

CHAPTER 1

Smart Grid Takes on Critical Standards Challenges

A smart energy grid, the promise of creating a modern power distribution system that uses the most advanced technologies, may be one of the most complex and technology-diverse standards development efforts in recent history. Global in scope, creating an interoperable smart grid—a network that will integrate information and communication technologies (ICTs) with the power-delivery infrastructure to enable bidirectional flows of energy as well as two-way communication and control—is considered an essential step to replacing most of the world’s aging and widely disparate technologies. Once it’s up and running, the smart grid is expected to reduce the duration and frequency of power outages and lower generation requirements by reducing inefficiencies in energy delivery. It could also provide more effective management of distributed generation and storage of electric power.

Most electricity grids are controlled by a network of legacy systems designed to control or operate a specific function or task and they usually do it well. The biggest challenge in creating a smart grid, according to a Nokia Siemens Networks study, is that different systems cannot share data with each other—they’re incompatible. Operational processes are also cumbersome and require manual steps to exchange

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information. Network models are built for each application and maintenance is increasingly costly. The new goal is to create a modern, or “smart,” electric grid that integrates the management of utilities through an infrastructure that takes advantage of the state-of-the-art information communication technology.

From a standards perspective, the Global Smart Grid Federation (GSGF), which works with the International Smart Grid Action Network (ISGAN) as well as with other national and international government policymakers to address the challenges of deploying smarter grids, has identified more than 530 different smart grid standards. But there’s also still plenty of work to do, mainly in the area of interoperability in many parts of the world where the GSGF says there is a great need for further harmonization.

While there is a basis for smart grid standards and interoperability in the international standard IEC 61850, the GSGF sees much of the additional work focused on distribution grid management, network communication, and metering infrastructure. Also, mapping exercises have identified at least 25 different definitions of interoperability. “Obvious gaps need to be managed and standardization is very time consuming,” the organization says in *GSGF Report—Smart Grid Interoperability*, published in June 2014. One of the important obstacles, according to the report is the lack of experts to involve in developing the needed standards. (IEC 61850 has evolved through at least 10 versions or updates and covers several electric power systems protocols, including the design of electrical substation automation, the definition of basic services required to transfer and store data, and testing requirements. It also calls for promoting interoperability between systems.)

Whatever the problems and goals, the smart grid is a significant business opportunity. Transparency Market Research (TMR) forecasts the value of the global smart grid market at \$118.1 billion in 2019, growing at a compound annual growth rate (CAGR) of 18.2% from 2013. (TMR warns that the lack of interoperability and open standards could easily hamper market growth, but notes that the emerging option of pre-paid electricity with the deployment of advanced metering infrastructure (AMI) should offset growth restraints and boost growth.) The demand for electricity in the United States has grown by 25% since 1990. Analysts see communication technologies evolving rapidly with vendors and service providers aggressively targeting their products to meet the expanded needs of utilities. Thierry Godart, president of Siemens Smart

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Grid Division North America, says, “The challenge to monitor, control, and manage millions of communicating grid devices from multiple vendors continues to grow dramatically as grid modernization drives usage of a few thousand device to tens of millions.” New generations of wireless technologies, including RF mesh networks (multiple path, RF channels often used by utilities for smart grid communications for their low operational expense and high reliability), along with point-to-multipoint, WiMAX, and 4G Long-Term Evolution (LTE) technologies, are showing greater potential for smart grid applications. Navigant Research anticipates the number of communications node shipments climbing to 124.7 million in 2020, up from 91.7 million in 2012.

A SYSTEM-OF-SYSTEMS

Utilities and others have been using the term “smart grid” since the late 1990s. But over the past few years, almost every country of any size in the Western Hemisphere, Europe, and the Asia-Pacific has created government-sponsored programs aimed at modernizing and contributing to the development of smart grid standards that result in more energy-efficient and sustainable power grids. “This is the world’s first system-of-systems, foundational standard that has been created from the ground up to inform smart grid interconnection and interoperability, and it happened in a rapid pace,” said Dick DeBlasio, IEEE 2030 Working Group chair, chief engineer at the National Renewable Energy Lab (NREL) facility of the US Department of Energy (DoE), and the IEEE Smart Grid liaison to the National Institute of Standards and Technology (NIST).

IEEE 2030 is the Institute of Electrical and Electronics Engineers standard designed to govern smart grid interoperability. Ratified by the IEEE Standards Association (IEEE-SA), the standard provides alternative approaches and best practices for achieving smart grid interoperability. It establishes the smart grid interoperability reference model (SGIRM) and provides a knowledge base addressing terminology, characteristics, functional performance and evaluation criteria, and the application of engineering principles for smart grid interoperability of the electric power system with end-use applications and loads. It also defines design tables and the classification of data flow characteristics necessary for interoperability. For all of its complexity and the integrated contribution of hundreds of people involved in its development, IEEE 2030

was put together in just 2 years. But the IEEE 2030 Working Group still had plenty of work to do on extensions well into 2013, including the final ratification of IEEE P2030.1—Guide for Electric-Sourced Transportation Infrastructure; IEEE P2030.2—Guide for the Interoperability of Energy Storage Systems Integrated with the Electric Power Infrastructure, and IEEE P2030.3—Standard for Test Procedures for Electric Energy Storage Equipment and Systems for Electric Power Systems Applications. (The “P” indicates the standard is still in the project, or development, stage.)

JUMP STARTING THE SMART GRID

The US Energy Independence and Security Act (EISA) of 2007 jump-started the development of a smart grid in the United States, charging NIST, an agency of the US Department of Commerce, with the primary responsibility to coordinate development of a framework to achieve interoperability of smart grid devices and systems. To start putting all the pieces together, NIST formed the Smart Grid Interoperability Panel (SGIP). Originally a public–private partnership, its initial task was to define requirements for essential communications protocols and other specifications, and to coordinate the development of these standards with other organizations. By 2012, the SGIP comprised of more than 780 member organizations representing 23 stakeholder categories, including at least 25 international standards development organizations (SDOs), government agencies, utility companies, equipment suppliers, trade associations, and venture capital firms.

The SGIP does not develop standards of its own, but it does serve an advisory role in accelerating the harmonization of new and emerging standards for the smart grid—not a small task for so many different SDOs working with hundreds of organizations representing their own interests to accelerate standards development and harmonization of interoperability of smart grid devices and systems.

The EISA legislation also directs NIST to work with the DoE in developing the framework for smart grid interoperability. It also authorized the DoE to develop a smart grid regional demonstration initiative. The passage of EISA followed by 2 years approval of the US Federal Energy Policy Act of 2005, which calls for state commissioners to consider certain standards for electric utilities, and was 2 years ahead of the American Recovery and Reinvestment Act of 2009 (ARRA), and

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Europe's Directive 2009/72/EC and 2009/73/EC, both of which are part of Europe's Third Package for the Internal Energy Market—programs that developed several standards initiatives, including mandates covering the 28-member nation states of the European Union (EU). By the end of 2010, SGIP had identified five “foundational” sets of standards for smart grid interoperability and cyber security that it pronounced ready for consideration by US federal and state energy regulators. The standards, produced by the International Electrotechnical Commission (IEC), focuses on information models and protocols for smart grid operations.

IEC 61970 and IEC 61968 provide a common information model, necessary for exchanges of data between devices and networks, primarily in the transmission (IEC 61970) and distribution (IEC 61968) domains.

IEC 61850 facilitates substation automation and communication as well as interoperability through a common data format.

IEC 60870-6 facilitates exchanges of information between control centers.

IEC 62351 addresses the cyber security of the communication protocols defined by the preceding IEC standards.

In 2011, NIST and the European Union's Smart Grid Coordination Group (SG-CG) jointly announced their intention to work together on smart grid standards development. Also, in 2011, the Obama Administration announced several additional initiatives designed to accelerate modernization of the country's electric infrastructure with new and interoperable smart grid technologies.

Economic and political issues are a big part of the story at global, national, regional, and local levels. In the United States, where both the federal and state governments have jurisdiction over the sale of electricity to consumers and commercial customers, a DoE study found that ARRA funding and matching support from utilities, as well as from the private sector in the DoE-managed Smart Grid Investment Grants (SGIG) and Smart Grid Demonstration Program (SGDP), generated a significant impact on the US economy. As of March 2012, the total invested value of \$2.96 billion to support smart grid projects generated at least \$6.8 billion in total economic output. Smart grid-related programs created at least 12,000 jobs by early 2012, according to the DoE study.

A separate report indicated that consumer sales of smart meters in the United States had reached a national penetration rate of 14% by the end of 2011, with rates in several states exceeding 25%. In fact, uneven sales of smart meters at regional and local levels were not uncommon, with positive consumer reaction to smart meter deployments in some areas and pushback in others, most of them directed at health and privacy concerns and increased electricity costs.

THE STANDARDS PRIORITY

In addition to identifying new standards needed for the smart grid, the SGIP has produced a list of more than 90 existing standards that it believes can be leveraged for grid modernization. The SGIP also published the *NIST Framework and Roadmap for Smart Grid Interoperability Standards, Release 2.0* in 2012 aimed at helping guide the technical community in developing their smart grid products and services. Two additional reports were published in 2013: *Strategic R&D Opportunities for the Smart Grid* and *Technology, Measurement, and Standards Challenges for the Smart Grid*, which outlines a “host of challenges” for power company system planners, industry and academic researchers, and senior decision makers concerned with development of the smart grid. In October 2014, NIST released the third version (designated 3.0) of *Framework and Roadmap for Smart Grid Interoperability Standards*, incorporating seven new standards that support interoperability, bringing the total to 74 standards and protocols. This new release also addresses the deployment of synchrophasors, which help engineers monitor the electrical flow along the grid to better maintain stability and efficiency in the system, and discusses the role of cyber security and expands on earlier discussion of testing and certification of smart grid standards. NIST has said it anticipates publishing a fourth version (4.0) of this report.

