# Smart Grid

## Building on The Grid

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# NEMA—Leading the Evolution of Smart Grid

As a member-focused standards-developing organization, NEMA—the Association of Electrical and Medical Imaging Equipment Manufacturers—has committed its full support to the evolution of the national electric grid. We believe that these changes are critical as we endeavor to meet increasingly higher standards in reliability, security, cost of service, power quality, efficiency, environmental impact, and safety.

To these ends, NEMA manufacturers are developing technologies that will be integral components of the Smart Grid deployment. From smart meters and super conductive wire, to home automation, energy storage, and real-time ratings, our members are providing the tools necessary to enable active participation by consumers, optimize asset utilization and operating efficiency, and provide resilience against physical and cyber attack and natural disasters.

Throughout the Smart Grid deployment process, NEMA will be actively working to identify the underlying standards and protocols necessary to support the implementation of our members' products.

We will endorse existing standards when appropriate, and will work to update, harmonize, and develop new standards in areas where gaps may exist. Through our relationship with various government agencies, we will shepherd the adoption and implementation of the standards that will ensure quality of service and interoperability.

We will measure progress throughout the Smart Grid deployment by constantly evaluating the level of intelligence in the grid. As devices move through the continuum of operation, communication, optimization, and collaboration, we can determine effectiveness.

Ultimately, Smart Grid is about serving the customer better and saving the customer money. Consumers come in all sizes—individuals, municipalities, military bases, industrial complexes.

High reliability can be designed into the distribution system, and the grid concept can help get us there. This change, however, must not impose undue costs on end-users. Rather, it should give them options to manage and optimize their energy usage. But these new capabilities only matter when there is reliable electric service.

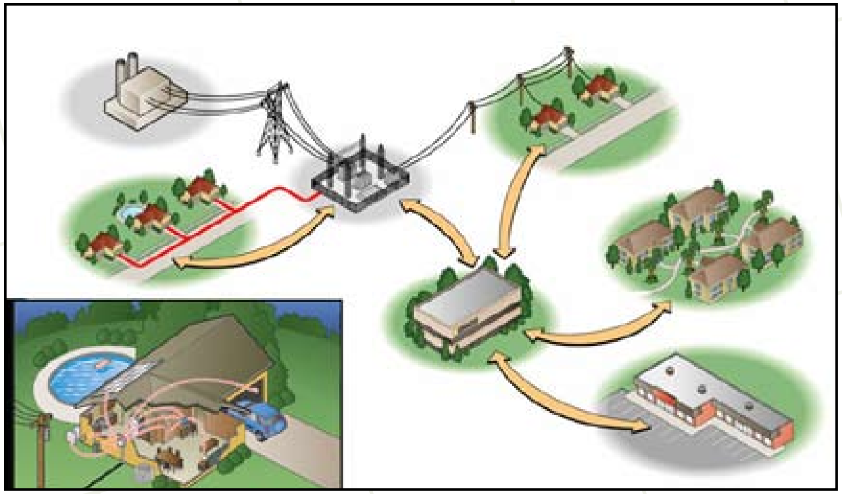

*Image courtesy of Southern California Edison

So it's not just about energy efficiency, but also about energy management at the consumer level. Public information and education must be aggressive so that everyone can take advantage of Smart Grid technologies and better manage energy usage, thus reducing energy costs. Smart Grid technologies will ultimately revolutionize how energy is delivered and consumed.

In the end, the object is to provide the milestones on the roadmap for legislators, regulators, utilities, and consumers as the nation achieves its Smart Grid objectives.

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# What is Smart Grid and Why Do We Need It?

Understanding the need for Smart Grid requires acknowledging a few facts about our energy infrastructure. The power grid is the backbone of modern civilization, a complex society with often conflicting energy needs—more electricity but fewer fossil fuels, increased reliability yet lower energy costs, more secure distribution with less maintenance, effective new construction and efficient disaster reconstruction. But while demand for electricity has risen drastically, its transmission is outdated and stressed. The bottom line is that we are exacting more from a grid that is simply not up to the task.

The term Smart Grid often evokes thoughts of high-tech microprocessor controls—and "chips" are sure to play a role in the long term, as will physically shoring up the hardware that will support the software. It requires the scrutiny of towers, anchors, poles, insulators, high performance cables, and wires—right down to the nuts and bolts that hold them all together. But Smart Grid is more than the sum of its parts. It is electricity with a brain. It listens, processes, remembers, responds, and even heals itself. It's all about adding "intelligence" to aging infrastructure and delivery systems, from the power plant to the appliances inside our homes.

And it will only become more vital as we make the transition to a carbon-constrained economy. There is widespread agreement that we need to use all forms of energy more wisely, but in particular we must shift from our reliance on fossil fuels to renewable sources. Current federal legislative proposals call for 10 percent of all electricity be from renewable sources by 2012, and 25 percent by 2025. The Smart Grid makes our energy supply more sustainable in terms of environment by enabling the integration of more renewable sources.

It is not possible to eliminate power outages from happening, but how the power system responds to these events determines how many customers are affected and for how long. A Smart Grid would automatically self-heal. Imagine the implications. A *smart* distribution grid is created when the switching points between circuits, as well as several points along each circuit, have the intelligence to automatically—and quickly—reconfigure the circuits to reroute power to as many customers as possible in response to an event. More intelligent switching points yield more options to reroute power to serve the load. Communication between those points makes self-healing a reality.

