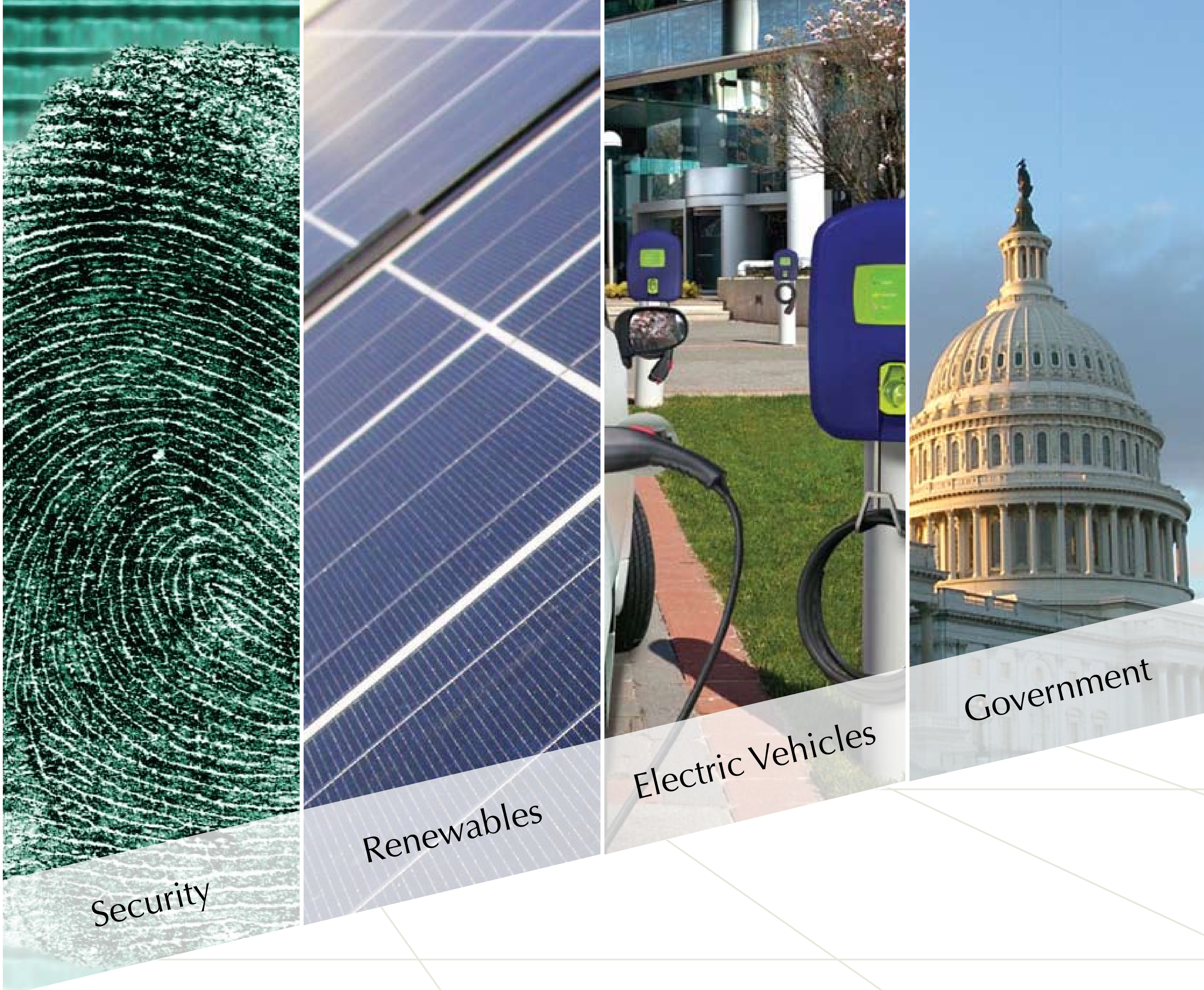

Smart Grid
Building on The Grid

volume 2

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Smart History of the Electric Grid

In order to see the future, a backward glance is helpful.

Throughout history, a number of distinct events have changed the course of our existence: in 1439, Johannes Gutenberg developed the printing press; in 1712, the first commercially successful steam engine was introduced; in 1886, Karl Benz patented the gas-powered automobile; and in the twentieth century, the Internet emerged and forever changed the way we communicate and exchange information.

An especially illuminating event occurred in 1879 when Thomas Edison invented what is considered to be the precursor of the modern light bulb. Three years later, in 1882, he flipped the switch on the first electric grid in lower Manhattan. In less than 100 years, electricity became widely available. It is now delivered by means of expansive electrical grids on every continent on Earth, and is integral to the various satellites that orbit her.

In the decades following this tremendous achievement, however, much of the electrical grid has grown old and outdated. Sadly, Edison would recognize much of today's installations. Too often, we find ourselves looking ahead toward the next technological evolution while our infrastructure is more than a century old.

NEMA believes we need to address the past as a means of moving forward.

The overtaxed and inefficient electrical grid has left the U.S. susceptible to security threats; inhibited alternative energy / conservation goals; and contributed to reliability problems, such as power quality disturbances and blackouts.

Smart Grid is the solution we desperately need to solve many global energy problems. Like the printing press, automobile, and light bulb before it, Smart Grid will change the course of human history. It is changing the way we think about and interact with our electrical system.

Monitoring Energy Usage

Where is the "Check Engine" Light for the Grid?

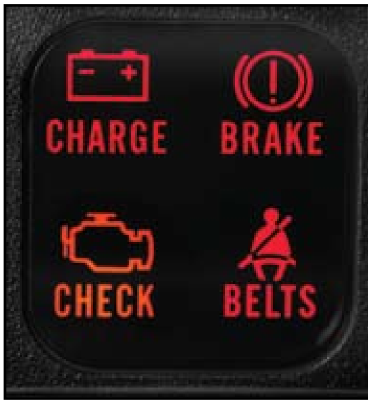
In one sense, you can compare the Smart Grid to the dashboard in your car.

In the early 1900s, when Henry Ford first started to use assembly-line methods to mass produce automobiles, there was very little in the way of instrumentation. Little by little, as the automobile evolved, ever-increasing amounts of operational information were made available to the driver.

Now, as you sit in the driver's seat, you get up-to-date information—on a split-second basis—about speed, fuel level, coolant temperature, engine efficiency, battery charge capacity, and so on. In addition to the information that is displayed full-time on the dashboard, there are a number of sensors working in the background that monitor a variety of critical functions and will illuminate an indicator when something goes wrong.