The SGIP is working closely on efforts to harmonize smart grid standards with EU countries and standards organizations—the European Committee for Standardization (CEN), the European Committee for Electrotechnical Standardization (CENELEC), and the European Telecommunications Standards Institute (ETSI). (Only standards developed by CEN, CENELEC, and ETSI are recognized as European standards in the European Union.) South Korea was the first to officially sign on with the SGIP in 2010. About 720 Japanese companies are involved in smart grid development. Columbia has its own

national standards organization, but reached out to the SGIP in 2013 to be one of its standards components. Brazil, India, and Ecuador also are on board with the SGIP.

The SGIP also has several priority-specific technical committees and working groups, all of them monitored by NIST.

Smart Grid Architecture Committee: The Smart Grid Architecture Committee (SGAC) maintains a conceptual reference model for the smart grid and develops corresponding high-level architectural principles and requirements.

Smart Grid Testing and Certification Committee: The Smart Grid Testing and Certification Committee (SGTCC) creates and maintains the framework for compliance, interoperability, and cyber security testing and certification for recommended smart grid standards.

Cyber Security Working Group: The Cyber Security Working Group (CSWG) identifies and analyzes security requirements and develops risk mitigation strategies to ensure the security and integrity of the smart grid.

Priority Action Plans: Priority Action Plans (PAPs) identify user requirements and standards-related gaps and issues for which a resolution is most urgently needed. PAPs also keep track of action plans. PAPs totaled 16 at one point, but the number keeps increasing, mainly to meet user requirements and fill gaps in standards. “We’re always looking to keep the pipeline full of new PAP proposals,” says John McDonald, chairman of the governing board of the SGIP and director of technical strategy and policy development at General Electric Energy Management-Digital Energy. The NIST-formed panel has a very detailed procedure to keep its PAPs and monthly meetings on schedule. “We have to be able to accelerate typical IEEE and IEC timeframes from five or six years to nine months, maybe 18 months, to get our work done.” That’s much faster than most global programs of this size and complexity. “We can’t afford five or six years to get a standard done,” says McDonald.

A few samples of completed PAPs:

PAP 7 focused on energy storage interconnection guidelines, resulting in the publication of IEC 61850-90-7, Information Model for Advanced Directed Energy Resources (DER) inverter functions, and the release of a new UL 1741 CRD, covering certification tests for

grid interactive DER and special purpose DER. The PAP results led the US Federal Energy Regulatory Commission (FERC) and the California Public Utility Commission (PUC) to initiate a new rulemaking process to consider requiring inclusion of new functions based on IEC 61850-90-7 and PTTT 1547a.

PAP 15 worked with SGIP working groups to review narrowband power line communication (PLC) standards for the SGIP Catalog of Standards. It completed its review of ITU-T Recommendation G.9902, G.9903, and G.9903, and raised several issues on security. PAP 15 also worked with ITU-T Study Group 15 to address these issues and to review the standard more broadly.

Domain Export Working Group: Domain Export Working Groups (DEWGs) are a function of the expert work groups and represent more of a strategic, long time-frame process (potentially a few years) to deal with business strategy, and to perform analyses and provide expertise in specific application domains. DEWG technical committees also identify gaps and, if appropriate, submits these for PAP and eventually board-level approval. Home-to-grid and distributed generation are areas of specific interest. With the fast emergence of transactive energy, the DEWG formed an ad hoc group to explore a framework for data sharing and usage arrangements between interacting parties, which eventually became a Transactive Energy Working Group (Business to Grid DEWG). DEWG also continues to develop scenarios for transmission bus distribution load models (TBLM), which facilitates communication between the energy management system and distribution management system, developing scenarios to address what it considers to be abnormal states and “very large scale events,” such as Hurricane Sandy, which hit the northeastern United States in October 2012. The DEWG also identifies user requirement gaps in plug-in electric vehicle fueling.

The SGIP also developed an intellectual property rights (IPR) policy to handle patents and related issues. “It’s one of the first things we did,” says McDonald. The European Patent Office (EPO), which has been seeking closer involvement with international standards organizations in recent years, renewed its memorandum of understanding (MoU) with the IEEE-SA in June 2013, updating the agreement they signed in July 2009. The EPO has similar agreements with ETSI, the ITU, and the IEC, through which they share

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data, and work to harmonize gaps in communications standards and interoperability. “Compliance to the same standard does not guarantee interoperability,” McDonald stresses. “Interoperability cannot be guaranteed on paper.” To ensure that devices and systems can talk to each other, the industry conducts so-called PlugFests, regular events where vendors come together for the first time to connect their products to test their interoperability.

STRICTLY BUSINESS

In January 2013, the SGIP transitioned from a strictly government-funded organization to a self-sustaining, tax exempt entity with the majority of funding coming from industry stakeholders. The organization became a non-profit 501(c)(3) legal entity, with a new identity, SGIP 2.0 Inc., but still dedicated to advancing the original mission of coordinating standards development and encouraging global harmonization. The SGIP 2.0 board has one member from each of the 22 specific stakeholder categories, plus an “at-large” category made up of three members. The at-large members were selected for their broad and lengthy standards development experience.

The change to a member-funded organization created a membership issue. As a result, the SGIP had to put a membership campaign together, “a value proposition story, and also continue to run the government-funded NIST organization,” says McDonald. The SGIP got \$750,000 from NIST near the end of 2012, and expects to receive an additional \$1 million from NIST in 2014 and in 2015. Still, the pay-to-play scheme created certain challenges. “In 2010, 2011, and 2012, we had approximately 800 organizations on the books,” says McDonald. “Figure 200 to 300 of those are active, and the rest are monitoring what’s going on. Of that number, 200 are from outside the United States. Each [member representative] is an expert in their own company and they’re used to getting their own way. And I have 25 of them.” As of July 2013, SGIP 2.0 had about 200 dues paying members. It was at about that point that the SGIP put out a formal call for a director of marketing and membership, a new position within the organization, tasked to attract new members and retain existing members. Patrick Gannon, formerly an executive with OASIS, was hired to fill the slot. The dues-paying member list climbed to about 230 by early 2014.

McDonald has spent much of his time on international outreach, signing MoUs with several countries through 2013 and into 2014. Among the countries that have begun investing in substantial smart grid infrastructure are Canada, Mexico, Brazil, India, Japan, Korea, Australia, China, and many EU member states. In addition, NIST and the International Trade Administration (ITA) have partnered with the US DoE to establish the ISGAN, a multinational collaboration of 17 countries. ISGAN complements the GSGF, a global stakeholder organization that serves as an “association of associations” to bring together leaders from smart grid stakeholder organizations from around the world. Several of these countries have gone beyond the MoU stage to full dues-paying members, giving them voting status. “Their goal is to harmonize their standards globally,” McDonald said. “This is extremely important. Without harmonization, you have trade barriers and that’s the goal of these MoU.” Several US federal agencies are focusing on the trade aspect of harmonization, including the US Department of Commerce, which has its own smart grid department.

UNITED STATES HAS A RUNNING START

Lucintel, a global management consulting and market research firm, says the US smart grid market has a running start, already showing double-digit growth, much of this is coming from the global installation of smart meters, which have been heavily promoted as the next generation of gas and electricity meters with intelligent features, like remote meter reading. Lucintel expects this market to reach about \$126.7 billion in 2017 with a CAGR of 13% over the next several years. Lucintel believes the infrastructure sector will represent the largest share of the smart grid market in terms of revenue, followed by communications, mainly from smart meter sales.

Spending by utilities upgrading their networks to meet smart grid standards had already reached \$23.68 billion in 2012, according to market analysis by ABI Research. “Utilities are investing in the rollout of a broad assortment of new applications and spending is driving new services from a wide range of vendors and consultants,” said Jonathan Collins, principal analyst at ABI Research. “The complexity of the new hardware, applications, and the expansive array of suppliers vying to deliver services continues to ensure that systems integrators benefit with

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a significant share of the spending.” This complexity of getting all of the pieces together was highlighted in a study by Pricewaterhouse Coopers LLC. Called *Smart Grid Growing Pains*, the report said, “Utilities are forming alliances with the auto and tech industries, adding layers of operational complexity.” But ABI’s Collins says these are the early years of smart grid investments; he expects spending to grow, reaching \$80 billion during 2018.

Clearly, equipment vendors are competing for a share of the billions that will be spent by utilities and others over the next several years. GTM Research, which tracks energy markets, has broken down the network grid into several key smart grid market segments. Its survey of 150 smart grid vendors has identified these segments as AMI, grid networking, transmission and distribution automation, soft grid, demand response, home area networks, building automation, smart enterprise, storage, renewable integration, and security. In 2013, when GTM Research published its survey results, most of the activity was in what has been referred to as the soft grid—utilities upgrading their patchwork of outdated IT systems to handle the unprecedented amounts of data that are expected to flow through the system. GTM says the soft grid alone represents a potential global market in the billions of dollars over the next several years.

SMART METER CONCERNS

For all of their success to date, and for all they reportedly bring to enhancing the electrical smart grid, smart meters have come under attack from a variety of sources on issues ranging from public health to privacy, and time-of-use pricing. A NIST report pitched the advantages of smart meters (“Without smart meters, consumers will have limited understanding of their energy usage, and utilities will be unable to gather sufficient data on energy consumption...”), but it has also recognized a resistance to smart meters. Some communities have even banning them. Toward the end of 2012, the Texas PUC drafted rules allowing millions of state businesses and consumers to opt out of smart meters. The opt-out wasn’t a final decision as it was subject to public comment before a final PUC vote. But that action was quickly followed by the Vermont Department of Public Service, which said it planned to evaluate how wireless meters could affect the public’s health and security. The Smart Grid Consumer

Collaborative chimed in with a website (WhatIsSmartGrid.org) to help consumers understand the benefits of the smart grid, but it focused on smart meters.