There is no one top priority. The foundation of Smart Grid is *The Grid* itself. Each component of that backbone—whether it is supply, demand, renewable sources, or distribution—represents the strongest (or weakest) link in the intelligence Smart Grid promises to deliver.

The basic concept is to add monitoring, analysis, control, and communication capabilities to the national electricity delivery system. This in turn can maximize the output of equipment, help utilities lower costs, improve reliability, decrease interruptions, and reduce energy consumption.

This is an exciting time for electrical manufacturing and the electric power industries. The focus on Smart Grid is driving technology innovation, acceptance, and implementation like never before. As its collective vision comes into focus, one thing is clear—a smart distribution and transmission grid will serve the customer better in many ways. The Smart Grid is not a panacea for our energy challenge. The multitude of technologies that compose the infrastructure are the keys to realizing our objective of abundant, sustainable, and affordable clean energy.

Meeting these mandates while maintaining the grid creates a major challenge.

# NEMA—Setting Standards

NEMA has accepted the challenge to promote our members' interests in the development of Smart Grid standards.

The lack of agreement on standards is increasing upfront costs and hindering how Smart Grid technologies will work together. NEMA members are leading the way in developing technologies and standards, from the turbine to the plug, and encouraging investment in these technologies and incorporation into the national electricity grid.

The experts at NEMA maintain that a primary goal of upgrading today's transmission and distribution grid into the Smart Grid is to maximize and manage the power transfer capacity of the existing grid—to squeeze more efficiency out of the existing infrastructure through the use of intelligent, automated supply and demand devices. A dynamic system will allow for greater choices by the consumer.

Writing the standards is just one step in the process. Safeguarding the industry against undue manufacturing burdens is another. Tax and other incentives for companies that produce, transport, and consume electricity more efficiently is yet one more.

These standards must incorporate the seven major characteristics described by the U.S. Department of Energy in its publication, *Metrics for Measuring Progress Toward the Implementation of the Smart Grid*:

- 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 attacks as well as natural disasters

As an active participant in refining the definitions and applications of these findings, NEMA is providing the benchmarks to implement and measure them, while simultaneously working to identify the underlying protocols that support their implementation. NEMA favors innovation on both supply and demand sides with an open testing and certification environment.

Security must be integral to the design of any Smart Grid component. At the same time, constructing the entire grid to the highest security standards would simply make it too costly. For example, The White House and the Willard Hotel are less than two blocks apart, but represent very distinct levels of security. A truly "smart" grid would allow interactions between grid components to ensure distinct priorities as well as self-healing responses to system disturbances.

Internationally, NEMA has taken a leadership role to develop a framework that includes protocols and model standards to achieve interoperability of Smart Grid devices and systems. NEMA is the U.S. Advisory Committee Administrator and the committee currently has 21 members from suppliers, government, utilities, and other stakeholders.

The electrical grid demands balance. Smart Grid standards provide it.

| Standards Recommendations | |
|---|---|
| **Grid Domain**<br>• Substation Automation<br>• Meter Communication Networks<br>• Meters & Residential Controls<br>• Home Area Network<br>**Candidate Standards**<br>• IEC 61850<br>• ANSI C12.19<br>• ANSI C12.22<br>• Zigbee, Climate Talk<br>**NEMA Supports International Standards**<br>• IEC Strategic Group 3 on Smart Grid<br>• U.S. Technical Advisory Group | **NEMA Standards Activities**<br>• Product groups (NEMA, ANSI, other)<br>• Hardware standards (transformers, switchgear, meters, motors, lighting, controls, high performance cables, etc.)<br>• Individual companies<br>• Input on specific issues<br>• Project teams<br>• Horizontal issues (Levels of Intelligence)<br>• Policy level (i.e., NIST activity) |

# How Smart is Smart?

Suppose an electricity supply chain—beginning with power generation and ending with a household appliance—could automatically correlate ever-changing supply and demand by exchanging information from the power plant to the home substation.

The concept is called Smart Grid. But what is *smart*? Or how smart is smart?

An electricity supply chain consists of three parts: generation (power plants); delivery (transmission and distribution networks); and customers (residential, commercial, industrial, military, etc.). Supply and demand have to remain tightly balanced at all times, since there is no commercial solution for large-scale storage of electricity to absorb any excess power or shortfall.

It is a complex and expansive system consisting of numerous primary elements interacting continuously through electrical, magnetic, and mechanical forces—far more complex than what might be ascribed to transportation or communication systems.

In the past, much of this balancing act was done by vertically-integrated utilities that controlled both the generation and the delivery system. This system, *The Grid*, is the backbone of industrialized societies. Yet it has aged, weakened, and is now subjected to operational scenarios and challenges never envisioned when it was developed decades ago. This is evidenced by increasing incidences of unpredictable events, such as blackouts, and threats of physical or cyber attacks. At the same time, our digital society depends on and demands a power supply that is highly available, highly reliable, and of highest quality.

*The Grid* is no longer adequate. *Smart Grid* has evolved as critical to future energy management and conservation because it will enable electricity producers to anticipate peak load times or to ensure that power is delivered based on fluctuating demands. Not only will it communicate these needs on a real-time basis, but it will also heal itself during interruptions to provide a continuous supply of energy. Customers will be charged higher rates for consuming energy during peak demands—and conversely credited for uploading energy from personal energy storage devices during these cycles.

Any product or device on the grid may be associated with any number of the “grid domains” defined by the U.S. Department of Energy—generation and storage; distributed energy resources; transmission systems; distribution systems; customer-utility interactions; electric market operations; and buildings, homes, and industries.

