ATTACHMENT 1

A REVIEW OF SMART GRID STANDARDS

GridSolar, LLC

State of Maine Public Utilities Commission
Docket No. 2010-267

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This appendix reviews and summarizes the ongoing development of standards that will govern development of the smart grid and its various components, and which will govern future technologies and operational changes. Development of these standards is highly dynamic and many future changes are expected. One of the primary tasks of a Smart Grid Coordinator will be to monitor the development and approval of such standards to ensure that all smart grid activities in the state comply with all existing standards and legal requirements, and that smart grid technologies and software systems are compatible with expected future standards and requirements.

1.1 Overview of literature and activities related to the development of standards for the Smart Electric Grid and its various components

There are three groups at the forefront of the development of smart grid standards: the National Institute of Standards and Technology (NIST), the Institute of Electrical and Electronics Engineers (IEEE), and the Electric Power Research Institute (EPRI). Additionally, there are smaller groups that contribute to the formation of standards including the GridWise Architecture Council, and the North American Energy Standards Board (NAESB). Below, we describe each of the groups and their respective efforts related to Smart Grid standards.

- **NIST:**

The National Institute of Standards and Technology (NIST) has *"primary responsibility to coordinate development of a framework that includes protocols and model standards for information management to achieve interoperability of smart grid devices and systems…"* as stated in the Energy Independence and Security Act of 2007. 42 U.S.C. § 17385(a). Under this Act, the Smart Grid Interoperability Standards Project received $10 million from the DOE, and it is now working on an accelerated schedule due to the prioritization of smart grid initiatives by the Obama administration. NIST develops reports based on an open public process that engages the broad spectrum of Smart Grid stakeholder communities and the general public. Additionally, NIST is partnered with the GridWise Architecture Council, founded in 2003 by the Department of Energy (DOE) to involve all electric industry stakeholders in the development of standards.

The **"NIST Framework and Roadmap for Smart Grid Interoperability Standards, Release 1.0,"** was released by the NIST Smart Grid Interoperability Panel (SGIP) in January 2010. The SGIP is comprised of 1,800 individual members representing 580

organizations worldwide.[1] NIST also consults stakeholders through extensive outreach efforts carried out by the Office of the National Coordinator for Smart Grid Interoperability. Additionally, report drafts undergo 30-day public review and comment periods, and all comments received are considered in the preparation of final reports.[2] NIST believes that Smart Grid interoperability standards should be developed and maintained through a collaborative, consensus-driven process that is open to participation by all relevant and materially affected parties and not dominated by, or under the control of, a single organization or group of organizations. As important, NIST strives to make the standards resulting from its process readily and reasonably available to all for Smart Grid applications.

The report contains a conceptual reference model to facilitate the design of an architecture for the overall Smart Grid and for its networked domains, as well as an initial set of 75 standards identified as applicable to the Smart Grid. Additionally, the report outlines an initial Smart Grid cyber-security strategy and associated requirements.[3]

The NIST conceptual reference model was included to create a common understanding of the Smart Grid system's major building blocks and how they interrelate. It consists of seven domains: bulk generation, transmission, distribution, markets, operations, service provider, and customer. This model provides a means to analyze cases, identify interfaces for which interoperability standards are needed, and to facilitate development of a cyber-security strategy.

The report also includes priorities for additional standards, revised or new, to resolve important gaps, as well as action plans under which designated standards-setting organizations will address these priorities. The eight priority areas for standardization are:

- Demand Response and Consumer Energy Efficiency
- Wide-Area Situational Awareness
- Energy Storage
- Electric Transportation
- Advanced Metering Infrastructure
- Distribution Grid Management
- Cyber-Security
- Network Communications

Cyber-security of the Smart Grid has been identified by NIST as a critical priority which must be achieved by incorporating security at the architectural level of the system. A NIST-led Cyber-Security Coordination Task Group consisting of almost 300 participants from the private and public sectors is leading the development of a cyber-security strategy and cyber-security requirements for the Smart Grid. The task group is

[1] Smart Grid Interoperability Panel Achieves New Milestones In Developing Standards. May 27, 2010. SGIP. http://www.smartgridnews.com/artman/uploads/1/standards.pdf
[2] Framework and Roadmap for Smart Grid Interoperability Standards, Release 1.0. Jan 2010. NIST.
[3] NIST Issues First Release of Framework for Smart Grid Interoperability. Jan 19, 2010. NIST. http://www.smartgridnews.com/artman/uploads/1/NIST_Issues_First_Release_of_Framework.pdf

identifying cases with cyber-security considerations; assessing risks, vulnerabilities, threats and impacts; performing a privacy impact assessment; assessing relevant standards; specifying research and development topics; developing a security architecture linked to the Smart Grid conceptual reference model; and documenting and tailoring security requirements to provide adequate protection.[4]