Until recently, however, there has been no such evolution on the electrical grid.

Many features of the Smart Grid will provide this kind of monitoring and will report the information to both the utility company and the consumer. The improved communication features will allow you to understand more about your energy usage so you can, metaphorically speaking, slow down, change gears, strive for better mileage, and save a few dollars on your electric bill.



Meanwhile, background monitoring programs can serve as the "check engine light" to notify the utility company if some critical component begins to fail or requires maintenance.

Since 2007, when NEMA was named in the *Energy Independence and Security Act* (EISA) to work with the National Institute of Standards and Technology (NIST) on the interoperability framework for Smart Grid, we have been at the forefront of Smart Grid development. As standards are identified, we work to see that they are implemented through the regulatory and legislative processes in order to drive success for the public and our members.

When it comes to empowering the fully-informed electric utility / electricity consumer pair, NEMA's role is to ensure that the appropriate standards exist or are developed to support Smart Grid.

Guideposts of Smart Grid

Why do standards matter in today's evolving Smart Grid?

The interoperable or smart electricity grid consists of many different products, woven into a complex system of systems that must seamlessly provide adequate and cost-effective electrical energy to power our homes, offices, schools, and businesses.

The scale and complexity of the electrical grid necessitate that those involved in developing and managing it share a common understanding of its operational details. This common understanding is ensured through standardization.

Interoperability is fundamental to the performance of the Smart Grid, which is managed and coordinated by exotic communications and control software. Together, these schemes are designed to be integrated into effective cooperation and two-way communication among the many interconnected elements of the power grid. Reliable and effective interoperability requires a foundation of standards.

For example, appliances integrated with smart meters can tell consumers how much power they are using and the cost, thus allowing them to have more control over energy bills. For the utilities, standards are the key to building, maintaining, and managing all of the pieces of the grid that must function in lockstep to ensure a safe, effective, and reliable supply of electrical energy, regardless of demand.

Integrating renewable power sources with utility scale transmission and distribution systems is another example where standards are fundamental.

Meter Upgradeability Standard

To support the development and deployment of Smart Grid, many electric utilities are making advanced metering infrastructure (AMI) and smart meter investments now to enable future Smart Grid, energy management, and consumer participation initiatives.

One of the critical issues facing electric utilities and regulators is the need to guarantee that technologies or solutions that are selected and installed by utility companies today will be interoperable and in compliance with future national standards. In order to preserve their investments, utilities want to ascertain that the systems they select will allow for evolution and growth as Smart Grid standards evolve.

To manage change in a dynamically growing Smart Grid, it is essential to be able to upgrade firmware, such as meters, in the field without replacing the equipment or "rolling a truck" to manually perform the upgrade.

Remote image download capability, a common practice today in many embedded computing devices, permits certain characteristics of the meter to be substantially altered on an as-needed basis. This is much like an iPod. After changing a playlist or purchasing a new song, the device automatically synchronizes and updates itself to include the new song. AMI incorporates this technology.

For investment in and deployment of smart metering to continue at an aggressive pace, the electroindustry has required standards to accommodate upgradeability requirements. These standards are needed to allow utilities to mitigate risks associated with "predicting the future" and to install systems that are flexible and upgradeable to comply with emerging requirements for the Smart Grid.

NIST identified the need for a meter upgradeability standard as a high priority requiring immediate attention. The objective was to define requirements for smart meter firmware upgradeability in the context of an AMI system for industry stakeholders, such as regulators, utilities, and vendors.

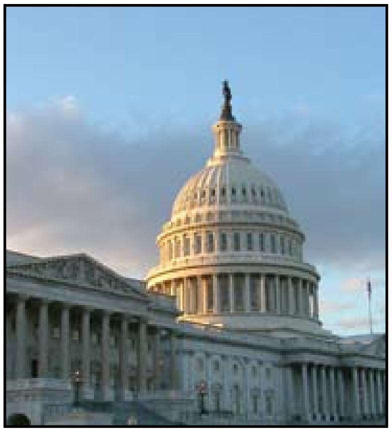
NEMA accepted the challenge to lead the effort to develop such a standard on an exceptionally rapid schedule. In just under 90 days, with the help of a team of meter manufacturers and electric utilities, NEMA published the first standard written from the ground up for Smart Grid, SG-AMI 1-2009 *Requirements for Smart Meter Upgradeability*.

This standard is used by smart meter suppliers, utility customers, and key constituents, such as regulators, to guide both development and decision making as related to smart meter upgradeability. It is available for download at no charge from NEMA's website (*www.nema.org/stds/sg-ami1.cfm)*.

NEMA has been in the standards business for more than 80 years. Accredited by the American National Standards Institute (ANSI) as a standards developing organization, NEMA maintains hundreds of standards on everything from the smallest connector in the common wall outlet to massive generators, and works to best position those standards on behalf of its members.

***SG-AMI 1-2009 Requirements for Smart Meter Upgradeability* is available for download at no charge from NEMA's website www.nema.org/stds/sg-ami1.cfm.**

Driving the Smart Grid Effort



Where do we begin to coordinate all of stakeholders of the Smart Grid?

The concept of a smart or intelligent grid has been around for many years. Many organizations, including the Electric Power Research Institute, Gridwise Architecture Council, and others have been promoting the concept prior to the twenty-first century.

The big push for using the term Smart Grid, however, and for providing a cohesive U.S. direction, resulted from the enactment of the *Energy Independence and Security Act of 2007* (PL 110-140, more commonly known as EISA).

With the breadth of energy, security, and communications policy involved in the implementation of the Smart Grid, a number of cabinet-level U.S. government agencies are involved in the effort. They include the Departments of Energy (DOE), Commerce (DOC), and Homeland Security (DHS); the Federal Energy Regulatory Commission (FERC) and Federal Communications Commission; the National Institute of Standards and Technology (NIST); and others.

With responsibilities firmly encoded in public law, and having each of the 50 states as stakeholders in the outcome, propagating the Smart Grid concept is truly an onerous task.