Utilities in the United Kingdom had expected to install smart meters in 30 million homes by the end of 2019, but UK authorities have delayed the program by at least a year. The United Kingdom's Department of Energy & Climate Change (DECC) said the postponement was the result of the energy industry requesting more time to design, build, and test various phases of the program. Ovum, a Melbourne-based organization that provides independent analyses of global technology programs and markets, was critical of the delay. "Giving retailers such as British Gas and EDF responsibility for the smart meter rollout created some unique issues," said Stuart Ravens, Ovum's principal energy and sustainability technology analyst. "In other deployments worldwide, metering is the responsibility of network operators, not retailers. So each network operator is responsible for discrete geographic areas and able to select the right communications technology for its area. In practice, this is usually a hybrid of different communications." According to Ravens, the DECC decided to divide Britain into three regions and invited tenders for each of these regions. Part of the tendering process was to request proof that each communications technology would work in the British deployment. "However," noted Ravens, "it did not commission any trials itself. If the tendering process were to proceed as previously planned, Britain would have commissioned a communications network for over 50 million meters that had not been properly tested."

Smart meters probably took their biggest hit with the promotion and release of a feature-length documentary, *Take Back Your Power*. Produced and directed by Josh del Sol, who became interested in smart meters when a friend in his home town of Vancouver became ill and blamed the smart meter in his home for his seemingly sudden health issues, the film is a blend of interviews with energy experts, government and regulatory officials, and environmentalists. Initially distributed in September 2013, the film suggests questionable industry practices in the implementation of networked control systems for power plants, and includes footage of utility workers installing smart meters without homeowner consent and property damage caused by technical problems with these devices. It also documents illnesses and inaccurate power bill increases. Also it reports that utilities in more than a dozen US states now offer opt-out programs to their customers, although most

charge a fee to exercise that option. As of April 2014, del Sol was developing French and Spanish subtitled versions of the film. Edison Electric Institute, a trade group representing utilities implementing smart meters, has declined to comment on the film.

IEEE AND THE SMART GRID

When the IEEE-SA began drafting smart grid standards in the mid-2000s, it focused on three domains: implantation, applications, and integration. Since then, the IEEE-SA has formed a multi-faceted smart grid program. By early 2010, the IEEE had launched IEEE Smart Grid, a global initiative to integrate its vast resource of technical expertise to further promote and develop global smart grid standards. The IEEE-SA has published more than 100 smart grid-related standards, 16 of which fall into the IEEE 802.11-related wireless networking category, along with at least 2500 papers on smart grid issues in more than 40 journals. It has also launched two cross-disciplinary and archival journals, *IEEE Transactions on Smart Grid* and *IEEE Transactions on Sustainable Energy*. The IEEE Smart Grid Web Portal (<http://smartgrid.ieee.org>) provides updates on developments in the field. The IEEE-SA has also added a smart grid website and a monthly smart grid newsletter, and published *The IEEE Standard 2030 Guide for Smart Grid Interoperability of Energy Technology and Information Technology Operation with the Electric Power System (EPS) and End-Use Applications and Loads* that provides a framework for setting future smart grid standards.

The NIST smart grid program, which has established both strategic relationships with the senior leaders of the major SDOs, as well as tactical relationships to provide specific revisions to existing standards, describes the IEEE as a “collaborative partner,” and has recognized IEEE standards for their value to various smart grid technologies. More than 20 IEEE standards are named in the *NIST Framework and Roadmap for Smart Grid Interoperability Standards Release 1.0*.

A few examples:

Guide for Smart Grid Interoperability of Energy Technology and Information, IEEE 2030-2011, the IEEE standard that governs smart grid interoperability.

Smart Metering, IEEE P1377, IEEE 1701, IEEE 1702, IEEE P1703, IEEE P1704, and IEEE P 1705.

Smart Grid into Home Devices Standards—IEEE 1547 series, IEEE 1675, IEEE 1775, IEEE 2030, IEEE P2030.1, IEEE 1901, IEEE P1901.3.

Home Networking Standards—IEEE 802, IEEE 1901, IEEE P1901.2, IEEE 1815, and IEEE 1905.1-2013, Standard for a Convergent Digital Home Network for Heterogeneous Technologies, were developed to provide a common interface to augment, and to unify widely deployed home networking technologies, including IEEE 1901-2010, the Standard for Broadband over Power Line (BPL) Networks: Medium Access Control and Physical Layer Specifications. IEEE 802.11 covers wireless local-area networks (LANs), Ethernet over twisted-pair cable, and multimedia-over-coax (Moca) 1.1 for home entertainment networking over coaxial cable. IEEE 1905.1 is the only industry standard that integrates wired technologies with wireless connectivity. “The main motivation behind IEEE 1905.1-2013 is to address a ubiquitous-coverage requirement by the service providers,” said Purva Rajkotia, chair of the IEEE 1905.1 Convergent Digital Home Networking Working Group. “By unifying established home networking technologies, today’s hybrid home networking systems and future home networking innovations and standards, what we are trying to achieve is to provide coverage at all places with the home.” Scott Willy, vice chair of the IEEE 1905.1 Convergent Digital Home Network WG, says that many people just have Wi-Fi with a router, and they drag an Ethernet cable to connect it to the router. “In other places, particularly in Europe, HomePlug technology is used for connecting the router to the set-top box for TV. In the United States, they’re using Moca for TV connectivity. The IEEE 1905.1 layer helps reduce and hide the home networking complexity from the consumer, but it also helps the operators manage that complexity across all the different networks as they become more pervasive throughout the home.”

The IEEE 1901.2, Standard for the Low-Frequency (less than 500 kHz) Narrowband Power-Line Communications for Smart Grid Applications, has been added to the mix to add performance with mandatory differential and more robust coherent modulation, with added enhancements for increased data rates. IEEE 1901 was developed for high-speed communications devices over electric power lines. The standard delivers data in excess of 500 Mbps in LAN applications and is used with transmission frequencies below 100 MHz.

CATALOG OF STANDARDS

IEEE 1901 has already been included in the SGIP Catalog of Standards, a compendium of standards and practices considered to be relevant to the development and deployment of a robust, interoperable, and secure smart grid. The HD-PLC Alliance has provided certification service for this coexistence spec, known as the Inter-System Protocol (ISP). (There are several types of standards based on BPL technologies; however, the instability of communications due to the interference among the different BPL technologies was a serious concern. With the coexistence requirement of NIST IR 7862, the PLC products used in energy management systems and consumer PLC products connected on the same power line will not interfere with one another, and will provide secure communications.)

The difference between 1901 and 1905.1 is that 1901 is a standard broadband PLC. It defines the MAC/PHY for broadband PLC, while IEEE 1905.1 defines an abstraction layer for multiple home networking technologies. The abstraction layer provides a common data and control Service Access Point to heterogeneous wireless and wired home networking technologies described in IEEE 1901 (PLC), IEEE 802.11 (Wi-Fi), IEEE 802.3 (Ethernet), and Moca 1.1. The standard is extendable to work with other home networking technologies. More specifically, IEEE 1905.1 enables the combination of different wired and wireless networking technologies inside the home to form a single network. It helps aggregate throughput, to transfer multiple simultaneous streams or to distribute heavy streams, especially video, over different paths to limit congestion and maintain reliability. HD-PLC also is compliant with the European EMC standard CENELEC EN 50561.1. “It is a significant achievement that HD-PLC contributed to major standardization efforts in the United State, Europe, China, Japan, and that it is now available all over the world,” said Toshiyuki Takagi, president of Panasonic System Networks Co. Ltd.

Japan adopted HD-PLC IEEE 1901 technology under standard guidelines developed by Japan’s Smart House Study Group and Smart Community Alliance. The IGRS-PLC IF standard that is fully compatible with HD-PLC IEEE 1901 (and promoted by the IGRS Alliance) has also been approved as a national standard in China. The HD-PLC Alliance also supports EN-50561-1, a European EMC standard for PLC. Jean Philippe Faure, CEO of Progilon SA, and a member of the board of the IEEE-SA, said, “As a leader in the industry, in

addition to HD-PLC product certification, we will actively promote the coexistence protocol recommended by NIST SGIP and compliance with international standards.”

TIMING IS EVERYTHING

Understandably, some standards take longer to develop than others. IEEE 1547, for example, moved quickly, winning approval of the IEEE Standards Board in June 2003 and the American National Standard Institute (ANSI) in October 2003. The standard, which, like so many other technical standards, is subject to revision by an IEEE-SA working group, provides a uniform standard for interconnection of distributed resources with electric power systems. It also provides requirements relevant to the performance, operation, testing, and maintenance of the interconnection.

By March 2013, the SGIP’s Smart Grid Architecture Committee (SGAC) was seeking assistance in several key areas, especially the power sector. Power standards organizations generally follow a variation of EPRI Intelligrid, a use-case methodology that depends on the architect’s ability to identify so-called actors, or roles, to support anticipated scenarios. Other standard bodies were taking a phased approach used by Open Group (a global IT consortium that focuses on interoperability and open source issues) and the Organization for the Advancement of Structured Information Standards (OASIS), a non-profit consortium accredited by the American National Standards Institute. In July 2013, the IEEE also approved what it calls the IEEE 3000 Standards Collection for industrial and Commercial Power Systems, which sets guidelines and establishes standards for virtually every aspect of power generation and distribution. IEEE 3001.8 is the first “dot” standard of the 3001 standard to focus on instrumentation and metering in industrial and commercial power systems. The Ethernet Alliance formed a Power-over-Ethernet (PoE) Subcommittee late in 2013 to support both new and ongoing IEEE 802.3 projects encompassing PoE and IEEE 802.3 Next-Generation Passive Optical Networking (EPON). The alliance was also promoting proposed PoE standards IEEE P802.3bu and IEEE 802.3bj, which address the 100 Gb/s Ethernet backplane and copper cable operations, and IEEE P802.3br, which specifies parameters for interspersing express traffic.

EUROPE'S INTERCONNECTED GRID

Most electrical grids in Europe are interconnected, requiring the various jurisdictions to harmonize their standards, policies, and the regulation of the electricity sector. The European Union is developing its own plan for smart grid deployment, enacting legislation aimed at moving smart development forward among its 28-nation members. The European Commission (EC), the executive arm of the EU, launched a Task Force on Smart Grids in January 2009 and within a year had established the European Electricity Grid Initiative. An R&D pilot program designed to integrate electrical power and demonstrate smart grid capabilities at several sites across Europe, called Grid4EU, is scheduled to be completed in 2016.