This means that each individual grid function must measure up to three simple questions:

- Does it provide information that other systems can use?
- Is its performance optimized?
- Can it work with other devices to achieve a common goal, like self-healing?

If the answers are yes, then *The Grid* has taken on intelligence. It has become the *Smart Grid*.

***The Smart Grid concept is critical to future energy management and conservation because it will enable electricity producers to anticipate peak load times and to ensure that power is delivered based on fluctuating demands.***

# NEMA Defines Levels of Intelligence

In order to maximize the power and integrity of the electricity supply chain, NEMA has devised a framework for classifying the smartness, or levels of intelligence, of each element of the electrical grid and its contribution to the performance of the whole. It is based on factors such as efficiency, availability, reliability, interoperability, sustainability, and security.

Applied to the Smart Grid, this matrix incorporates levels of intelligence that range from "dumb" (Level 0) to fully predictive systems (Level 5).

**Level 0:** Primary equipment with no intelligence of its own operating state; all monitoring, control, and actuation are external and require direct human contact to actuate or interpret (such as a position status indicator, a locally flashing fault-indicator light, or an audible signal).

- ***Examples:*** static appliances, such as old water heaters that maintain a constant water temperature; transmission lines; cables, connectors, capacitors, insulators, generators, poles, and wire

**Level 1:** Ability to signal/transmit beyond the physical boundary of the node via electronic digital communications to another device; component-level intelligence that only has local sensing with or without local actions; electronic digital communications, either one-way (status reporting) or two-way (status plus remote actuation); remote reporting capability and/or remote actuation.

- ***Examples:*** relays, thermostats, voltage regulators of generators, tap changers of transformers, digital fault recorders, meters, and breakers

**Level 2:** First level at which local control is possible; self-actuation, basic automation; master-to-slave/peer-to-peer information exchange among Level 1 devices to coordinate actions of devices in a neighborhood.

- ***Examples:*** simple, closed-loop controllers, distribution feeders, automated meter reading, and substations

**Level 3:** Automation beyond simple self-actuation; Level 3 devices or nodes are aware of some desired operating state and will pursue actions in order to adjust their performance with respect to that state; self-optimized, adaptive behavior.

- ***Examples:*** peer-to-peer devices in different neighborhoods, such as multiple substations

**Level 4:** Information exchange between Level 2 masters and regional wide-area control units; implies the notion of hierarchical operating states and introduces networked intelligence; goes beyond self optimization; involves multiple devices or nodes functioning jointly in order to obtain a desired system state; characterized by a common semantic framework where two systems exchange data with each other, even if the inner workings of each system are quite different.

- ***Examples:*** energy management systems

**Level 5:** Some form of automated analysis or information exchange among Level 4 regional systems aids in the coordination of each center's regional actions; system-wide application of advanced control technologies.

- ***Examples:*** devices and algorithms that analyze, diagnose, and predict conditions, and then take appropriate corrective actions to eliminate, mitigate, and prevent outages and power quality disturbances; power suppliers and systems share supply-and-demand information across a continent; cooperating control centers across a continent

*For more information, see "Standardizing the Classification of Intelligence Levels and Performance of Electricity Supply Chains," December 18, 2007, http://www.nema.org/smartgrid/WhitePaper_IntelligentElectricitySupply.pdf*


# Smart Meters—Consumer Connection to Smart Grid

A smart meter generally refers to a type of advanced meter that identifies consumption in more detail than a conventional meter and communicates that information back to the local utility for monitoring and billing, a process known as telemetering. These meters include additional functions to power measurement such as communication, data storage, remote programming, and time-of-use rates, and are intended to be deployed as advanced metering infrastructure (AMI) solutions.

The North American transmission and distribution grid is both strained and constrained. Increasing efficiency of energy consumption lowers stress on the system. Advanced metering contributes to the ability to model grid operations, one step in building a Smart Grid. AMI promises to conserve energy and contain costs while providing higher levels of customer service and improving delivery of energy.

Smart meters integrate with other devices, such as thermostats and remote controls, so that customers can monitor electric energy price changes in real time and plan usage accordingly.

AMI is a crucial element in building the Smart Grid and is integral to the seven characteristics of Smart Grid proposed by the Department of Energy:

1. **Enable active participation by consumers.** Having the ability to monitor electricity usage in real time gives consumers meaningful feedback on how their habits affect cost. It provides them the opportunity to make more informed decisions about how and when they consume electricity.

2. **Accommodate all generation and storage options.** Supporting the connection and use of distributed generation and/or energy storage requires the accurate measurement of actual energy supplied by distributed energy resources. This includes distributed storage devices, which at the residential level will appear first in the form of electric vehicles. A properly designed AMI system enables full bi-directional energy measurement at the billing

meter and allows for retrieval of measurement data from the device itself or an associated sub-meter.

3. **Enable new products, services, and markets.** As new products and services related to end-use energy management continue to evolve, new markets will emerge to take advantage of the value created by improved energy efficiency. The key to enabling participation in new energy markets lies in linking the demand for electricity to the price of electricity in real time.

4. **Provide power quality for the range of needs in a digital economy.** Because of the enhanced capabilities of the electric meters that make up AMI, technology will, for the first time, enable utilities to monitor voltage at the point of electricity delivery to every customer on their systems. In doing so, they will take a proactive position in identifying areas of their distribution systems where voltage levels are chronically out of tolerance, and address those problem areas before customers experience equipment malfunction or failure.