However, it is the Assistant Secretary of the Office of Electricity Delivery and Energy Reliability (OEDER) in DOE who is required to "report to Congress concerning the status of smart grid deployments nationwide and any regulatory or government barriers to continued deployment." The law goes on to state that:

> *The report shall provide the current status and prospects of smart grid development, including information on technology penetration, communications network capabilities, costs, and obstacles. It may include recommendations for State and Federal policies or actions helpful to facilitate the transition to a smart grid. To the extent appropriate, it should take a regional perspective. In preparing this report, the Secretary shall solicit advice and contributions from the Smart Grid Advisory Committee created in section 1303; from other involved Federal agencies including but not limited to the Federal Energy Regulatory Commission ("Commission"), the National Institute of Standards and Technology ("Institute"), and the Department of Homeland Security; and from other stakeholder groups not already represented on the Smart Grid Advisory Committee.*[1]

[1] PL 110-140 *The Energy Independence and Security Act of 2007*, § 1302

With respect to the Smart Grid standards, section 1305 of EISA specifies:

> *The Director of the National Institute of Standards and Technology shall have primary responsibility to coordinate the development of a framework that includes protocols and model standards for information management to achieve interoperability of smart grid devices and systems. Such protocols and standards shall further align policy, business, and technology approaches in a manner that would enable all electric resources, including demand-side resources, to contribute to an efficient, reliable electricity network. In developing such protocols and standards—*
>
> *(1) the Director shall seek input and cooperation from the Commission, OEDER and its Smart Grid Task Force, the Smart Grid Advisory Committee, other relevant Federal and State agencies; and*
>
> *(2) the Director shall also solicit input and cooperation from private entities interested in such protocols and standards, including but not limited to the Gridwise Architecture Council, the International Electrical and Electronics Engineers, the National Electric Reliability Organization recognized by the Federal Energy Regulatory Commission, and National Electrical Manufacturers Association.*[2]

In weighing its responsibilities under EISA, DOE convened an industry panel to comment on its responsibilities. As a result, DOE in June 2008 published its *Metrics for Measuring Progress Toward the Implementation of the Smart Grid,* which states that standards for the smart electrical grid must incorporate seven major characteristics:

- ❖ enable active participation by consumers
- ❖ accommodate all generation and storage options
- ❖ enable new products, services, and markets
- ❖ provide power quality for the range of needs in a digital economy
- ❖ optimize asset utilization and operating efficiency
- ❖ anticipate and respond to system disturbances in a self-healing manner
- ❖ operate resiliently against physical and cyber attack and natural disasters

[2] IEEE is the Institute of Electrical and Electronics Engineers
NERC is the North American Electric Reliability Corporation

In a similar show of public-private partnership, and after spending time evaluating the Smart Grid environment and inventorying available Smart Grid–related standards, NIST established the Smart Grid Interoperability Panel (SGIP) in November 2009. According to its charter, the mission of the SGIP is to provide "coordination of all stakeholders of the Smart Grid to accelerate standards harmonization and development.

To support this mission, SGIP includes:

- 22 stakeholder categories representing the breadth of the electrical industry
- 600+ member companies
- 1,800+ individual participants
- a governing board structure elected from the stakeholders plus three at-large members
- a charter and bylaws to cover operating policy
- membership opportunities for domestic and international interests

Because of its responsibilities to work with NIST on the interoperability framework as cited in Section 1305 of EISA, NEMA is a fundamental supporter of the SGIP and is very actively involved in its operation. Five member company representatives and one staff person were elected as members of the inaugural SGIP governing board.

NEMA has also been represented in both the chair and vice chair of the governing board, as well as plenary secretary. The association's objective for the future of Smart Grid is to continue to provide quality leadership and make sure that the human capital required to run the SGIP is well supported by both NEMA staff and member companies.

Smart Meters—

The Consumer Connection to Smart Grid

As we entered the twenty-first century, a number of electric utilities went through a deregulation process with their state utility commissions that included the introduction of new billing structures, such as market-driven pricing. In a market-driven scenario, instead of having a flat-rate pricing scheme for electricity 24 hours a day, 7 days a week, variable pricing mechanisms can exist where the cost per kilowatt-hour may change based on the day, time of day, or may be even more dynamic based on weather conditions and expected load requirements.

Because the grid must remain in balance at all times, this movement toward more flexible pricing schemes left utility companies and government regulators with a challenge to find a means to more accurately measure electricity consumption so that it could be properly matched with generation capacity.

The technology in traditional electrical meters (known as electro-mechanical meters) can only measure total electricity consumption and as such, provides no information for when the energy was consumed. This gap has eventually been filled through the advent of the new smart electrical meters.

Smart meters provide an economical way of accurately measuring when energy was used, allowing price-setting agencies to introduce different prices for consumption based on time of day and season. Concurrently, smart meters can be used to provide consumer access to any available energy usage data, as well as measure the output of alternative energy means, like wind turbines or solar energy panels. In some states, this allows consumers to sell excess energy that they generate back to the utility.

Combining this form of consumer empowerment with the ability to curb usage expense (based on knowledge of demand pricing and load conditions) is a major motivation for replacing the installed base of traditional meters with the new smart meters.

The result is that the key consumer connection to the Smart Grid is the smart meter.

Standards development efforts are the cornerstone to transitioning to smart meter technology and ensuring interoperability across product and communications lines. What you really need to know about smart meter standards, such as the ANSI C12 series developed and administered by NEMA, is that they form the language the meter uses to provide two-way communication with the utility company.

In the Smart Grid environment, 100 percent of the energy use charges that appear on an electric bill will be tracked and communicated through the use of smart meter standards. This is the basis of advanced metering infrastructure (AMI).

As a collaborative suite of standards, ANSI C12 aims to:

- provide the basic performance criteria for electric meters (ANSI C12.1)
- define the physical aspects for maintaining the safety of electric meters (ANSI C12.10)
- create a specification for the ports and connectors on the meter (ANSI C12.18)
- define the data tables that will hold the usage information (ANSI C12.19)
- create a standard for the accuracy of the measurements (ANSI C12.20)
- specify a way to connect to the meter via telephone modem (ANSI C12.21)
- specify a way to connect to the meter using a data network (ANSI C12.22)

NEMA and the ANSI C12 committee are also working on ways to define testing criteria for electric meters, the results of which could become the ANSI C12.23 standard, and are finding a way to incorporate SG-AMI 1 *Requirements for Smart Meter Upgradeability*.

With so much critical customer usage and power quality data depending on the accurate measurements made by the smart meter, it becomes absolutely imperative that standards such as ANSI C12 are continually reviewed and rigorously maintained.

The key consumer connection to the Smart Grid is the smart meter.