The British Parliament has been working on smart grid-related energy legislation and market-related issues since at least 2011. Energy policy in the United Kingdom is shared across agencies, but the DECC is responsible for energy policy in the country, and the Office of Gas and Electricity Markets (OFGEM) regulates the United Kingdom's national electric infrastructure. OFGEM published a Smart Grid Vision in December 2009 and a more detailed Smart Grid Routemap in February 2010. There's also an Electricity Network Strategy Group (ENSG). The United Kingdom is an EU member and subject to its directives, but its smart grid vision is keyed to developing and supporting a

Regional smart grid deployment hotspots

Region	Hotspot 1	Hotspot 2	Hotspot 3
Asia-Pacific	Distribution automation	Network operations software	Transmission modernization
China	Distribution automation	AMI	Transmission modernization
Europe	Network operations software	Analytics	AMI
Latin America	Transmission modernization	AMI	Distribution automation
North America	Analytics	Network operations software	Distribution automation

FIGURE 1.1 Distribution automation will be a major market driver globally according to a study of the global smart grid market by GTM Research. GTM has examined the expected growth rate of individual regions as well as the cumulative global growth rates of discrete smart grid technologies. From: GTM Research.

cost-effective transition to a low-carbon economy. According to the literature, the “Smart Grid will help the U.K. meet its 2020 carbon targets, while providing the foundations for a variety of power system options out to 2050.”

With no official smart grid roadmap going into 2013, France was running behind most of its neighbors in getting with the program; however, Gimelec, an industry association, published what it called an approach paper. The *White Paper on Intelligent Energy Management* was created for industry debate of most of the features of smart grid programs—quality and efficiency of electric power transmission, computer data management, intelligent metering systems, active building management, and the integration of electric vehicles. The paper anticipates the rollout of 35 million smart meters in France by 2018.

CHINA GOES SMART

China ranked second behind the United States in smart grid investment in 2012, spending \$3.2 billion, a 14% increase over 2011, and continues to boost its investment in its electrical infrastructure. China’s transmission upgrades are expected to reach more than \$72 billion in revenue by 2020 on a cumulative basis. China also plans to install 300 million smart meters by 2015. According to the 12th Five-Year Plan for Grid Intelligence Construction of Smart Grid Corporation of China (SGCC), smart meter bid invitations occupied 97.18% of the total meter bidding for smart grid-related equipment in 2012, reaching a bid invitation volume of 78,043,000 units. “Overall,” Bob Lockhart, senior research analyst with Navigant Research, says, “smart grid development in China will generate \$127 billion in cumulative revenue from 2012 to 2020.” China’s home electronics and IT industries, such as IGRS and ITopHome, have gradually developed a comprehensive set of national standards for home networking, while telecom operators, including China Telecom and China Unicom, are promoting smart home services targeting high-income households.

For India, having experienced two major blackouts in 2012, one of which left 600 million people without electricity, the smart grid is a priority. The India Smart Grid Forum, which has the support of the Indian government’s Ministry of Power, says India’s power system has roughly doubled in the past decade and grew similarly in the previous

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decade. (The forum's membership is global in scope; its American members include IBM, Texas Instruments, Oracle, Cisco Systems, and Honeywell.) India operates the world's largest synchronous grids with 250 gigawatts connected capacity and about 200 million consumers. However, 40% of the population has no access to electricity and per capita consumption of electricity in India is one-fourth of the world average. The potential demand by 2032 is estimated to be as high as 900 gigawatts. The forum held regular workshops through 2013 to finalize a program that fits into the country's 12th Five-Year Plan (2010–2015). "The Ministry of Power wanted to start work on the Smart Grid Roadmap after the Five-Year Plan allocations were final," said Reji Kumar Pillai, managing director of Magnetar Venture, an India-focused clean tech venture capital fund, and president of the India Smart Grid Forum. As for the development and adaptation of appropriate standards, the forum expected its first set of smart grid standards "relevant to the Indian context" to be in place by 2014. Based on the outcome of its pilot programs, full rollout of smart grids in pilot project areas are expected to be in place by 2017—in major urban areas by 2022, and nationwide in India by 2027.

The Indian government created the Restructured Accelerated Power Development and Reforms Program (R-APDRP) in 2008 to essentially transform the power distribution sector in India. Through this program, utilities plan on building an IT infrastructure with applications and automation systems. India's government has put together about 14 demo/pilot smart grid projects that are under implementation by different state distribution utilities and cover a range of issues and programs that are scheduled to be completed by 2015—from advanced metering and outage management to distributed generation, peak load management, and power quality. The boom in this sector has also attracted several IT majors who have formed partnerships to develop smart grid solutions in India. The Indian government has also created the India Smart Grid Task Force to accelerate the deployment of smart grids across the country.

Demand response is a key. Another big step by the India Smart Grid Forum is to form a strategic relationship with the OpenADR Alliance whose focus is to promote the development and adoption of the Open Automated Demand Response (OpenADR) standard. The plan is to help India's utilities improve and maintain their grid reliability and provide their customers with demand response-enabled products and services.

In Japan, the Ministry of Economy, Trade, and Industry (METI) already had working relationships with international standards groups, including the IEEE, the IEC, and CEN/CENELEC. METI sets the country's energy policy, and operates Japan's grids; Japan has two separate grids that operate at different frequencies. Each service area is owned and operated by a different electrical power company. Japan also formed the Japan Smart Communities Alliance that represents a cross-section of views from industry, the public sector, and academia to formulate plans for smart grid standards and technology. Japan's smart grid plans are complicated by the phase out of its nearly 50 gigawatts of nuclear capacity over the next few decades. (Nuclear power had produced about 30% of Japan's electricity prior to the 2011 Fukushima crisis.) Rather than overhaul its entire grid infrastructure, Japan plans to invest in renewable energy and integrate it into the grid, using alternative power sources such as solar, wind, and nuclear for homes and commercial buildings—without any major disruptions of its energy supply. One possible solution promoted by Japanese consortia is to create a decentralized system that would subdivide the existing grid into interconnected cells of varying sizes and assign the equivalent of Internet Protocol addresses to generators, wind farms, and other grid sources within the cells to power the country's needs.

South Korea's smart grid policies and development are being driven to a large extent by a perceived requirement for national security and economic growth and a series of extreme weather events over the past several years. The country's electricity network is largely state controlled, but its historical interest in green technologies has helped create an environment of aggressive smart grid programming in the country. In 2011, South Korea's legislature approved the Smart Grid Promotion Act, which provides a framework for sustainable smart grid projects and a plan for smart grid development and commercialization. The Korea Smart Grid Association, made up of both government and private sector interests, and the Korea Smart Grid Institute, are leading ambitious national programs that emphasize a smart power grid and smart transportation. All of the country's programs emphasize coordination between the government and industry. The country hopes to complete the final planned phase of its smart grid program between 2020 and 2030.

The Middle East and North Africa (MENA) region is among the leaders in smart grid development among emerging markets. Smart grid activity is largely a state-driven process in MENA with the strongest

potential in the Gulf States, where high electricity consumption is expected to drive smart meter deployments.

THE SMART GRID IN CITIES

“Smart city” means different things to different people, but proponents of the concept believe that localizing modern information technology infrastructures is critical to the development of a fully harmonized smart grid. Most smart city initiatives are being realized by working with vendors to integrate existing and evolving technologies. For Deutsche Telekom, it’s parking, which the company initiated as a pilot program for motorists in the Italian city of Pisa. Deutsche Telekom will install a sensor-based parking system in Piazza Carrara, in the city center that (among its other features) analyzes historical traffic data to optimize the flow of traffic.

Globally, most projects tend to be more ambitious—and more complex. In the United States, several communities are already working with area utilities to better meet their energy, transportation, public health and safety, and conservation requirements for the future, becoming testing grounds for cross-functional technologies. Smart city developments are considered critical to the economy of some regions, but it’s a tricky business for thousands of revenue-strapped municipalities worldwide. Hoping to bring some momentum to the process, more than a dozen technology firms with expertise in smart energy, water, and transportation have formed the Smart Cities Council. Key issues include not just financing, but also technology, policy, and citizen engagement. The council was formed to help deal with these issues.

Ovum believes that developing an interdependent smart grid at local levels is a way national governments can “reanimate” their economies. “The smart city market is at a tipping point,” says Joe Dignan, chief public sector technology analyst at Ovum. “Having been led by IT industry stalwarts such as IBM and Cisco for the last five years, it needs a fresh injection of ideas to take it to the next level. We believe the developer community will add the required impetus.” Dignan believes that developers are key actors in the smart city debate for three key reasons: initially, unlike the IT industry, they can live with the 5–10 years return-on-investment models inherent in smart city developments. Second, their physical infrastructure enables them to work at the junction between the key smart city metrics of sustainability, quality of life,

and competitiveness. Finally, he says that developers have years of experience in project financing and a comprehensive understanding of the financial instruments required.

Getting more cities on board with the smart grid may require some of them to consider new business development models. “Both federal and private funding is instrumental in promoting innovation and interest in smart cities,” says Farah Saeed, the energy and environmental principal consultant for Frost & Sullivan. “Early benefits are enticing more cities to adopt these initiatives; however, the rate of transition will vary, and the intent to deploy will oscillate between the decision to rectify energy, security, and public service issues such as traffic and safety. Public concerns regarding privacy issues, customer reaction to inconsistent messaging, and unclear standards may discourage cities from making prompt decisions, but it is the future of cities as the world becomes increasingly more connected.”

Smart-city development is one of the Chinese government’s top public works goals, providing significant opportunities for intelligent building suppliers. According to China’s Ministry of Housing and Urban-Rural Development, 90 areas across the country, including 37 prefectural cities, 50 districts/counties, and three towns have been selected as pilot projects for smart-city development. Numerous state-owned and private enterprises are investing in the initiative. China Development Bank, for example, has committed to lend \$12.9 billion for various smart-city projects between 2013 and 2015. According to Messe Frankfurt, organizer of the Shanghai Intelligent Building Technology Fair, Shanghai leads East China’s intelligent building market.