Through the NIST workshops, NIST determined that many potentially useful standards will require revision or enhancement before they can be implemented to address Smart Grid requirements. In addition, stakeholders identified gaps requiring entirely new standards to be developed. In all, a total of 70 such gaps or related issues were identified. Of these, NIST developed a series of Priority Action Plans in order to address the most urgent 15 areas of additional scrutiny. Each of these fifteen plans includes a series of defined tasks with specified deliverables, under aggressive milestones:

- PAP 01: Guidelines for use of IP protocol suite in the Smart Grid (mid 2010)
- PAP 02: Guidelines for use of wireless communications in the Smart Grid (mid 2010)
- PAP 03: Common specification for price and product definition (early 2010)
- PAP 04: Common scheduling mechanism for energy transactions (early 2010)
- PAP 05: Standard meter data profiles (year-end 2010)
- PAP 06: Smart meter upgradeability standard (completed)
- PAP 07: Energy storage interconnection guidelines (mid 2010)
- PAP 08: Common information model for distribution grid management (year-end 2010)
- PAP 09: Standard demand response signals (early 2010)
- PAP 10: Standards for energy use information (mid 2010)
- PAP 11: Interoperability standards to support plug-in electric vehicles (year-end 2010)
- PAP 12: DNP3 Mapping to IEC 61850 Objects (2010)
- PAP 13: Harmonization of IEEE C37.118 with IEC 61850 and precision time synchronization (mid 2010)
- PAP 14: Transmission and distribution power systems models mapping (year-end 2010)
- PAP 15: Harmonize power line carrier standards for appliance communications in the home (year-end 2010)

The objective of the NIST plan, moving forward, is to create a robust, ongoing, "built-in" standards process that supports cycle after cycle of smart grid innovation. The resulting process could lead to new collaborative methods and vehicles for developing and deploying standards in technology-based markets, especially during the early phases when standards - or the lack of standards - can strongly influence the course of further technology development and diffusion and the growth and competitiveness of industries.

On May 27th, 2010, NIST reported that two of the 15 PAPs were completed:

- PAP 04: Common Scheduling Mechanism

[4] Framework and Roadmap for Smart Grid Interoperability Standards, Release 1.0. Jan 2010. NIST.

- PAP 05: Standard Meter Data Profiles

- **IEEE:**

The IEEE, an independent nonprofit organization dedicated to the advancement of electrical technologies, has developed over 900 active industry standards to date. **IEEE Standard 1815**, ratified by IEEE in June 2010, and released in July 2010, represents a strong industry consensus and dictates a standard for smart grid electric power systems communications. The robust, multi-layered Distributed Network Protocol (DNP3) set forth in the standard outlines an agile, forward-looking architecture enabling better optimized and more secure information gathering, exchange, and use, particularly in Supervisory Control and Data Acquisition (SCADA) systems. Expanding on widely used industry protocols, the comprehensive standard also preserves prior significant infrastructure investments by remaining backward compatible with existing object models, but it also ensures adaptability to future technologies, a high level of device interoperability, and security of smart grid control/communication systems.[5] The final publication of IEEE 1815 will be a critical step towards the standardization of smart grid technologies, and the implementation of such systems.

The IEEE Standards Association creates standards on a very open basis, allowing anyone who is affected by or interested in the standard to contribute to working groups and drafts. The final standard must receive approval by 75% of the ballots, and anybody who is in the IEEE-SA or who has paid a balloting fee may cast a ballot. Recommendation for final approval is given first by the Review Committee; then, the IEEE-SA Standards Board must approve the draft by a majority vote.

IEEE 1815 has also garnered strong backing from leading organizations and institutions, including NIST. IEEE 1815 supports NIST PAP12 DNP3 Mapping to IEC 61850 Objects under the NIST Priority Action Plans (PAP) established in 2009. IEEE has over 100 standards and standards in development relevant to the Smart Grid, including over 20 IEEE standards named in the NIST Framework and Roadmap for Smart Grid Interoperability Standards.