A Cleaner Brand of Energy—

Renewables, Energy Storage, and the Smart Grid

An *enervore* is an energy eater, as defined by NEMA member Lawrence E. Jones. Under this definition, every organism on our planet can be considered an enervore, yet our species sits alone at the top of the food chain. Our ever-growing population is experiencing diminishing resources and significant climate changes demanding new efficient ways to satisfy our energy appetites.

Renewable energy, once considered impractical because of inconsistent sources and geographical limitations, is being transformed into a viable solution, thanks to Smart Grid and the NEMA companies working to integrate renewable technology. Its use can reduce our dependence on non-renewable fossil fuels, our production of atmospheric carbon dioxide, and our need to import energy sources.

Policy incentives and technology developments influence the functions of generation and transmission. On the policy front, government incentives encourage low-carbon generation. But renewable sources that create electricity without CO_2 emissions have limited usefulness for load balancing. On the technology front, a variety of energy storage technologies have been demonstrated to be practical. Energy storage devices adeptly balance load and generation, but do not produce energy on their own.

While sources of renewable energy are diverse (e.g., biomass, geothermal, hydro, trash combustion), solar, wind, and marine are prominent on the Smart Grid horizon.

Solar

Every day, a clean and abundant power source rises in the eastern sky.

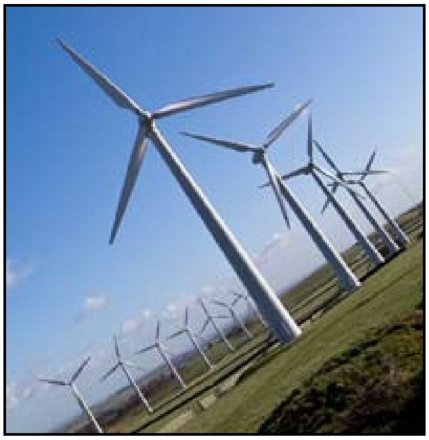
This renewable power, by definition, is the conversion of solar energy into electrical energy. The two primary methods are photovoltaic cells, where solar power is directly converted to electricity, or concentrated solar power, where the sun's energy is focused to boil water, which indirectly provides power.

Solar power represents the most versatile form of renewable energy. It powers homes and factories, energizes transportation and roadway messaging, and even provides electricity and hot water to soldiers in the field.

Until recently, the need for improved electrical grid technology and expansion prevented the widespread application of solar energy. NEMA and its member companies, however, are at the forefront of emerging renewable technology by successfully marrying the sun's power to the Smart Grid, making the production and transmission of solar energy far more efficient.

Within a Smart Grid system, solar power could be generated in the Southwestern U.S, where sunshine is consistent, and distributed throughout the Northeast, where the energy is sorely needed. Individual consumers could even install personal solar panels and sell any excess electricity back to their local utility company. The result—dramatically reduced energy use.

Wind



If solutions have been blowing in the wind for millennia, why can't we get that power into our homes?

While windmills were first developed to automate grain-grinding and water-pumping, today's sleek turbines represent one of the most widely utilized sources of renewable energy.

Until somewhat recently, the production capacity of wind turbines was limited by their overwhelming size and weight, primarily because of copper wiring used in construction. Advances in wiring technologies now allow the construction of smaller wind turbines capable of producing more energy at a dramatically reduced initial cost. This translates into financial and environmental savings.

Generally speaking, an acre of trees will eat about four tons of carbon per year. For the most recent data through the end of 2008, 125 million residential customers in the U.S. use an average of 920 kilowatt-hours (kWh) per household. Across all carbon generating entities, the average CO_2 generated per kWh in the U.S. is 1.35 pounds.

Based on estimates by the U.S. Energy Information Administration, the statistical and analytical agency within the U.S. Department of Energy, as well as the Environmental Protection Agency and Upson EMC, for every 10,000 homes powered by wind energy per year, 6,210 tons of CO_2 and 920 kWh are saved.[3] This is the equivalent of removing 776 SUVs from the road[4] or planting 1,692 acres of trees.[5]

Throughout the world, countries are taking aggressive steps to ensure this form of energy production becomes an integral part of the Smart Grid.

Marine

Some say the wave of the future is marine energy.

Although marine energy has not received the same level of attention as solar or wind, it is growing as a viable source of clean, renewable energy. Also referred to as ocean energy or ocean power, marine energy refers to the energy carried by ocean waves, tides, salinity, and ocean temperature differences.

Marine currents are more predictable than wind and solar power, and oceans are close to many, if not most, densely populated areas. And while marine energy is only available along coastlines and large bodies of water, it represents one of the most consistent forms of renewable power.

[3] *www.eia.gov/cneaf/electricity/esr/table5.html*
[4] *www.epa.gov/oms/consumer/f00013.htm*
[5] *www.upsonemc-carbonoffset.com/C02treestore.aspx*

Marine energy is categorized as:

- current power—ocean currents
- osmotic power—salinity gradients
- ocean thermal energy—temperature differences at varying depths
- tidal power—moving masses of water
- wave power—surface waves

The introduction of Smart Grid has spurred the growth of marine technologies as increases in efficiency and improved methods of transmission are developed.

Nuclear Energy

Nuclear energy is a component of the bulk generation domain in the Smart Grid. With mounting concerns regarding dependence on foreign oil and fossil fuels, the subject of nuclear energy is receiving renewed and well-deserved attention. According to *carbonfund.org*, on average, electricity generation produces 1¼ pounds of carbon-based waste for every kilowatt hour. However, in Vermont, where much of the electricity comes from nuclear power, it's closer to half an ounce.

Unlike some other energy alternatives to fossil fuels, nuclear energy does not experience periods of unavailability, nor does it require a related energy storage capability. Modern developments in smaller, more easily established micro- and full-scale nuclear plants make this energy source more feasible and achievable. Considering the steadily increasing per capita usage of electricity, nuclear energy is an important component to ensure adequate power availability.

Nuclear energy can also react more rapidly than other fossil fuel alternatives in terms of demand response, and the strong security and protection associated with nuclear power plants dovetails with infrastructure security concerns. Likewise, the high levels of plant sophistication and controls lend nuclear power to coupling with Smart Grid systems. Micro-plants could also be leveraged to establish a distributed grid system, whereby power is generated closer to the end user, reducing power losses from long line transmission and reducing the effects of natural disasters on power availability. NEMA has researched and continues to monitor developments and opportunities in the field of nuclear power to see where our strong expertise can be best brought to bear.