WIRELESS EVERYWHERE

Wireless technologies are a significant component in the smart grid infrastructure. The very widely used IEEE 802 family of standards that includes Ethernet, Wi-Fi, Bluetooth, and ZigBee is already playing a major role in the smart grid, including wide area networking apps like advanced metering backhaul and substation and distribution automation. Yet, according to Reportlinker.com, another market research firm, in home area networks, Wi-Fi-based nodes have not made serious headway against ZigBee wireless mesh networks. Wi-Fi solutions have been used in numerous municipal utility smart grid deployments, but some utilities have expressed concern about interference and poor propagation for

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solutions based on IEEE 802.11, the Wi-Fi standard. Still, Navigant Research forecasts that annual shipments of Wi-Fi communications nodes for smart grid applications will surpass 1.2 million worldwide by 2020.

The WiMAX Forum was promoting its WiGrid initiative in 2013, when its own Smart Grid Working Group published system profile requirements to support the adaption of WiMAX technology for smart grid networks. The proposed WiGrid System profile is an Ethernet version of IEEE 802.16 that includes numerous new features that allow uplink centric data communications, lower latency, extended range, and enables the use of new frequency bands that various utilities hold, mainly 1.4 GHz, 1.8 GHz, 2.3 GHz, 3.65 GHz, and 5.8 GHz. These developments, along with emerging wide-range 802.11-based standards, are expected to lead to broader acceptance and deployment of Wi-Fi and related technologies for grid applications.

Navigant sees other opportunities for ZigBee and EnOcean Alliance-based standards replacing proprietary, vendor-specific wireless RF technologies as a way to ensure device interoperability. The research firm sees ZigBee and EnOcean products accounting for nearly half of all wireless building control node shipments by 2020. A key milestone for the EnOcean Alliance came in 2013 with the ratification of its wireless standard, ISO/IEC 14543-3-10, an effort led by the IEC, and the first wireless standard optimized for energy-harvesting solutions for switches and sensors powered by energy drawn from movement, light, or changes in temperature rather than batteries. An example of an energy-harvesting device would be an energy-autonomous, thermostatic radiator valve, which only uses heat as an energy source and communicates with another solar-powered control device.

With more than 300 company members in 34 countries, EnOcean is organized very similarly to the ZigBee Alliance or the Bluetooth Special Interest Group. “While various forms of wireless controls have been used for at least a decade, the ZigBee and EnOcean standards are catalyzing mainstream market adoption,” says Bob Gohn, senior research director with Navigant Research. “Though wireless will not displace traditional wired controls, it will be an essential tool in every supplier’s solutions toolbox, especially for retrofit projects.”

With ZigBee Home Automation and ZigBee Smart Energy up and running, the ZigBee Alliance said in 2010 that it would examine operating the ECHONET Consortium’s (an organization promoting the development of basic software and hardware for home networks) ECHONET

Lite application on the ZigBee IP stack using the 920 MHz option of 802.15.4g. Japan's Ministry of Internal Affairs and Communications designated the 902 MHz band for active low-power radio systems in December 2011. In February 2012, Japan's METI endorsed the IP-based ECHONET Lite standard, which defines application level communications for electric appliances and electronic equipment to connect to a home energy management system, as the Japanese Smart House Standard. The ZigBee Alliance then worked out an agreement to collaborate with the ECHONET Consortium to develop a certification program for products based on ECHONET standards, mainly ECHONET Lite, using the ZigBee IP networking protocol. Since then, the Wi-SUN Alliance, a global association of companies formed to create interoperable wireless solutions for energy management and smart utility applications based on IEEE 80.15.4g, announced it had completed its Wi-SUN ECHONET Lite specification and that it is now ready for product development.

In January 2013, the Wi-SUN Alliance published ECHONET Lite Version 1 as a standard communications interface. The interface has been accepted as a Telecommunications Technology Committee standard in Japan (TTC JJ300.10), and was adopted by the Tokyo Electronic Power Co. Version 1 includes an encryption and authentication process between smart meter and home energy management systems and between home energy systems and home electrical appliances. The more recently published Version 2 adds new features that ensure seamless interoperability, standardizes the pairing of devices, and simplifies installation and maintenance for consumers and custom installers. The alliance certified its first product supporting the ECHONET Lite profile in February 2014, with NEC and Toshiba jointly and successfully completing testing of a smart meter communications module. Wi-SUN and the HomePlug Alliance, which focuses on developments in PLCs networking, have agreed to collaborate on promoting interoperability across both wireless and power line-wired connectivity in the smart grid. (HomePlug's Netricity certification program promotes the adoption of the IEEE 1901.2 PLCs standard, and is targeted for outside-the-home smart grid networks.) The relationship is expected to empower member companies of both alliances to share requirements and specifications for media access control (MAC) and transport layer profiles to facilitate interoperability of Internet Protocol-based smart grid applications.

Another group, the UPnP Forum, established in 1999 to promote device-to-device interoperability and to support standards in the

connected home, doesn't see a smooth ride in getting the job done. "Standards provide a common communications architecture from a utility or energy provider into home networks and between all of the intelligent devices," says Scott Lofgren, UPnP's vice president and treasurer. "It's all about the customers, many of whom are not willing to buy all new devices just to support integration with smart grid and smart energy platforms, nor are they willing to live with technology islands that cannot communicate with each other."

ADVANTAGE, CONSUMER

Other standards organizations have become deeply involved in smart grid standards development. The ANSI Energy Efficient Standardization Coordination Collaborative (EESCC) released a draft for public comment of its EESCC Standardization Roadmap V1.0 in early 2014. Intended to be a resource for US industry, government, and consumers, the roadmap identifies areas where additional standardization work is needed to advance energy efficiency within an already built-out environment, and recommends timelines for how to proceed. The EESCC's primary focus is on standards and conformity assessment activities that have direct impact on US markets. More than 50 member organizations and 4 federal agencies, involving more than 150 experts from industry, standards, and code developing organizations, and other groups have participated in the roadmap's development.

The WiMAX Forum is targeting smart grid networks as a vertical business opportunity. The forum published *WiMAX Forum System Profile Requirements for Smart Grid Applications* in January 2013, detailing work done on WiGRID, an Ethernet version of IEEE 802.16 standard for Utility Field Area Networking applications with additional features for uplink data communications for utilities apps at 1.4 GHz, 1.8 GHz, 2.3 GHz, 3.65 GHz, and 5.8 GHz. The forum continues to investigate advances in WiMAX technology that would interoperate with other broadband wireless technologies.

One of the ZigBee Alliance's biggest accomplishments has been the development of Smart Energy Profile 2.0 (SEP 2). SEP 2 enables service providers and utilities to wirelessly communicate with and manage common household devices such as smart thermostats, in-home displays, and appliances. There's even a Consortium for Smart

Energy Profile 2 (CSEP)—essentially, a consortium of home networking consortiums—founded by the ZigBee Alliance, HomePlug Alliance, and Wi-Fi Alliance, who work together to promote interoperability standards for home networking. CSEP has taken on the task of defining SEP 2 testing and certifying the products of CSEP member alliances. ZigBee's Light Link, already a global standard, lets consumers add wireless control to their home lighting, including light bulbs, LED fixtures, switches, and remote control devices. "We're starting to get the retail space with Light Link in Apple stores," said Dr. Bob Heile, chairman emeritus and chief technologist of the ZigBee Alliance. "We're taking advantage of the fact that we couple very easily with other technologies. We don't have to be embedded inside of other smartphones; you have a Wi-Fi link, you have a Bluetooth link, and there's a little adapter that you can pick up for a pittance. You can run a ZigBee network in your house, or anywhere."

In early 2014, the ZigBee Alliance announced that a group of its smart grid members and several leading smart metering companies were developing a communication profile aimed at achieving true plug-and-play interoperability between the members' wireless smart grid Neighborhood Area Network (NAN) products and solutions. The ZigBee group defines NAN as a utility's last mile, an outdoor access network that connects smart meters and distribution automation devices to wide area network (WAN) gateways such as RF collectors, or data concentrators and field devices. The alliance anticipates a global requirement from regulators and utilities for standards-based interoperable NANs. Open global standards provide utilities with a wider choice of product features, increased price competition, reduced supply risk and flexibility in selecting vendors while assuring that products will interoperate seamlessly. The alliance says that existing IEEE and Internet Engineering Task Force (IETF) standards on their own do not ensure interoperability due to the many options available within the standards, and expects the NAN specification will fill the gap by selecting the most appropriate options between standards and defining a communication profile with certifiable interoperability.

In order to ensure interoperability, a full wireless communication protocol is being defined for layers 1 through 4 of the ISO communication stack to provide a harmonized transport network supporting different IP-based applications. Layers 1 and 2 will be based on the IEEE 802.15.4g (ZigBee) amendment to the IEEE 802.15.4-2011

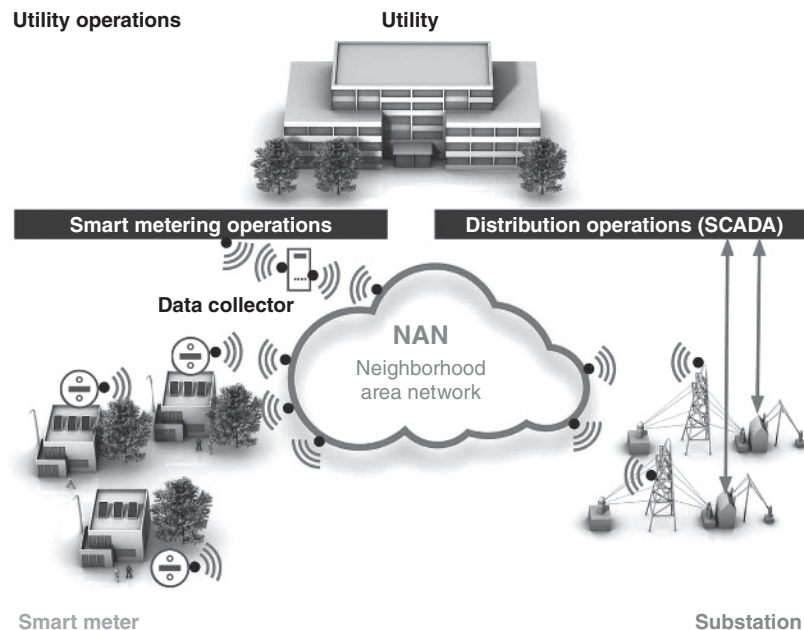


FIGURE 1.2 The NAN is defined as a utility’s last mile, outdoor access network that connects smart meters and distribution automation devices to WAN gateways such as RF collectors or data concentrators and field devices.