5. **Optimize asset utilization and operating efficiency.** A proper AMI system has the ability to measure, record, and retrieve data sufficient for highly detailed usage analysis of all the components of the distribution system.

6. **Anticipate and respond to system disturbances in a self-healing manner.** AMI systems do have some capabilities, such as outage notification messages that are sent by all AMI meters upon sensing loss of power, and restoration messages that are generated by the meters when power is restored.

7. **Operate resiliently against physical and cyber attacks as well as natural disasters.** The entire concept of Smart Grid relies on interconnected devices with high levels of automation. Cyber security becomes one of, if not the most, important issues relative to Smart Grid.

**For more information:**
www.nema.org/smartgrid

# Phasor Measurement Units—Hands and Feet of Smart Grid

When utility companies think Smart Grid, they think efficiency, reliability, and reduced costs. And that thought process starts with phasor measurement units (PMUs). Not only does this term denote a technology for measuring parameters in electrical networks, it also represents a method to detect the health of the system in real time. They are considered one of the most important measuring devices in the future of power systems.

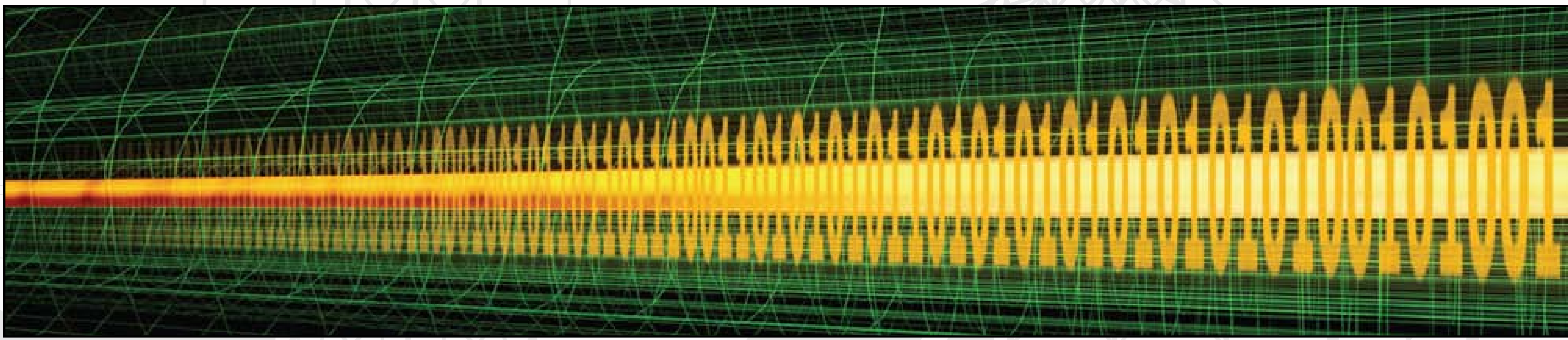
In order to understand PMUs, it helps to picture a warehouse. A warehouse typically stores enough of a commodity to meet the needs of the consumer—not so much as to run out of space, but not too little as to create a shortage. PMUs guarantee that there is just enough energy to meet the needs of the consumer—not so much as to create a storage problem, or so little as to create a blackout. Communication is the key to the proper balance of supply and demand. PMUs provide that communication.

Regardless of the power source (wind, coal, nuclear, etc.), a generator's output must equal or exceed consumer demand. It's a simple ratio—as need increases, voltage decreases.

Enter synchrophasors. A phasor is a complex number that represents properties found in electricity. Phasor measurements that occur at the same time are called "synchrophasors." They measure voltages and currents at diverse locations on a power grid. Because they are truly synchronized, real-time comparisons can be used to assess system conditions. Synchrophasors are the inventory-control drones that provide critical information about the peaks and valleys of energy generation to keep the ratio balanced.

Currently, PMUs measure the electrical waves on a grid to determine the health of the system at any given time and then supply instantaneous data on how that system is operating. Their role is to balance output and need. They also provide data used to predict supply and demand. In the future, PMUs can be used to enhance voltage and system stability. Research is underway to provide tools that system operators can use to make proactive decisions. This technology has the potential to change the economics of power delivery.

This real-time monitoring is aimed at optimizing output, preventing outages, and reducing maintenance. If communications infrastructure serves as the backbone for Smart Grid development at the transmission level, PMUs serve as the hands and feet.



# Plug-in Hybrid Electric Vehicles—Driving the Smart Grid

Plug-in hybrid electric vehicles (PHEVs) are not only an answer to America's increasing energy crisis, they are a viable solution for increasing the reliability and efficiency of the national electric grid. These are smart vehicles. To say that they communicate is just the start. They can also reduce air pollution, greenhouse gases, and dependence on foreign oil while using renewable energy sources, engaging electricity back-up management, providing greater national energy security, and stimulating job creation.