Energy Storage

Energy storage (ES), quite simply, is the ability of a substance to accumulate energy and store it for use at a later time.

ES devices adeptly balance load and generation, but do not produce energy on their own.

The most basic application of an ES system is to accumulate electrical energy from a source on or off the grid and store that energy for delivery, when requested, to a load. Off-grid resources in isolated areas, like solar and wind farms, need to store energy when the sun is shining and the winds are blowing.

With advances in electrical energy storage, it is now possible to do just that.

Consider the plug-in hybrid electric vehicle (PHEV). Not only can it reduce air pollution and dependence on foreign oil, it is also a viable solution for increasing the reliability and efficiency of the national electric grid.

PHEVs can only fully recharge through a physical connection to the grid. Bidirectional transmission, or V2G (vehicle to grid), allows a win-win situation.

For example, a utility may determine that demand is peaking on a particularly hot day. The utility would be able to locate and compensate participating PHEVs that are fully charged and do not need that stored energy at the time, and they could upload power to the grid. Alternatively, when the PHEV is energy-depleted, the owner pays to draw energy and charge its battery from the grid.

PHEVs and other energy storage (ES) technologies are vital to Smart Grid. Just as a wind-up clock stores potential energy, ES amasses its power and promises a dynamic wakeup call. Simply put, without ES technologies, there can be no Smart Grid.

ES technologies can:

- balance the grid's load with generated power
- achieve a more reliable power supply for end-use customers
- stabilize intermittent sources of renewable energy
- electrify transportation (cars, trains, traffic signals, etc.)
- provide uninterruptible power supplies for data centers and national defense

The national effort to develop a modern, smart electrical grid will require storage devices to supply customers with energy when the need is greatest.

Transmission Corridors

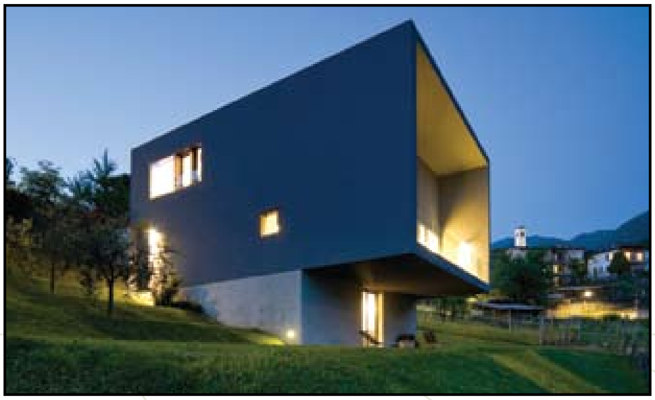
Everyone wants to harness the energy from wind, sun, earth, and tides, but moving it can be tricky. Renewable sources are typically not proximate to energy-consuming sites; they are also intermittent and lack flexibility.

Connecting energy generation to where energy is needed—by homes, schools, businesses, factories, military installations—is the critical role that transmission lines play in deployment of the Smart Grid.

Transmission lines move electricity from generating sources to end users. Transmission corridors, the tracts of land over which wires and other connections traverse, quite simply are the lifeblood of the electrical grid.

As a result, transmission planning and siting is paramount to successful implementation of renewable energy technologies. Obtaining a permit to construct a transmission corridor, however, is an arduous, multi-year process involving state and federal authorities.

A proposed corridor must consider safety; environmental impact; scenic and historic sights; existing land use; soil, plant, and wildlife habitats; and landscape.



According to the Federal Energy Regulatory Commission (FERC) website,[6] the following guidelines must be determined and an environmental impact study must be conducted for each application:

- ❖ Is the project eligible for an electric transmission construction permit?
- ❖ Is the project in the public interest?
- ❖ Will the project reduce transmission congestion and protect and benefit consumers?
- ❖ Is the project consistent with sound national energy policy and will it enhance energy independence?
- ❖ Will the project maximize the use of existing facilities?

And FERC is just one federal agency with jurisdiction over transmission corridors.

To illustrate the challenges and opportunities of transmission siting, NEMA created *Siting Transmission Corridors*, a transmission roadmap based on the game *Chutes and Ladders*[7] (*www.nema.org/transmissioncorridorsgameboard*).

[6] FERC, Transmission Line Siting, *www.ferc.gov/industries/electric/indus-act/siting.asp*
[7] *Chutes and Ladders* is a trademark of Hasbro, Inc. for its board game

NEMA supports a clear national policy that provides federal authority over transmission planning, siting, and cost allocation. Without a streamlined, advanced transmission system that moves renewable energies from source to end use, the U.S. will face difficulty in harnessing the promise of renewable energy and in meeting energy independence goals.

NEMA and its member companies are in the energy solutions business—that is why we have taken on the challenge to address the laborious manner that is used to site transmission lines.

While renewable sources, like wind and solar, are popular concepts, they are typically located far from where energy is needed. We need an efficient process to deliver that energy. The current system of transmission planning, cost allocation, and siting can take from 7 to 14 years. Government approvals ("red tape") take up to three years while "green tape," the tactics used by environmental activists, also prolongs and prevents new corridors.

It is expected that $100 billion will be spent implementing Smart Grid worldwide. But without new transmission lines, which are integral to the creation of a sustainable energy portfolio, job growth, and economic opportunity, we cannot accelerate the use of renewable energy generation.

A Win-Win Relationship—

High Performance Buildings for a Smarter Grid

When is a building not just a building? When it's high performing. And smart.

New construction and retrofit projects affect virtually every product in the electroindustry. High performance buildings (HPBs) are integral to the widespread implementation of Smart Grid.

One example of NEMA's work in high performance buildings that directly impacts Smart Grid is the development of an interoperability standard for communication between the HPB and the grid. SPC-201P *Facility Smart Grid Information Model* (Proposed) is being developed under the leadership of the National Institute of Standards and Technology (NIST). NEMA and ASHRAE (American Society of Heating, Refrigerating and Air-Conditioning Engineers) are co-sponsoring it.

Working in cooperation with approximately 60 major stakeholders, ranging from major companies to industry associations, SPC-201P will define an abstract, object-oriented information model to enable appliances and control systems in homes, commercial buildings, and industrial facilities to manage electrical loads and generation sources in response to communication with a smart electrical grid and to communicate information about those electrical loads to a utility provider.