- **EPRI Intelligrid Consortium:**

EPRI is an independent, nonprofit center for public interest energy and environmental research and development. Member organizations represent over 90% of the electricity generated in the United States, including many major utilities. EPRI also brings together scientists, engineers, regulators, and hi-tech manufacturers to cover every area of power generation, delivery, and use, including health, safety, and environment. The Intelligrid Consortium is a group within EPRI which is working to provide utilities with a step-by-step procedure for integrating the communications networks and intelligent devices critical for tomorrow's power delivery system. The Integrated Energy and

[5] http://smartgrid.ieee.org/ieee-smartgrid-news/89-ieee-delivers-critical-1815-dnp3-standard-in-record-time

Communication System Architecture (IntelliGrid Architecture) is the first step in enabling the future smart grid system. It is a set of high level concepts that are used to design a technology independent architecture as well as identify and recommend standard technologies, and best practices. This standards-based open architecture specifies basic requirements and processes, but allows for flexibility in meeting the requirements. By outlining the standards, procedures, and systems of the IntelliGrid Architecture, EPRI strives to attain interoperability among grid components, as well as to avoid the installation of costly proprietary equipment that cannot be integrated or upgraded efficiently. The key project areas are:

- Fast Simulation and Modeling: This project is developing a high-performance "look-ahead" capability for a self-healing grid, one that is capable of automatically anticipating and responding to power system disturbances while continually optimizing its own performance. This work develops functional requirements, followed by software design and testing. The result will be a software system that provides faster-than-real time simulation and modeling of electricity grid dynamics.

- Communications Protocols for Distributed Energy Resources: IntelliGrid will encompass highly automated smart distribution systems including small generators and storage devices located near customer loads. An open communications architecture will allow these devices to be added to the system over time without custom redesign of the communication and control system at every incremental addition.

- Consumer Portal: IntelliGrid's two-way energy portal transforms the traditional meter into a communications gateway that empowers consumers and helps utilities reduce costs and offer new value-added energy services including demand response, net metering, automated meter reading, energy management, real-time pricing, and appliance management.[6]

EPRI published its final report, entitled **"The Integrated Energy and Communication Systems Architecture, Volume I"** in August 2004 as a series of printable documents, computer models, and web-browser navigable hypertext pages. The primary contributors to this architecture report are: GE Global Research (Primary Contractor), EnerNex, Hypertek, Lucent Technologies, Systems Integration Specialists Company, Inc., and Utility Consulting International.

To develop IntelliGrid Architecture, a diverse team of industry experts was assembled with representation from utilities, vendors, consultants, researchers, and project managers. This team followed established steps of 'good system architecture design', specifically:

1. **Gathering requirements** from stakeholders across the industry.
2. **Analyzing** the requirements using modern methodologies and tools.

[6] IntelliGrid: Smart Power for the 21st Century. 2005. EPRI.

3. **Evaluating** the state-of-the-art in communications technology.
4. **Designing** the architecture by identifying common components and services.
5. **Capturing** the architecture design and recommendations using web technology.

Three key steps of system architecture design remain to be executed: (i)**Testing** the principles of the architecture in prototypes and pilot projects; (ii) **Implementation** and validation of the design in real-world, large-scale systems; and (iii) **Integration** of the lessons learned into further iterations of the process.[7]

- **GridWise Architecture Council**

The GridWise Alliance is a nonprofit public-private partnership dedicated to modernizing the energy system of the United States. The GridWise Architecture Council was formed by the U.S. Department of Energy in 2003 to promote and enable interoperability among the many entities that interact with the electric power system. These include businesses such as energy customers, utilities and vendors as well as associations, regulators, public agencies and elected representatives. This balanced team of 90 stakeholder representatives proposes principles for the development of interoperability concepts and standards. Decisions are made on the basis of consensus. The Council provides industry guidance and tools that make it an available resource for Smart Grid implementations.[8] Pacific Northwest National Laboratory assists and supports GridWise on behalf of the DOE, and it actively coordinates GridWise's efforts with other similar programs such as NIST, EPRI's IntelliGrid program, the Consortium for Electric Reliability Technology Solutions (CERTS), and the Washington State University GridStat program. Solutions are held to a variety of business, usability, information technology, regulatory, and governance principles in order to ensure the highest levels of stakeholder consensus and longevity.