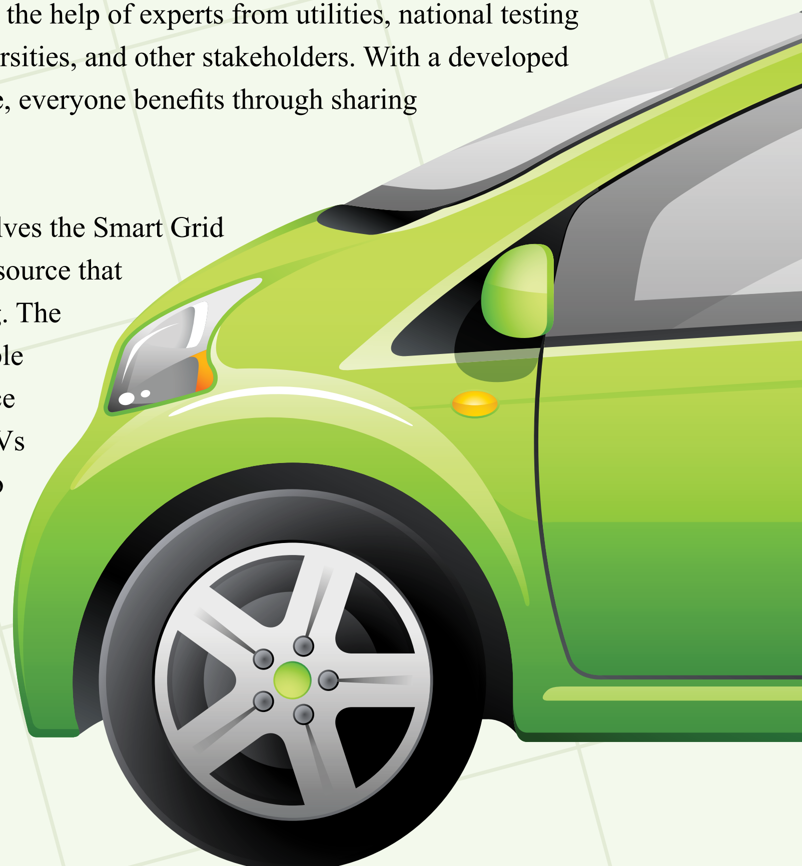
Once just a concept, PHEVs are now a reality. Similar to hybrid electric vehicles (HEVs), PHEVs have a much larger battery assembly that allows an extended range while operating on all-electric mode. Like HEVs, PHEVs are able to switch to gasoline power via a small internal combustion engine.

PHEVs, however, are very different when it comes to recharging. HEVs recharge by means of a rechargeable energy storage system that allows kinetic energy to be collected through regenerative braking and/or an electrical generator powered by the internal combustion engine.

PHEVs can only fully recharge through a physical connection to the electrical grid. It is this physical connection and recharging requirement that also presents another very special and potentially enormous benefit to the automobile owner, utility company, and country.

Bi-directional transmission, or V2G (vehicle to grid), is being demonstrated with the help of experts from utilities, national testing laboratories, universities, and other stakeholders. With a developed V2G infrastructure, everyone benefits through sharing energy.

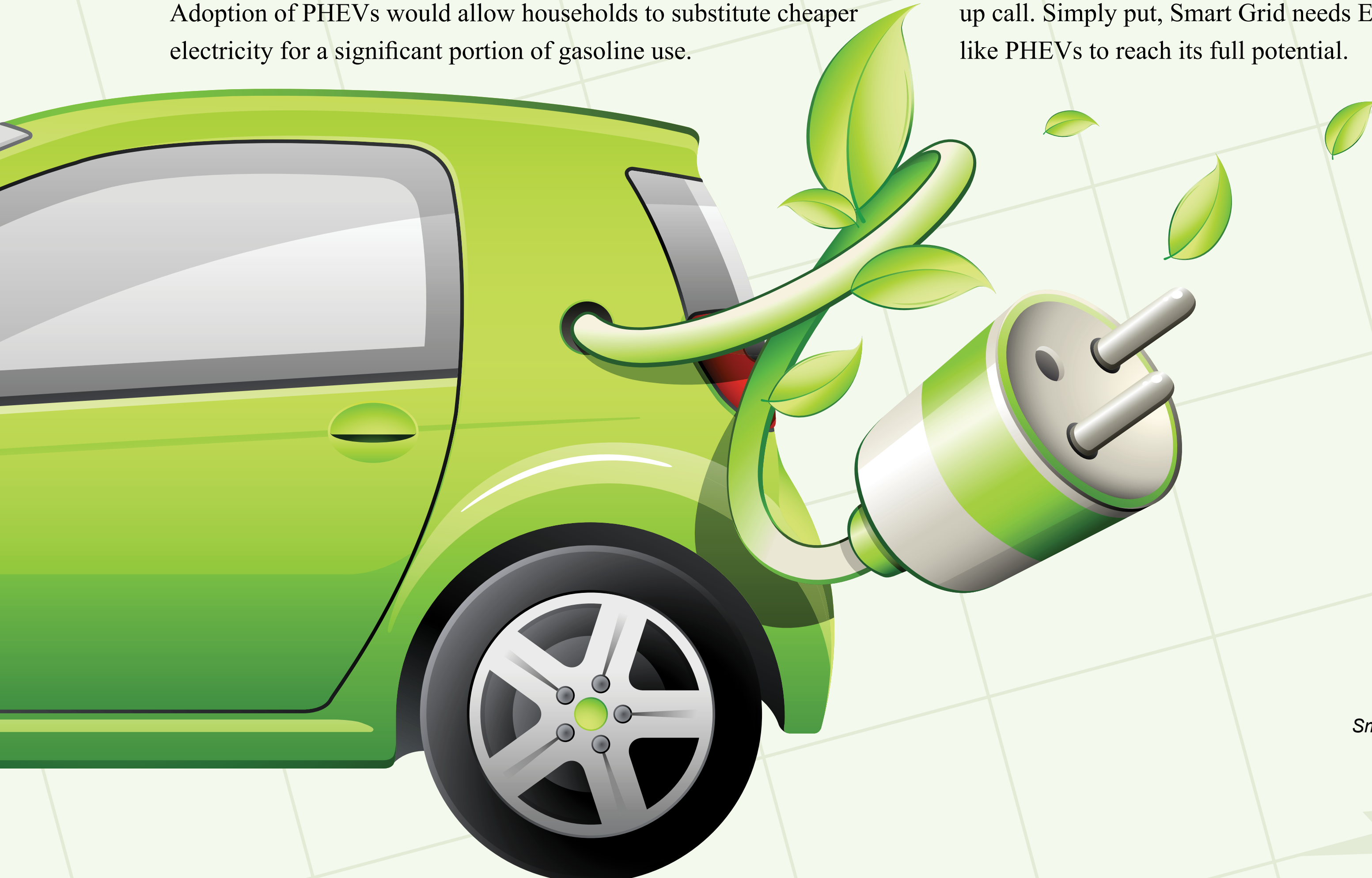
One scenario involves the Smart Grid notifying a utility source that demand is peaking. The utility would be able to locate and source participating PHEVs and enable them to upload power to