This model provides the basis for common information exchange between control systems and end-use devices found in single- and multi-family homes, commercial and institutional buildings, and industrial facilities that is independent of the communication protocol in use. It provides a common basis for electrical energy consumers to describe, manage, and communicate about electrical energy consumption and forecasts.

SPC-201P defines a comprehensive set of data objects and actions that support a wide range of energy management applications and electrical service provider interactions including, but not limited to, on-site generation, demand response, electrical storage, peak demand management, forward power usage estimation, load-shedding capability estimation, end load monitoring (sub metering), power quality of service monitoring, utilization of historical energy consumption data, and direct load control.

Modeling the energy characteristics of equipment and systems that consume, produce, and store energy found in residential, commercial, and industrial facilities provides a great tool for the facility owner. By modeling the energy characteristics of this equipment, the characteristics of a facility's energy needs can be determined.

Object-oriented information enables appliances and control systems in homes, buildings, and industrial facilities to manage electrical loads and generation sources in response to communication with a smart electrical grid and communicates information about those electrical loads to utilities and other electrical service providers.

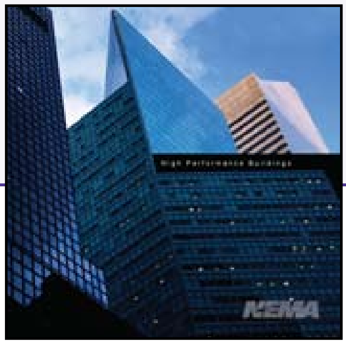
Win-Win Protocol

When this information is included in equipment and communicated with a protocol, everyone wins:

- ❖ a facility owner can understand what factors influence the facility's energy consumption
- ❖ energy consultants can determine how to effectively reduce the energy profile of a facility
- ❖ architects and engineers can design facilities with optimum energy profiles
- ❖ controls manufacturers can create products that monitor and manage the facility energy profile
- ❖ energy providers can more accurately forecast energy demand as well as the reactions to energy supply constraints
- ❖ SPC-201P will pave the way for further developments in the collaboration between HPBs and the Smart Grid.

In response to government and industry trends toward energy efficiency, increased occupant productivity, safety, and cost-effectiveness, NEMA established a High Performance Buildings Council (HPBC). The council's focus is to expand the market for existing electroindustry technologies in the built environment for approximately 450 NEMA member companies.

The member companies involved with HPBC represent a cross section of product groups. The council is the one place in the electroindustry that brings together a program in government relations, codes and standards, and industry marketing specifically focused on HPBs.

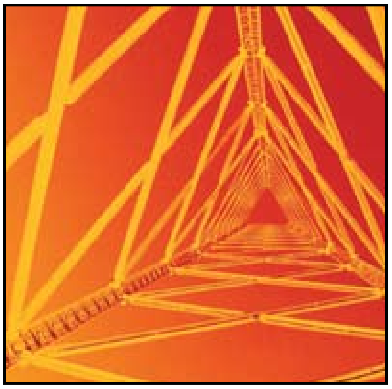


High Performance Buildings booklet

Available at *www.nema.org/HPBbooklet*

Microgrids—

Achieving Local Goals



A big area in electric grid architectures sounds undersized—the microgrid.

Microgrids are pockets where electrical loads and sources are interconnected and managed on a local basis. A microgrid can be small—as in a net-zero building, a data center, a collection of buildings in an office park, even a college campus.

On the other hand, a microgrid can be huge—as in an entire military base. A forward operating base or a military field hospital are excellent examples of microgrids. In the tactical environment, they use generators and solar power together to power the facility.

Microgrids represent a unique frontier in terms of electric grid development: anyone can set one up. They are operated by non-regulated entities (although a utility company could establish a microgrid service area), and generally exist for the purpose of supporting a service that the utility company doesn't offer.

The integration of a distributed generation source could be a set of rooftop solar panels, better power quality in remote area, or as a hedge against the possibility of utility company outage. Considering the data center and field hospital examples above, microgrid quality and stability take on increased magnitude.

A concept that is somewhat related to microgrids is "islanding." It represents a technique that has been in use by grid and commercial building operators for decades when there is an unplanned grid outage.

An island must have the ability to operate in an isolated mode, that is, to operate in an autonomous way, similar to the power systems of physical islands.

Since islanded microgrids are isolated from any power grids, the decrease in generation or load-shedding can be used to maintain the frequency when a power imbalance between supply and demand occurs.

Enabling Smart Grid Functionality

NEMA is an enthusiastic supporter of microgrids as an enabler for Smart Grid functionality. As more variability is introduced at the consumer level with the introduction of residential wind and solar power, electric vehicles, and the growing interest in high performance commercial buildings, the balancing areas for electricity services will continue to get smaller. Microgrids also represent the ultimate in consumer control as they can optimize their electricity sources on an individual basis.

While much of the future of microgrids has yet to be written, the one thing that is certain is the ever-changing nature of electricity demand. It is moving the industry toward a model that requires much more local control—which is a core characteristic of a microgrid.

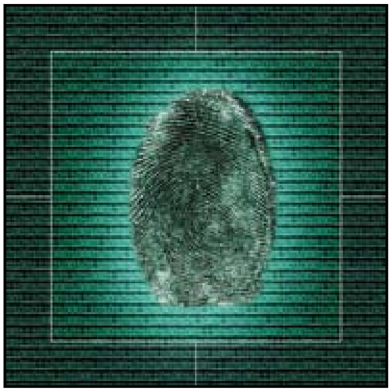
There are many benefits of smart microgrids:[8]

- accelerate improvement
- increase reliability
- help consumers save money
- generate revenue
- encourage economic growth
- make the grid "futureproof"
- reduce carbon footprint

[8] *GalvinPower.org*

Cybersecurity—

Securing the Grid



Cybersecurity is an area of growing concern in the Smart Grid. A breach in the grid would have a couple of immediate effects: first, utility service interruptions (including their potential disruptions to business, commerce, and other activities); and second, the unavoidable scramble between utility companies and manufacturers to patch the breach.

This could involve countless hours of research and development staff time, contractors, and consultants, etc., which would be a considerable financial burden on the utilities and manufacturers alike. The implementation of those patches would involve potential changes to the manufacturing process, deployment of the patches to the installed base, product recalls, rebates, and many other expensive options, not to mention the potential for lawsuits, both valid and frivolous, based on the outages caused by the breach.

For this reason, NEMA members are interested in standardizing common approaches to cybersecurity across utility areas of control as well as state boundaries. It is critical to invest the time and resources upfront to select the optimal architecture, minimize risks, and attain a reasonable balance between costs and security.