Source: ZigBee Alliance

standard that enables the development of interoperable NANs. Layers 3 and 4 will be based on IETF standards, including the Internet’s IPv6 network layer, associated networking schemes, appropriate routing and transport protocols, and relevant security mechanisms. Today’s existing smart grid applications, such as smart metering and distribution automation, will run on top of the interoperable wireless IPv6 communications profile. Another key aspect of the NAN standardization process is to establish a test and certification program supported by independent test houses with the aim of certifying the interoperability of different manufacturer’s smart grid products. The ZigBee Alliance has said it will maintain a register of certified smart meter and smart products to give utility customers confidence in their selection of a smart grid vendor.

Several companies from around the world have already participated in a number of “proof of concept” events (often called PlugFests) to test the interoperability of the PHY/MAC functions that will be included in the NAN standards. All participants’ NAN products were able to communicate with each other through the PHY/MAC layers. Several

companies also demonstrated interoperability for basic IP functions. Formal approval of a NAN standard was expected by the end of 2014 and will include the technical specification, protocol implementation conformance statement, and a certification test plan.

LEVERAGING HOME NETWORKS

The HomeGrid Forum's G.hn (gigabit home networking) standard has also been logged into the SGIP's Catalog of Standards. G.hn enables very high speed in-home networking using existing household wireless (power line, phone line, and coax), and the delivery of high-quality networked entertainment packages, including IPTV and supporting smart grid applications. Both HomePNA and G.hn are home networking technologies that leverage existing in-home wiring to establish home networks. Due largely to the emergence and development of G.hn home networking technology, the HomePNA Alliance and HomeGrid Forum have merged. The HomeGrid Forum's focus has been on promoting G.hn, while the older HomePNA technology is often selected by large service providers worldwide for IPTV deployments. "However, the obvious future direction for all wireline home networking is to migrate to G.hn," Eran Gureshnik, president of HomePNA said at the time of the merger of the two groups. Eric Puetz, AT&T director of industry standards, and an active member of both the HomePNA Alliance and HomeGrid Forum, said, "AT&T sees the merger of these two industry organizations as a great step towards advancing and harmonizing these standards-based home networking technologies." The newly merged association is expected to have about 70 members, including 28 service providers, and will be called the HomeGrid Forum.

The core focus of both organizations was to support technologies based on open ITU-T standards that provide wired home networks for service providers with high-speed networks. Both technologies are competing with MoCA home networking technology, which has seen surging demand, particularly in North America. Both G.hn and MoCA also compete with Wi-Fi standards like IEEE 802.11ac, which can distribute video wirelessly in homes. (G.hn chipsets were just beginning to ship in mid-2013.) "MoCa is again driving growth in the home networking market, particularly shipments of video gateways in North America," says Jeff Heynen, directing analyst for broadband access and pay TV at Infonetics Research. The Multimedia-over-Coax Alliance announced

the availability of a certification program for products implementing the MoCa 2.0 specification for its members at the beginning of 2014. “We are open for business to begin testing MoCa 2.0,” said Charles Cerino, MoCA’s president. “We already have several manufacturers in line to begin their certifications.” The new MoCa certification program enables manufacturers to verify their next-generation of connected home technology products. MoCa 2.0 offers two performance modes of 400 Mbps and 800 Mbps net throughputs (MAC rate), respectively. MoCa 2.0 supports packet error rates as low as one in 100 million with a nominal latency of 3.6 ms. Standby and sleep modes are included in the spec to help with power management in the network. Culver City, CA-based National Technical Systems is the exclusive certification testing facility for MoCa 2.0.

With so many member companies with a stake in the market at some level, the Consumer Electronics Association has formed its own CEA Smart Grid Working Group to serve as an information exchange forum for smart grid projects and policies affecting its market sector, and organized a Home Networks Committee to study standards development opportunities for smart grid-related consumer electronic products. The CEA also published a new standard, ANSI/CEA-2045, for a modular communications interface (MCI) for energy management. ANSI/CEA-2045 devices encompass sensors, thermostats, and appliances, as well as energy-related equipment such as energy management hubs, energy management controllers, and residential gateways. The CEA also worked with the SGIP on the development of a standard that specifies a plug-in module with a wired connection between a residential device and external communications. Communication links may be provided for power line carrier and radio frequency (RF), depending on the home area network installed, or the connection to the access network of an energy-management service provider. The standard specifies a base and an intermediate message set for demand response. Using the RS-485 and Serial Peripheral Interface (SPI) supported by most chips today, the MCI protocol is capable of passing application messages through several protocols between the communications module and the end device. The Electric Power Research Institute (EPRI) has conducted laboratory interoperability tests to determine the standard works as intended. The choice of message set depends on the program offered by the energy and equipment supplier.

The CEA has also formed the R7.8 Working Group 2 to develop a new standard to enable home electronics to communicate energy use

data to smart energy management systems and apps. The new standard will be called CE-Energy Usage Information (CE-EU) and will conform to the North American Energy Standards Board Usage Information (NAESB-EUI) model, which forms the basis for the national Green Button initiative. “Product manufacturers already understand how much energy a device will use during operation, based on its design,” said Brian Markwaller, senior vice president of research and standards at the CEA. “By programming that information into the device and enabling the device to calculate how much energy it uses over time, manufacturers can help homeowners accurately capture the data for their energy management systems and applications.”

The CEA standard will be compatible with the relatively new Green Button “Download My Data” and “Connect My Data” initiatives. Green Button defines how consumers and authorized third-party services can access a history of their total home energy usage and cost based on smart meter readings. With each device able to report its own energy usage, consumers will be able to determine how much energy each CE-EUI-compliant device consumes and make better informed decisions. The standard will be network agnostic, operating over Wi-Fi, Ethernet, ZigBee, and Z-Wave. An estimated 20 million to 30 million customers in the United States (commercial and residential) were expected to have access to their data in the Green Button format by mid-2013. (In California, Pacific Gas and Electric, and San Diego Gas and Electric are already Green Button-enabled.)

AHAM, the major appliance trade group, meanwhile, has been working with EnerNex Corp., a consulting firm that has helped NIST organize its smart grid programs, to draft a detailed review of all home network technologies. AHAM will use the review to advise its member companies on smart grid issues.

CONFORMITY ASSESSMENT

Some published standards don’t indicate how they should be tested, making them difficult to implement. To ensure that products, technologies, and services conform to specific standards, the IEEE-SA and IEEE Industry Standards and Technology Organization (IEEE-ISTO), which supports members’ technical work groups and helps accelerate market acceptance of new products and technologies, has developed an IEEE Conformity Assessment Program (ICAP) specifically targeting

key stakeholders and subject matter experts in the power systems community.

The key role of the ICAP is to establish program policies and procedures, initiate certification programs across multiple technology sectors and eventually certify products that have successfully completed testing and have been deemed compliant. ICAP will assess and implement where applicable, the best practices as stated in the *Interoperability Process Reference Manual* developed by the SGIP's SGTCC. Ravi Subramaniam, ICAP's technical director, says, "Utilities globally can reap significant benefits from this important and industry supported initiative. One example of this effort is the ICAP Synchrophasor Conformity Assessment Steering Committee (SCASC), formed in June 2013 to develop and deliver a consensus-based testing and certification program for phasor measurement units (PMUs). Synchrophasors provide real-time measurement of electric power grids to help ensure stable operations and avert blackouts. PMUs are used in systems where many of these devices, manufactured by different vendors, provide synchronous measurements to one or more PMU applications. "If PMU applications are to become vital to the operation of the power system, they must be conformant to the latest PMU performance standard," says Allen Goldstein, chair of the ICAP-SCASC. The certification program is based on IEEE C37.118.1-2011, the IEEE Standard for Synchrophasor Measurements for Power Systems. "The standard was created with clearly defined requirements to address the need in power system for improved operation and functionality," says Ken Martin, chair of the IEEE C37.118.1 Working Group. In August 2014, the IEEE-SA signed an agreement with Michigan-based Consumer Energy to support development of a synchrophasor conformity assessment program to provide testing of PMUs' compliance under IEEE C37.118.1.

NIST has also contributed to the development of the IEEE C37.118.1 standard and the Synchrophasor Test Suite Specification. "Conformity assessment is the logical next step to standards development. It is crucial to ensure a consistent testing methodology amongst test laboratories that produces compatible results. Establishment of a conformity assessment program is an important step toward realization of this goal." ICAP-SCASC program participants include NIST, Arbiter Systems, Inc., Doble Engineering, Electric Power Group LLC, ISO New England, Macrodyne Inc., Mehta Tech, Inc., PJM Interconnection, Quanta Technology, RTDS Technologies Inc., Southern California Edison, the Smart

Grid Demonstration and Research Investigation Lab of Washington State University, and Schweitzer Engineering Laboratories, Inc.

In late 2014, the IEEE-SA took on full operation of ICAP from IEEE-ISTO, which operated the program since it was established in 2008. "Conformity assessment is of growing relevance because it gives industry and consumers the confidence they need that standards-based products will actually work as intended and interoperate in a multi-vendor environment," said Adam Newman, senior director, business development and alliance management for IEEE-SA. "The transition of ICAP to IEEE-SA helps establish a seamless link among standards implementation, conformity assessment, and product certification eventually leading to streamlined market adoption."

