissions by 27%.[17]

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 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



ATTENTION FOREIGN OIL SHOPPERS...

According to EEI, at 2009 fuel prices, PHEVs will run on the gasoline equivalent of roughly 75 cents per gallon.

Although some consumers will opt for continued passivity, many more want to be involved in managing how and when they consume energy.

SMARTER GRID IN MOTION: **A PROGRESS REPORT.**

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.

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 more 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 device that keeps them apprised of their energy use as well as dynamic pricing.

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

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

outage minutes) and have the sense that they can control their energy usage. More broadly, they'll be able to do their part to reduce peak load, which gives rise to both environmental and economic benefits.

PLACES

Austin, Texas

Austin Energy, a municipally-owned utility committed to innovation to control costs, 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.[18] 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 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.

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.

*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 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. Utilities 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 based upon stakeholder needs, user feedback and market requirements.

SMART GRID MATURITY MODEL
Levels, Descriptions, Results

LEVEL	ONE: Exploring and Initiating	TWO: Functional Investing	THREE: Integrating Cross Functional	FOUR: Optimizing Enterprise Wide	FIVE: Innovating Next Wave of Improvements
DESCRIPTION	*Contemplating Smart Grid transformation. May have vision but no strategy yet. Exploring options. Evaluating business cases, technologies. Might have elements already deployed.*	*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.*	*Smart Grid spreads. Operational linkages established between two or more functional areas. Management ensures decisions span functional interests, resulting in cross-functional benefits.*	*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.*	*New business, operational, environmental and societal opportunities present themselves, and the capability exists to take advantage of them.*
RESULT	Vision	Strategy	Systemization	Transformation	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

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.

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, you will recall that the Smart Grid is characterized by DOE to represent 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?

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 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.

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.

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 DOE-sponsored 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. Public and private entities and their representing associations – collectively referred to as the Smart Grid community – can also benefit from Clearinghouse access.

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's 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 future before us requires a thoughtful approach and a more expansive view.

NEXT STEPS: **PEOPLE POWER.**

We're depleting fossil fuels millions of times faster than it took to create them. In response, we must adjust our energy consumption and resources into sustainable equilibrium. On its face, it is an undertaking so unthinkably enormous as to cause paralysis. But it is paralysis that our planet cannot afford. Consider the ramifications of doing nothing about implementing a Smart Grid.

According to the National Renewable Energy Laboratory (NREL), if we do nothing, U.S. carbon emissions are expected to rise from 1700 million tons of carbon per year today to 2300 million tons of carbon by the year 2030.[19]

Similarly, while the application of technology is not a panacea, without the Smart Grid, even the boldest energy-efficiency initiatives are not enough. The Census Bureau projects that in 30 years, the United States will be home to 100 million more people, roughly a third more than we have today. Leading organizations like EPRI and others have run the numbers and hold that population growth and a return to a sound economy will more than eliminate the gains from efficiency programs.

The future before us requires a thoughtful approach and a more expansive view. The Smart Grid galvanizes plans and technologies available now to drive our country in the direction of sustainability. It is the best way forward to increase our stock of renewable energy, to maximize energy efficiency and conservation and to lessen the need for more.

The time is right for Smart Grid adoption.

Simply reading recent headlines indicates that a large-scale grid modernization effort must begin, and begin now:

In early 2009, the Environmental Protection Agency (EPA) ruled that carbon dioxide and five other gases are dangerous to our public health and welfare.

Around the globe, countries are considering pursuit of greenhouse gas legislation, suggesting that public awareness of issues stemming from greenhouse gases has never been higher.

As an environmentalist, your involvement is crucial in assisting all stakeholders in validating the environmental benefits that will accrue from the Smart Grid.

According to NREL, "utilities are pressured on many fronts to adopt business practices that respond to global environmental concerns."

A 2009 ABC News/Washington Post poll finds broad acceptance on the government's role in combating climate change. 75% of respondents support federal controls on the release of greenhouse gases in an effort to reduce global warming, 54% "strongly." Regulation wins support even though 77% express concern about its impact on the cost of things they buy. However, even among those who are "very" concerned about the cost impact, two-thirds support the regulation of greenhouse gases nonetheless.

HOW YOU CAN GET INVOLVED

As an environmentalist, your involvement is crucial in assisting all stakeholders in validating the environmental benefits that accrue from the Smart Grid. Such a role will ensure that all tools, technologies and processes are fully and impartially evaluated with respect to climate-change activities and results. Weighing in on new demand-response technologies in development could, for example, accelerate the speed with which the grid and its operators might alleviate local constraints.

BE PART OF THE SOLUTION

Crafting the clean-energy future we all want requires your active participation. Fortunately, an effort of this magnitude has no greater ally than the Smart Grid. Become one of its architects by learning more about the Smart Grid and its progress and by educating your colleagues about it. Resources are available on the following pages. In addition, reaching out to regulators and other stakeholders will better inform your perspective and help identify a common agenda with respect to the Smart Grid.

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*

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