Additionally, states must work together to provide utilities with a uniform security implementation approach. If public utility commissions do not lead with a common approach, then it will be very difficult for utility companies, manufacturers, the National Institute of Standards and Technology (NIST), and standards development organizations (SDOs) to coordinate their security standards development efforts. A disjointed approach to security will only increase the level of difficulty for manufacturers to provide interoperable solutions.

In supporting the NEMA mission as it relates to cybersecurity, our objective is to promote the competitiveness of the U.S. electrical product industry through the development of standards and advocacy of policy in federal and state legislatures, as well as in executive and regulatory agencies.

NEMA efforts in cybersecurity focus on three areas:

- **Technical Standards.** Whether in hardware/devices or software systems, the standards supporting cybersecurity need to be compatible with existing, widely-accepted grid management systems and practices. Identifying these standards early in the Smart Grid lifecycle permits manufacturers to build cybersecurity into their product lines.
- **Legislative Support.** The fast path to widespread adoption of cybersecurity measures will naturally include incentives. Any legislation dealing with Smart Grid, cybersecurity, and energy policy needs to include incentives for utilities and manufacturers in such areas as adoption of best practices and implementation of security measures. Given its importance to the process, research and development should be specifically targeted for incentive programs.

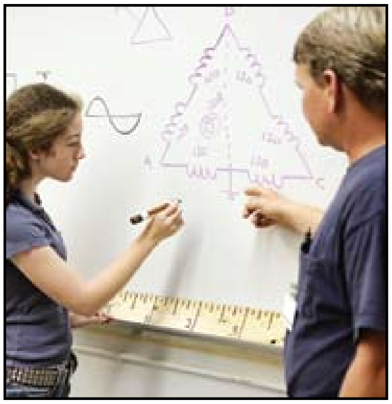
- **Regulatory Governance.** Regulators need to consider concepts like layering and segmentation when applying standards for cybersecurity, and must carefully weigh issues associated with voluntary versus mandatory implementation of a security measure. Rulemaking should be geared to help utilities move faster to replace legacy systems that do not meet emerging Smart Grid standards.

For the application of any standard in the cybersecurity arena, the concept of how that standard will be supported after deployment needs to be considered. It must be operationally sustainable. In a distributed operating environment with literally millions of nodes (i.e., the grid), manual maintenance is not a viable option.

The application of a security standard as a component of a larger grid architecture needs to permit remote administration and maintenance. If a truck has to roll every time a breach occurs and personnel must manually re-key a security solution, security remains exposed.

An affordable Smart Grid requires advance planning and remote maintenance.

Vids 4 Grids



When President Obama advocated the advancement of the century-old electrical grid with $11 billion in financial support for various initiatives in the *American Recovery and Reinvestment Act of 2009* (the Stimulus Bill), the industry knew Smart Grid was coming and fast.

But with an aging workforce that has created a brain drain in the power systems engineering field, the question is not whether we need a Smart Grid, but whether our human capital will be able to support it.

Over the next 20 years, the Smart Grid should be a prime creator of jobs in the electrical industry, but what exactly does that mean? A major implication is that if higher education does not teach its students about this development, our ability to implement, support, and advance Smart Grid technologies across the electrical grid will come to a grinding halt.

To address the dire need for workforce training in the electric power sector, the electrical industry and education sector need to work closely to ensure that tomorrow's workers obtain crucial education on today's Smart Grid technologies.

NEMA has taken significant steps to educate the emerging workforce with a grant from the Department of Energy (DOE). NEMA's *Vids for Grids: New Media for the New Energy Workforce* (V4G) is one of 54 Smart Grid workforce training programs funded by the Stimulus through DOE and the only one awarded to a non-profit association.

In collaboration with George Mason University, Northern Virginia Community College, and member manufacturers, V4G introduces Smart Grid concepts to tomorrow's engineers by integrating new media into engineering core curricula.

The 10-minute videos are available on NEMA's Vids4Grids's YouTube Channel (*www.youtube.com/vids4grids*). Each is shot onsite at a member facility to show how Smart Grid equipment is manufactured, explain electrical engineering concepts, and portray careers in electrical manufacturing. They educate high school seniors and college freshmen about capacitors, conductors, connectors, dynamic line ratings, energy storage, flywheels, industrial automation, lighting management systems, meters, surge arresters, and switchgear.

To learn more about Smart Grid technology, visit *www.youtube.com/vids4grids*.

NOVA Northern Virginia Community College

DEPARTMENT OF ENERGY · UNITED STATES OF AMERICA

VIDS 4 GRIDS

GEORGE MASON UNIVERSITY

Looking Ahead—

The Smart Future is Here

Smart Grid seems to promise a lot:

- ❖ greater control of the grid by utilities
- ❖ cost-saving options for consumers
- ❖ fewer outages
- ❖ self healing capabilities
- ❖ across-the-board operational efficiencies
- ❖ access to renewable energy sources
- ❖ enhanced security and reliability

With these ideals in mind, it's only natural to ask, "When will we see these changes?"

Some are already here.

With millions of smart meters already installed, the seeds for the Smart Grid have already been sown. The next step is to use the communications capabilities that the meter can provide to drive the applications that will change the way we interact with our electricity providers and our energy usage.

The first step in this process is education. In a 2010 EcoAlign survey,[9] 70 percent of the respondents were not familiar with the phrase "Smart Grid." It is one thing to tell the consumer about the features and functions of Smart Grid, which are largely based on technical changes to the infrastructure, but communicating the value those changes will bring is a completely different issue.

Some people are simply looking for an opportunity to save money on their electric bill, while others see the ultimate goal in terms of the environmental benefits associated with the reduction of coal-fired power and the widespread integration of renewables. Smart Grid enables both of these opportunities.