As utilities work to enhance current electricity infrastructure and introduce new technologies for the smart grid, the need for data aggregation requirements increase and automation plays a larger role in the reporting process. To help facilitate this requirement, the IEEE-SA has begun to develop standards for phasor data concentrators (PDCs): one example is IEEE PC37.247, a standard for PDCs for power systems. The standard's purpose is to improve interoperability of devices, systems, and applications that use synchrophasors and other synchronized data by standardizing requirements for PDCs. "Because PDCs are becoming more common, their functionality requires standardization," says Vasudev Gharpure, chair of the IEEE Phasor Data Concentrators for Power Systems Working Group. "This project provides the requirements for what functions PDCs must perform and how it should perform them, which is the purpose of our working group." Another standard under development, IEEE PC37.248, Guide for Common Format for Naming Intelligent Electronic Devices, is intended to provide consistency to the point that automated systems and anyone unfamiliar with a particular electrical system could determine what entities the intelligent electronic devices (IEDs) are monitoring or reporting. This guide standard also provides a common convention for naming physical and virtual IEDs and various environments where device names are needed and how a common naming convention would be beneficial. Both development projects are intended to product standards that improve fault management and other smart grid functionality. As a PMU measures electrical waves on an electricity grid, the synchrophasor data is collected using PDC technologies—either on-site or at centralized locations, depending on the electric utility's requirements.

CYBERSECURITY BECOMES A MAJOR ISSUE

Cybersecurity was a major issue in the United States long before February 2013 when President Obama issued Executive Order (EO 13636), calling for the development of a voluntary, risk-based set of standards, guidelines, and practices to help organizations manage cyber risks. Somewhat ironically, the order directed NIST, which heads up the country's smart grid program through the NIST-formed SGIP, to lead the cybersecurity program. By the end of 2013, NIST, now responsible for developing standards, guidelines, tools, and metrics to protect non-national security federal information systems, released its *Preliminary Cybersecurity Framework* to help business owners and operators reduce cybersecurity risks in industries such as power generation, transportation, and telecommunications. NIST also requested public comments on the first revision of its guidelines for secure implementation of smart grid technology. The draft document, *NIST Interagency Report 7628 Revision 1: Guidelines for Smart Grid Cybersecurity*, was the first update since the initial version of the guidelines was published in September 2010. NIST says the update was prompted by the dramatic expansion in the use of smart grid technologies in those 3 years. Since then, NIST has released a *Framework for Improving Critical Infrastructure Cybersecurity* that organizations, regulators, and others can use to create or improve comprehensive cybersecurity plans. Labeled Version 1.0, it is described as a "living" document that will need to be updated to keep pace with changes in technology, cybersecurity threats, and other factors. NIST has already revised its *Guidelines for Smart Grid Cybersecurity* with new sections on the relationship of smart grid cybersecurity to the NIST Cybersecurity Framework, testing and certification, and regulatory changes in privacy.

NIST has also requested public comment on at least two documents that could, at some point, impact smart grid operations. One draft document, *NIST Cryptographic Standards and Guidelines Development Process* (NIST IR 7977), describes how the agency develops cybersecurity standards. It outlines the principles, processes, and procedures of NIST's cryptographic standards efforts. Following the public comment period, NIST said it would review its existing standards and guidelines to ensure they adhere to the principles laid out in NIST IR 7977. "If any issues are found," NIST's Donna Dodson, who oversees the process, said, "they will be addressed as quickly as possible."

NIST has also issued a call for public comment on its plans to update a guide that would better determine how it is protecting federal data and networks. Called *Assessing Security and Privacy Controls in Federal Information Systems and Organization: Building Effective Assessment Plans (SP 800-53A)*, it features several changes from the 2010 version of the same guide, with an emphasis on evaluating critical information systems and infrastructure.

NIST has formed the SGIP Cybersecurity Committee (SGCC), which is led and managed by the NIST Information Technology Laboratory's Consumer Security Division. A key objective of the committee is to advance the development and standardization of cybersecurity in the electric smart grid by 2016. Part of the plan calls for the committee to evaluate existing standards, identify cybersecurity gaps, and provide recommendations on how to fill those gaps, including communications standards that might be necessary to fulfill the cybersecurity mission.

How serious an issue is cybersecurity for the energy sector? Cybersecurity has been a top priority for utilities for some time as utilities in the United States report daily attempts to access their IT systems. The US Department of Homeland Security reported 111 IT attacks against the energy sector during the first half of 2013, compared with 81 for all of 2012. Sixty-one percent of the energy executives surveyed by SMART Modular Technologies early in 2014 said they considered security to be a big problem for the smart grid, while 64% believed the grid is not prepared for security threats. Nearly 4 out of 10 (38%) believed that "government standards" are the best way to remedy smart grid security concerns.

While a number of initiatives are in place for cybersecurity, rules vary between different operators, utilities, and regions. Several US federal agencies involved in promulgating or developing requirements for cybersecurity for the grid include the Department of Homeland Security, the FERC, the DoE, and the NIST. FERC has granted the North American Electric Reliability Corporation (NERC), a non-government standards organization that oversees and regulates the reliability of North American electrical grids, the legal authority to oversee the so-called bulk power system (BPS) in the United States, including enforcing reliability standards with all users, owners, and operators of the BPS. The BPS is an interconnected electrical system of generators and transmission facilities. It does not include local electrical distribution facilities,

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but if it is disrupted, it impacts multiple locations. Some states have their own BPS regulatory requirements.

An internal study by FERC, disclosed in a March 13, 2014, article in the *Wall Street Journal*, suggests the United States could suffer a coast-to-coast blackout if saboteurs knocked out just nine of the country's 55,000 electric transmission substations. According to the article, a memo prepared at FERC in June 2013 for senior government officials by the then FERC Chairman Jon Wellinghoff, noted, "Destroy nine interconnection substations and a transformer manufacturer and the entire United States grid would be down for at least 18 months, probably longer." No federal rules require utilities to protect vital substations except those at nuclear power plants. The *WSJ* said FERC gave the electrical power industry until June 2014 to propose new standards for the security of critical facilities, such as substations.

One of the major trends that could impact cybersecurity planning, according to Research and Markets, is the increase in leasing of communication network services. "Several power utilities have entered into contracts for leasing the smart grid communication network services to various telecom companies, or to other service providers. This trend appears to be the strongest in the U.S., with approximately 20% of the power utilities leasing smart grid communications networks to third parties." Michela Menting, a senior analyst for cybersecurity at ABI Research, says efforts by governments and standardization bodies to tackle vulnerabilities within power control systems are raising the level of awareness of the potential for cyber-attacks on electrical grids. But he thinks operators need to view cybersecurity as an integrated requirement for the smart grid.

ETSI created a technical committee on cybersecurity in March 2014. It was not clear how much of an impact the new ETSI group would have on the development of the smart grid, but Jorge Romero, ETSI's director general, said at the time that "Our newly created technical committee aims to produce strong, interoperable, trustworthy and transparent standards for a secure digital market." More than 100 ETSI member organizations from industry and academia expressed interest in joining the new committee.

If there's any upside to the threat posed by cyber-attacks on the smart grid, it's that it represents a potentially huge market opportunity for companies that provide cybersecurity products and services. One of the key market drivers, several analysts believe, is that, unlike traditional power grids, smart grids facilitate two-way communication systems, which

would operate through smart grid communication networks. Vendors dominating this market space are Silver Spring Networks, Itron, Sensus USA, Landis+Gyr, and Elster Group SE, but several other big players include IBM, ViaSat, Cisco, SAIC, Black and Veatch, Lockheed Martin, Sierra Wireless, Sprint, Verizon Communications, and Siemens. Another factor, according to the market research firm TechNavio, is that advancements in technology have led to an increase in network connectivity in many power utilities, which has boosted the chances of cyber-attacks on these utilities. Against this analysis, TechNavio expects a big jump in the global cybersecurity market in the energy sector, which it expects will reach about \$200 billion by 2015. There has also been a growing number of utility cybersecurity consulting programs that could eventually create a sub-smart grid cybersecurity market that Navigant Research believes could top \$600 million by 2020. Although not specifically a part of the national smart grid program, the US DoE's National Energy Technology Laboratory put out a call in April 2013 for applications to conduct research, development, and demonstrations that could lead to the deployment of next-generation cybersecurity tools and technologies for the US energy infrastructure. The objective is to enhance the cybersecurity of energy delivery control systems.

In July 2014, two more research groups urged the US government to take steps to protect the nation's electric grid. The Congressional Research Service, which takes on special research projects requested by members of Congress, recommended that the US Congress take a closer look at the grid-vulnerabilities on a national level, especially the internal security measures taken by individual utility companies, which it suggested may not be sufficient. The Battelle Memorial Institute, which operates six of the US Energy Department's laboratories, issued a report with essentially the same observation. The Congressional Research Service said an attack on an electrical substation—even one that serves a relatively small area—“could have catastrophic consequences.” Similarly, the Battelle study said the utilities should more closely consider how an attack on a regional electric system might impact larger areas.

SOLAR FLARE THREATS

One area that doesn't get as much attention as cybersecurity, but that hasn't slipped through the cracks at the NERC and other federal agencies and SDOs involved in smart grid standards development is solar

flares and the possibility that these geomagnetic events could someday simply unplug everything in the world that depends on electric power. The historical marker is popularly known among scientists as the “Carrington event,” named for the British astronomer Richard Carrington who charted a solar burst in 1859 that knocked out power in Quebec and parts of the US Northeast. According to NASA, the most recent noteworthy demonstration of what solar flares can do occurred in 1989 when a geomagnetic storm took out a large transformer in New Jersey. A 2009 study by the National Academy of Sciences warned that a massive geomagnetic attack on satellites and interconnect power grids could result in a blackout from which the United States may need 4–10 years to recover. In May 2012, a US Geological Survey report estimated a 6% chance of another Carrington event in the next decade. So, where does this fit into the work of the SGIP? Is this something it even thinks about? “Continually,” says SGIP Chairman John McDonald.

Several papers on the subject were delivered at the CIGRE USNC Grid of the Future Symposium on the subject, held in October 2013. (CIGRE is the International Council on Large Electric Systems, a permanent non-government and non-profit international association based in France to facilitate and develop the exchange of engineering knowledge and information globally on high voltage transmission of electricity. The USNC is the US National Committee of CIGRE.)