the grid, and the PHEV owner would be compensated. Alternatively, when the PHEV is energy-depleted, the owner pays to draw energy and charge its battery from the grid. Using advanced metering, the consumer can determine the best time and price for doing this. Adoption of PHEVs would allow households to substitute cheaper electricity for a significant portion of gasoline use.

PHEVs and other energy storage (ES) technologies are vital components to Smart Grid. Just as a wind-up clock stores potential energy, ES amasses its power and promises a dynamic wake up call. Simply put, Smart Grid needs ES systems like PHEVs to reach its full potential.

*PHEVs can reduce air pollution, greenhouse gases, and dependence on foreign oil while using renewable energy sources, engaging electricity back-up management, providing greater national energy security, and stimulating job creation.*



# Storing Energy, Leveling Loads

Energy storage allows for improved management of electricity in a power grid, essentially allowing energy producers to send low cost off-peak excess electricity to temporary energy storage sites that become energy producers when electricity demand is greater. This reduces the cost of peak-demand electricity by making off-peak energy available when demand is high without having to provide excess generation capacity that would not be used most of the day.

NEMA recognizes the immediate need to develop systems that allow electrical energy to be stored and easily accessed to meet demand whenever needed. Its members are on the cutting edge of developing technologies and making the products that will play a fundamental role in the 21st century electrical grid. Their portfolios comprise the products, systems, and software involved in the development, usage, and maintenance of energy storage sites that can temporarily store energy that can be available at any point on request.

These products can be categorized as stationary storage, i.e., fixed assets that tend to have greater capacity, and mobile storage, smaller capacity devices that can be deployed and redeployed based on availability and need.

This combination of technologies provides the means to level loads, provide quality backup power, shave peaks, and reduce intermittency across the entire Smart Grid.

Energy storage provides the balance between the grid's load and the amount of power generated. Having a stockpile of energy that can be tapped into on demand and especially during peak-demand hours is very important to ensuring that adequate energy is always available.

# Renewables Promise 21st Century Energy

According to U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy, alternative—or renewable—energy sources currently provide about 11 percent of the nation's energy supply. Generally referred to as "clean," these sources are often regional in nature and dependent on variable sources.

A critical element of Smart Grid, especially when it comes to alternative power sources, is energy storage. We need the ability to capture energy when the winds are blowing, the sun is shining, and the tides are turning and then store it for later use when the air is still, the clouds are thick, and the tides are slack.

Renewable energy falls into several general categories:

- Hydropower
- Bioenergy
- Geothermal
- Hydrogen
- Ocean
- Solar
- Wind

In order for renewable energy to be competitive with traditional sources, it needs to be cost effective and reliable. Energy storage is key to achieving sustainable energy.

# Dollars and Sense

Those in the energy industry need no introduction to the urgency of grid modernization, but for the general public, Smart Grid has rapidly emerged from the esoteric to a Super Bowl ad. In Cabinet appointments of energy-policy heavyweights, the Obama administration has launched the machinery of the federal government into a new phase of electric power investment. From new energy positions to the regulatory authority of the Federal Energy Regulatory Commission (FERC) and the massive research and development (R&D) budget of a stimulated Department of Energy (DOE), the course for action has been energized.

Grid investment will benefit from R&D. DOE is promoting new energy solutions through innovation as well as a national lab system that would function as the nation's intellectual "crown jewels." DOE will also likely make use of various public-private partnerships, where academic research can be quickly transitioned to commercial viability.

The economic stimulus legislation, H.R. 1 American Recovery and Reinvestment Act of 2009 (ARRA.09), contains a mix of spending and tax incentives. It directs DOE to study the transmission constraints of delivering renewable energy. Pending legislation would expedite transmission corridors to deliver clean and renewable energy while creating a national framework for all transmission facilities. These bills would help remove roadblocks that have substantially delayed the construction of new grid capacity. Congress continues to consider proposals that employ renewable energy zones and use energy storage to optimize the use of transmission.