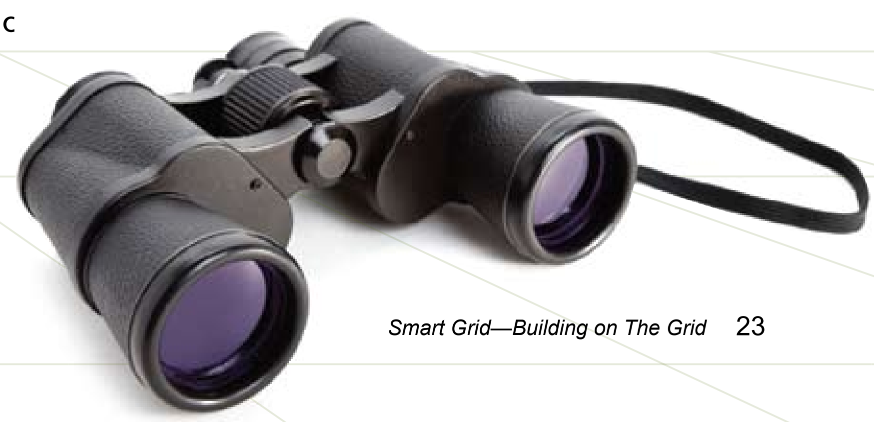
NEMA's role in this future has several elements. In short, we seek to:

- ❖ develop standards that advance the growth and commercialization of Smart Grid technologies and systems
- ❖ promote education on the advantages of Smart Grid technologies for U.S. and state government legislators and regulators, and consumers
- ❖ encourage private and public sector support for Smart Grid demonstration projects
- ❖ perform public advocacy on issues relating to the development and adoption of Smart Grid technologies and standards

As the principal guiding document for the U.S. Smart Grid effort, the *Energy Independence and Security Act of 2007* states, "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."

It is with these goals in mind that NEMA commits itself to the vision of a Smart Grid.

[9] *www.ecoalign.com/node/362*, May 25, 2010



NEMA is leading the way in Smart Grid technologies by encouraging investment in the national electricity grid and developing new product standards. NEMA was named in the Energy Independence and Security Act of 2007 as a participant in efforts to enhance the productivity, efficiency, and sustainability of the electricity grid. The basic concept of Smart Grid is to add monitoring, analysis, control, and communication capabilities to the national electricity delivery system in order to maximize throughput of the system while reducing energy consumption. Smart Grid will also allow homeowners and businesses to utilize electricity as efficiently and economically as possible.

Smart Grid technologies from NEMA members can improve the reliability, security, and efficiency of the electrical grid. Intelligent devices can automatically adjust to changing conditions to prevent blackouts and increase capacity. The next steps in the evolution of Smart Grid are to develop standards and provide necessary funding. Uniform standards will simplify new equipment selection and installation. Several financial mechanisms under consideration, such as Department of Energy matching funds, rate recovery incentives, and accelerated depreciation, will help manufacturers and utilities finance new investments.

NEMA

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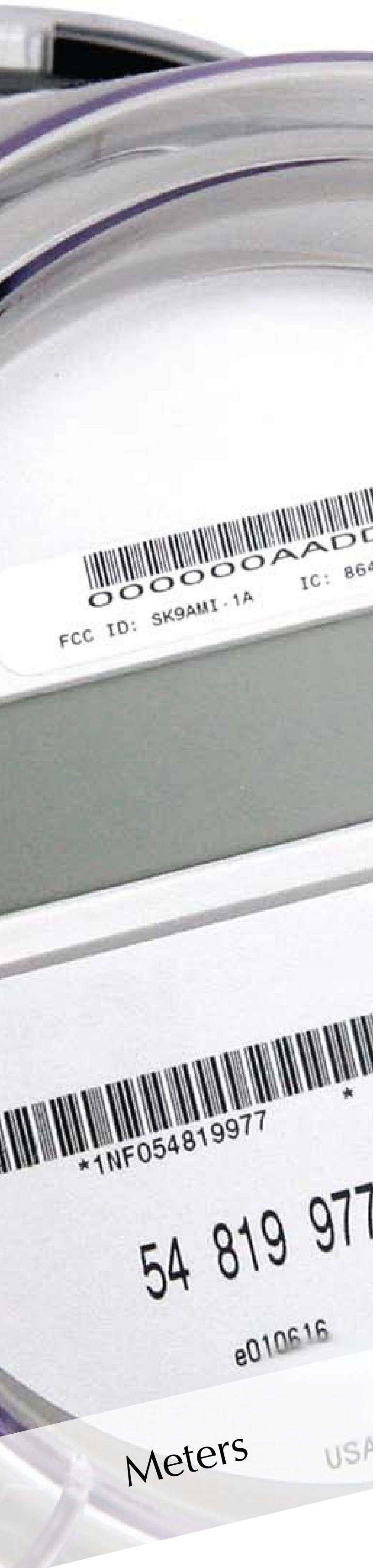

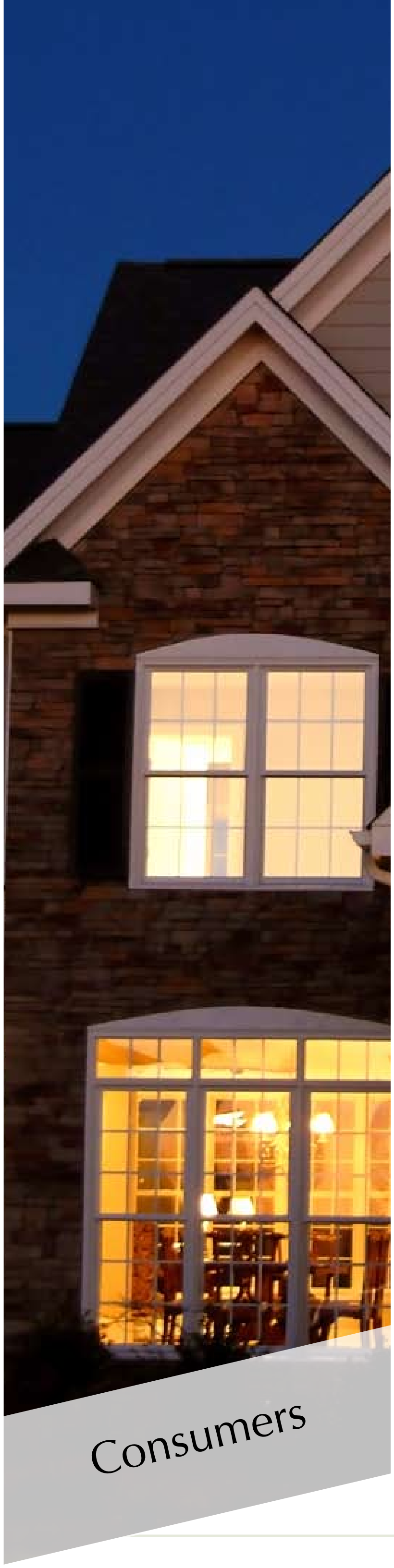

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