In fact, there are standards programs that address geomagnetic disturbances (GMDs). One of the most recent developments came in January 2014 when FERC proposed a new reliability standard intended to mitigate the impact of GMDs that can have potentially severe, widespread effects on the operation of the nation’s bulk-power systems. FERC says this is the first step in implementing what it calls its final rule in May 2013 in which the agency directed NERC to develop new mandatory reliability standards that address GMD vulnerabilities.

NERC is developing the new standards in two stages. Initially, NERC would submit one or more reliability standards that require owners and operators of bulk-power systems to develop and implement operational procedures to mitigate the effects of GMDs. In the second stage, NERC would submit reliability standards that require owners and operators of bulk-power systems to conduct an assessment of the potential impact of GMD events on bulk-power system equipment. Under the directive, “If the assessments identify potential impacts from benchmark GMD events, the reliability standards should require owners and

operators to develop and implement a plan to protect against instability, uncontrolled separation, or cascading failures of the bulk-power system” caused by a GDM event. FERC says it is not directing NERC to include specific requirements for GMD reliability standards, “nor are we pre-judging what [NERC] eventually submits for approval,” but the commission does offer a few possible strategies for protecting large electric utilities from GDMs, one of which is instituting specification requirements for new equipment. Under the May 2013 final rule, NERC is required to file the second stage reliability standards in January 2015.

Curiously, Tropical Storm Irene and Hurricane Sandy that pounded the New Jersey coastline and other Mid-Atlantic coast regions of the United States, and an NFL Super Bowl power outage did little to raise the public’s awareness of global development of the smart grid. A survey of utility customers by Pike Research, a part of the Energy Practice of Navigant, the market research group, found that 73% of the survey’s respondents are concerned about the amount of money they spend each month for electricity. But the survey also indicated that less than one-third of respondents were familiar with smart grids, and about one-fourth said they’re unfamiliar with smart meters. According to the market research firm, “Even as utilities invest in these new technologies, they struggle to effectively communicate both the benefits of smart grids and the possibilities they make available to the end user.” So, do people believe the money being poured into smart grid programs is being well spent? Sixty-three percent of the Pike survey’s respondents said they are interested in better managing energy used in their homes. NIST has also said it needs to do a better job of educating policy makers and the general public about smart grid technologies to gain a wider acceptance of new policies and regulations.

Can the smart grid actually be built? The GSGF asks this question in its own 2012 report. There is significant progress, but as the report suggests, there also are challenges. Energy management systems for homes and commercial buildings are in development to meet the “smart” demands of the new grid, and utilities are developing new network control and communication systems. Modular energy management systems for homes and commercial buildings are in development, and several utilities are implementing centralized and decentralized network control systems. Smart metering has already been implemented in several locations globally, although interoperability continues to be an issue among vendors. Complex smart grid projects are operational in Japan and South

Korea. The smart grid is an emerging part of India's nationwide energy policy. Similar projects are well underway elsewhere. Electric vehicles are considered in most smart grid programs, but they're expensive and market penetration is low. Ironically, the biggest challenges, according to the GSGF, may be technical advancement outpacing standards development and the ability to maintain a meaningful regulatory framework.

John McDonald believes strongly that global harmonization of the smart grid is possible. "The smart grid has brought us into a new era of what we call solutions that we have never really done before. For many years, we have developed and sold devices and systems. They're developed as products. A solution is different. We go to the customer and ask, 'What are your business needs? What keeps the CEO up at night? Is it system reliability? Is it OEM costs?' We put all of that into an integrated solution to address those needs." The driver, he says, is the customer. "This was the play with the \$5 billion in stimulus funds. It was an integrated solution. If you're putting these components together, and they need to be integrated and work as a solution, the only way they will work is if they comply with the same standards and they interoperate. That's putting more emphasis on standards."

MORE TO COME

But there's still much to do in building out the smart grid. "The scale of what remains to be done is enormous," says Pike Research in a study conducted in early 2013. Pike says there is no single "smart grid solution" that will work for all utilities. In fact, the number of smart meter deployments suggests that many utilities have yet to set out key elements of a smart grid program, such as an AMI. That could change as most of them are preparing to do so over a period of several years.

A report card published early in 2013 by the American Society of Civil Engineers gives the US energy network a grade of D plus—unchanged from the society's earlier report in 2009. The society says utilities may have to spend as much as \$1.5 trillion by 2030 to expand and update the nation's electrical infrastructure. Obviously, ICTs have a crucial role in the development of the smart grid, particularly in heavily populated urban areas where an estimated 65% of the world's population now lives. Malcolm Johnson, director of the Telecommunications Standardization Bureau of the ITU, speaking at an ITU symposium in

Geneva in May 2013, said the implementation of ICTs in urban development will require seamlessly interoperable applications, regardless of the service provider or vendor. “This will require the development of international standards, harmonizing frequency spectrum, and the application of enabling policies and best practices.”

Clearly, standards development will have to work hard to keep pace with smart grid research. To help with the process, IEEE Smart Grid Research is building a comprehensive resource portfolio to help drive continued advancement of the global smart grid, including vision documents and research materials that address problems and challenges over the short- and long-term. “With IEEE Smart Grid Research, we are moving into the full lifecycle of standards-related activities by adopting a proactive, forward-looking approach from the pre-standard activities to real-world adoption and implementation,” said Bill Ash, strategic program manager, IEEE-SA. Ash said the IEEE-SA is building a portfolio of resources ranging from long-term vision and roadmap documents to research papers that explore today’s pressing challenges, and to help keep stakeholders advancing their work. “This will enable us to create a pipeline for incubation of innovative technologies to standards development and market acceptance, supporting global growth of the smart grid market.”

IEEE Smart Grid Research is focusing on five areas: power, computing, communications, control systems, and vehicle technology. The plan is to have a long-term vision document, reference mode, and roadmap for each of these sectors, as well as short-term research available for addressing more immediate concerns. The materials will cover projections of where the smart grid will evolve to technology challenges and opportunities, and areas where additional research is needed.

Among the first resources available will be three downloadable vision documents. One is *IEEE Grid Vision 2050*, which addresses the smart grid power landscape and offers a long-range view of power as it relates to the smart grid, including existing and future technology developments. Another is *IEEE Smart Grid Vision for Computing: 2030 and Beyond*, which looks at the evolution of smart grid operational concepts and computing technologies. This document aims to spur investment in computing technologies facilitating smart grid visions and improving power system performance. The third document, *IEEE Smart Grid Vision for Communications: 2030 and Beyond*, lays out a vision of the smart grid for the year 2020 from a communications perspective. It

also details goals for different constituencies, and how communications should evolve to enable key smart grid functionality.

Development of IEEE Smart Grid Research is the result of a collaborative effort of the IEEE-SA and its relevant IEEE technical societies, which are partnering to develop long-term documents in each of the five technology topic areas. Participating societies include the IEEE Communications Society, IEEE Computer Society, IEEE Control Systems Society, IEEE Intelligent Transportation Society, and the IEEE Power & Energy Society.

“IEEE Smart Grid Research will provide research topics and problem statements for where further research and investment are needed for smart grid technology development,” said Georges Simard, editor-in-chief of *IEEE Grid Vision 2050*. “By providing future snapshots of years 2015, 2020, 2030 and beyond, these projects allow us to look past today’s smart grid event horizon and chart a successful course for the smart grid of tomorrow.” Two research papers are already available: *Global Consumer Socialization of Smart Grid*, and *Cyber Security for the Smart Grid*.

Good market data is hard to come by. Zpryme’s Smart Grid Index says government data and statistics are usually 1–2 years behind in the utilities sector. Additionally, major industry announcements and deals only capture a small fraction of market activity. This lack of data can lead to poor investment decision criteria for utilities and technology vendors operating (or seeking to enter) the smart grid space. Much of the technology needed to improve the cost efficiency, reliability, and coordination of today’s electrical infrastructure (automation, communications, and information technology) is readily available, but modernizing current systems, actually creating a smart grid, is critical in meeting growing capacity requirements. Another factor is the economic picture, which continues to change, with a general slowing in demand in the energy sector. Electricity consumption in the United States has fallen in four of the five years through 2012, and was expected to decline again in 2013, according to the country’s Energy Information Administration. One result of this has been a consolidation of utilities across the industry; the US electricity industry dropped from 244 investor-owned utilities in 1995 to 193 in 2011, with more consolidation since then. Zpryme’s Smart Grid Index says government data and statistics are usually 1–2 years behind in the utilities sector. Additionally, major industry announcements and deals only capture a small fraction of market

activity. This lack of data can lead to poor investment decision criteria for utilities and technology vendors operating (or seeking to enter) the smart grid space.

Over time, substantial investments will be needed to modernize power grids through new technology and other improvements. Smart grid-related technology and services have been growing rapidly and are expected to reach nearly \$43 billion in the United States by 2014 and more than \$171 billion globally. While the conventional electric grid was arguably the largest engineering project of the twentieth century, the smart grid will likely be one of the largest—if not the largest—engineering projects of the present century.

Meanwhile, the primary document for creating the next-generation “smart” energy grid got its first major update in 2 years beginning in April 2014 when NIST requested public comment on a draft of the *NIST Framework and Roadmap for Smart Grid Interoperability Standards, Release 3.0*. The new document builds upon the updates the February 2012 *Framework Release 2.0*, NIST’s outline of the plan to transform the nation’s aging electric power system into an interoperable smart grid. “There have been many remarkable advances in smart grid infrastructure since the release of the last edition,” said Chris Greer, director of NIST’s Smart Grid Program Office. “By 2015, nearly a third of the 144 million meters in the United States will be smart meters. Through the Green Button effort, more than 45 electricity suppliers nationwide have committed to providing 59 million homes and businesses with access to their energy usage data. This new edition embraces this remarkable progress and provides a foundation for working together for the smart grid of the future.”

Bill Ash says years will pass before smart grid technologies are fully integrated for improved efficiencies and better reliability. “It’ll be years, as well, before consumers have full access to affordable home energy management systems, smart appliances, smart homes and applications to run those technologies become available for smartphones, tablets, and the like,” says Ash. “Those technologies and apps are beginning to appear, but widespread adoption will take time.”