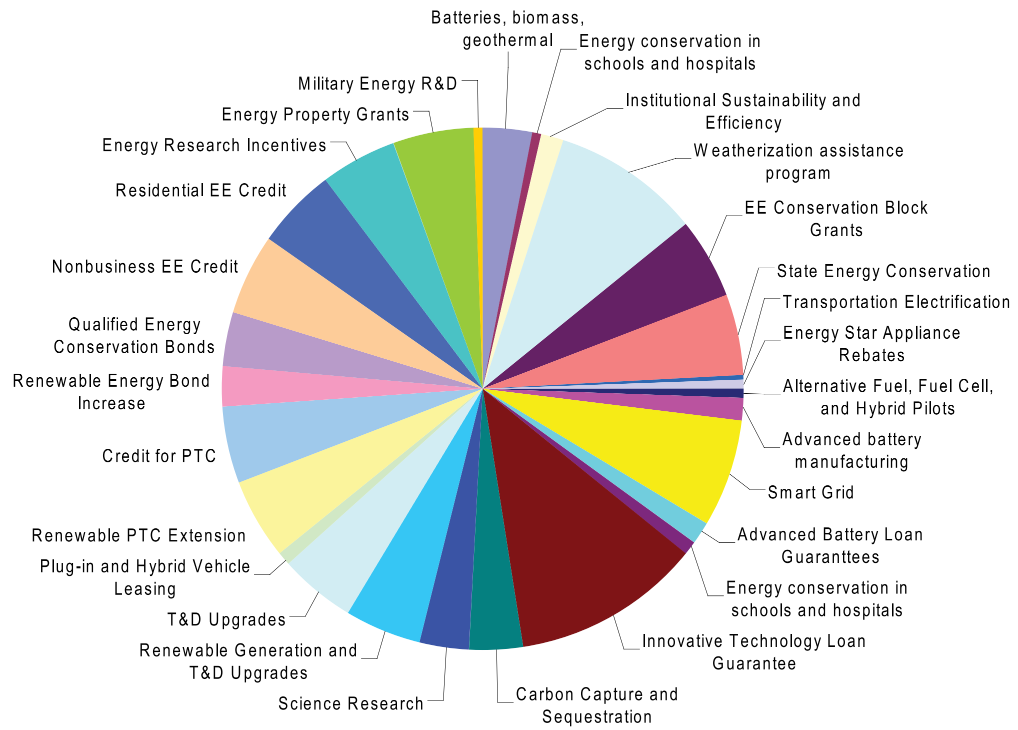
Other proposals encourage interconnection-wide planning, as opposed to state-by-state designs, regardless of the intended generation source. Under both proposals, FERC, in consultation with the states, would have the ability to authorize the construction of new transmission lines. A clear nationwide siting process will help this country build the necessary lines to connect clean renewable generation with growing needs and will help create domestic jobs now while building a grid for the future.

ARRA.09's energy package includes provisions to accelerate the modernization of the nation's electricity grid with

- $4.5 billion for Smart Grid technologies
- $6 billion for making federal buildings energy-efficient
- $3.5 billion for states to address their energy challenges
- $8 billion loan guarantee program to support renewable energy during the economic crisis
- $2 billion for energy efficiency and renewable energy research development and deployment, including energy storage
- $11 billion for new transmission lines

To support deployment of renewable energy supplies, tax provisions to extend the production tax credit through 2012 are included. In 2008, Congress passed a NEMA proposal that temporarily allowed businesses to recover the costs of capital expenditures made in 2008 faster than the ordinary depreciation schedule by permitting these businesses to immediately write off 50 percent of the cost of the new property. Congress is likely to extend this benefit for 2009 expenditures and potentially for 2010. NEMA is also supporting efforts to extend the enhanced small business expensing provision through 2009 of $250,000 for capital expenditures.

***Stimulus Expenditures on Energy and Efficiency***



# NIST Issues Smart Grid Overview

As the nation's measurement and standards institute, the National Institute of Standards and Technology (NIST) has responded to a congressional mandate that it take a leadership role in setting the standards to ensure an interoperable and open energy infrastructure. In collaboration with the Department of Energy (DOE) and organized by key Smart Grid domains, NIST has issued a draft report in support of the Energy Independence and Security Act of 2007 (EISA.07), which provides an encompassing overview of Smart Grid.

This report identified the revitalization of the electric power grid as one of the nation's top priorities and incorporates congressional recognition of NEMA as a stakeholder in the development of Smart Grid standards.

DOE defines Smart Grid as an automated, widely distributed energy delivery network characterized by a two-way flow of electricity and information, capable of monitoring and responding to changes in everything from power plants to customer preferences to individual appliances. By incorporating the benefits of distributed computing and communications, the Smart Grid will deliver real-time information and enable the near-instantaneous balance of supply and demand at the device level. This advanced network will make it possible to lower the high costs of meeting peak demand, and will support the incorporation of distributed and renewable energy sources.

Full implementation of the Smart Grid will enable new opportunities and support innovations, including:

- Nationwide use of plug-in hybrid electric vehicles, including the ability to return stored energy to the grid
- Seamless integration of renewable energy sources, like wind and solar
- A new era of consumer choice
- Integration of green building practices with the grid
- Large-scale energy storage
- High performance cables to improve efficiency on transmission corridors

NIST has identified the integral role that NEMA and other relevant standards development organizations (SDOs) will play in identifying, prioritizing, and recommending standards, and in calling attention to unmet standardization needs. As standards and gaps are identified, NIST will consider the priorities reflected in the business objectives and use cases, and the level of funding available, to determine where best to contribute.

Working with DOE, NEMA, other SDOs, Smart Grid stakeholders, and other interested parties, NIST plans to create an interoperability knowledge base (IKB) whose primary purpose will be to enable effective communication and collaboration within the large and diverse community of Smart Grid stakeholders. As a cornerstone of NIST's planned interoperability framework, the IKB will be the national clearinghouse for information supporting the development of a fully interoperable Smart Grid.

While NIST has initiated an overall Smart Grid interoperability program that, if resourced for success, will yield tremendous benefits, it is clear that the scope of the NIST interoperability framework is daunting. It's the entire electricity network from generation through the power grid, making it the most sophisticated machine ever built.

***The NIST report identified the revitalization of the electric power grid as one of the nation's top priorities and incorporates congressional recognition of NEMA as a stakeholder in the development of Smart Grid standards.***

# The Next Step—Implementing Interoperability Standards

Advanced metering infrastructure (AMI) and demand response (DR) are considered by many to be the first phase of Smart Grid. Both are key to full interoperability.

In its 2008 Demand Response and Advanced Metering Survey, the Federal Energy Regulatory Commission (FERC) focused on the current state of AMI and DR, along with estimates of the penetration of these techniques by region and state. According to the survey, potential peak-load reduction has increased, with significant activity occurring at the state, federal, and company level. About eight percent of customers in the U.S. are in some kind of DR program, which represents a large increase in customer enrollment and the number of entities that offer DR programs.

Many obstacles, however, remain before the fully interoperable grid becomes a reality. Government and industry have begun programs and processes to address most of these barriers, but significant work remains to be done. One next step is for industry to submit standards to the National Institute of Standards and Technology, which in turn will endorse and refer them to FERC for rulemaking. Upon approval, they can be implemented to build the new AMI network.

Two standards recently published by NEMA address this issue directly. ANSI C12.19-2008 *Utility Industry End Device Data Tables* presents common structures for encoding data in communication between end devices and utility enterprise collection and control systems using binary codes and XML content. ANSI C12.22-2008 *Protocol Specification for Interfacing to Data Communication Networks* is a new application-level standard that describes the process of transporting C12.19 table data over a variety of networks. This standard promises advanced interoperability among communications modules and meters by employing advanced encryption.

Together, the C12 standards enable strong, secure Smart Grid communications, including confidentiality and data integrity, which are integral to the AMI infrastructure.

# NEMA Recommends Specific Process to Implement Interoperability

NEMA advocated for the inclusion of the Smart Grid (Title 13) in the Energy Security and Independence Act of 2007. At that time, Congress asked NEMA to partner with the National Institute of Standards and Technology (NIST) in its Smart Grid Interoperability Framework to develop specific process recommendations for implementing the framework specified by Congress.

First, NEMA recommends that NIST set up a process to deem a standard "interoperable." Standards development organizations (SDOs), like NEMA, may continue to develop voluntary standards as the market requires. Since some federal programs or tax benefits may be triggered upon NIST approval, an SDO may also ask NIST to conduct an interoperability review to ensure compatibility with existing Smart Grid standards. NIST would then notify the Federal Energy Regulatory Commission (FERC) that a standard has been approved on its technical merits.

Congress has provided FERC with the authority to mandate standards after NIST approval and after obtaining "sufficient consensus." The American National Standards Institute (ANSI), which is responsible for accrediting the procedures of SDOs (including NEMA), requires SDO processes that meet the "sufficient consensus" requirement. These criteria include openness, lack of dominance, balance, coordination and harmonization, notification, consideration of views and objections, consensus vote, appeals, and written procedures. These requirements facilitate wide stakeholder participation and are designed, at their core, to promote consensus. FERC should determine that a Smart Grid standard approved through an ANSI-accredited process meets the "sufficient consensus" requirement.

Finally, an SDO can petition FERC for adoption of a specific standard. FERC should approve a standard if it is in the national interest, has demonstrated consensus through an accredited standards development process, and has been approved as an interoperable standard under the institute's framework. NEMA recommends that FERC consider sunset mechanisms to accommodate advances in technology and the corresponding standards revisions.

This process clearly identifies the role of the federal bodies. NIST bears the technical role in ensuring that each new standard is compatible with existing and previously adopted standards. FERC's role is to mandate standards that are necessary to promote just and reasonable rates, as well as ensuring the reliability of the bulk power system. This process also provides the private sector with a voluntary choice: standards may be submitted for regulatory approval or can remain wholly in the private sector.

# ABCs of Smart Grid

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| AMI | *Advanced Metering Infrastructure* |
| ANSI | *American National Standards Institute* |
| ARRA.09 | *H.R. 1 American Recovery and Reinvestment Act of 2009 (Stimulus Bill)* |
| DOE | *Department of Energy* |
| DR | *Demand Response* |
| EIA | *Energy Information Administration (Section of DOE)* |
| EISA.07 | *Energy Independence and Security Act of 2007* |
| EREN | *U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy* |
| ES | *Energy Storage* |
| FERC | *Federal Energy Regulatory Commission* |
| HEV | *Hybrid Electric Vehicle* |
| IKB | *Interoperability Knowledge Base* |
| NAESB | *North American Energy Standards Board* |
| NARUC | *National Association of Regulatory Utility Commissioners* |
| NEMA | *The Association of Electrical and Medical Imaging Equipment Manufacturers* |

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|---|---|
| NERC | *North American Electric Reliability Corporation* |
| NIST | *National Institute of Standards and Technology* |
| PHEV | *Plug-in Hybrid Electric Vehicle* |
| PMU | *Phasor Measurement Units* |
| SDO | *Standards Development Organization* |

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.

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