The **"GridWise Interoperability Context-Setting Framework Version 1.1,"** published in March 2008, describes the goals and the preliminary results of the Council. It states that **the role of the Council is not to design the emerging smart grid system or to create standards**; the Council's role is to bring the right parties together to identify actions, agreements, and standards that enable significant levels of interoperation between automation components. Additionally, the GridWise Architecture Council acts as a catalyst to outline a philosophy of inter-system operation that preserves the freedom to innovate, design, implement and maintain each organization's role and responsibility in the electrical system.[9]

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[7] The Integrated Energy and Communication Systems Architecture, Volume I. EPRI IntelliGrid.
[8] GridWise Interoperability Context-Setting Framework. Mar 2008.
http://www.gridwiseac.org/pdfs/interopframework_v1_1.pdf
[9] GridWise Interoperability Context-Setting Framework. Mar 2008.
http://www.gridwiseac.org/pdfs/interopframework_v1_1.pdf

- **International Electrotechnical Commission (IEC)**

The IEC is an international electrical standards development organization, providing a large catalogue of standards across the electricity industry. With the creation of the IEC Smart Grid Strategic Group (IEC SG3) in 2008, the IEC is taking a leading role in the electrical industry in terms of Smart Grid development. This Smart Grid Strategic Group is now providing a "one-stop shop" for the large number of Smart Grid projects that are being launched worldwide, by creating standards that cover all aspects of smart grid technology and implementation.

The IEC Smart Grid Strategic Group has already made the early releases of their standards available through a web portal allowing Smart Grid projects easy access to them, as well as guidance to make the most of them [www.iec.ch/smartgrid]. In addition, an action plan guiding the different IEC Technical Committees towards a comprehensive set of harmonized global standards, supporting the smart grid requirements, is fully underway.[10]

The **"IEC Smart Grid Standardization Roadmap,"** 1st edition, published in June 2010, outlines the strategy of the IEC SG3, bringing together experts from 14 nations to develop protocols and model standards to achieve interoperability of smart grid devices and systems. The IEC SG3 acknowledges the work done by NIST and is actively offering NIST support on the PAPs, where the work of the two organizations overlaps and has an international focus.

- **North American Energy Standards Board (NAESB)**

The NAESB is a nonprofit, public-private partnership that has close ties with the Federal Energy Regulatory Commission, the Department of Transportation, the Department of Energy, and various state commissions. Additionally, the NAESB works closely with the Mexican Comision Reguladora de Energia (CRE) and the Canadian National Energy Board (NEB). The purpose of this organization is to create a forum where companies can create the standards that will govern them, for review by the aforementioned federal and state agencies. The NAESB standard development process has been accredited by the American National Standard Institute (ANSI), and it is used to create standards in wholesale electricity, wholesale gas, retail electricity, and retail gas. Industry coordination is key, requiring both wholesale and retail entities to jointly develop necessary inter-system standards. NAESB is in a unique position, with a structure that can accommodate all industry participants in an established process for reaching consensus across multiple market interests.

[10] IEC Smart Grid Standardization Roadmap. June 2010. SG3.
http://www.iec.ch/zone/smartgrid/pdf/sg3_roadmap.pdf

NAESB develops standards using the "FERC proposed statement and action plan for smart grid policy" as a starting point, noting where FERC asked for comments. Standards take 4-12 months to develop. They are only available to member organizations that pay dues when they are completed, via the NAESB website. The four major focuses in its smart grid activities are: demand response, interoperability, cyber security, and congestion management/curtailment.[11] NAESB also influences standards through NIST, as it routinely submits comments and proposes modifications for the Priority Action Plans.

NAESB's **"Smart Grid Policy,"** published March 19, 2009, outlines a national regulatory/rate structure strategy to employ during the transition to a smart grid on a national scale, while also outlining the basic framework for smart grid standard requirements.[12]

Other organizations that are creating standards for the Smart Grid[13]

- CEN, CENELEC, ETSI Focus Group on standards for the Smart Grid, Europe
- European Commission Task Force on Smart Grids
- European Utilities Telecom Council (EUTC), ICT for Smart Distributed Generation (ICT4SDG)
- Grid Modernization Collaborative (GMC)
    - Virtual organization for expanding collaboration on smart grid activities, established by Energy & Environmental Resources Group (E2RG). Members include U.S. DoE, EPRI IntelliGrid, and GridWise
- The Internet Engineering Task Force (IETF), USA
- ISO/IEC JTC 1 Special Working Group Smart Grid, International
- ITU Telecommunication Standardization Sector Focus Group on Smart Grid, International
- Korea Smart Grid Association (KSGA), Korea Smart Grid Institute (KSGI)
- Next Generation Energy Study Group, Japan
- Organization for the Advancement of Structured Information Standards Blue Initiative (OASIS Blue Initiative)
- Supporting Energy Efficiency in Smart GENeration grids through ICT, EU
- Smart Grid Australia (SGA)
- State Grid Corporation of China (SGCC)
- SIP Forum Smart Grid Special Interest Group
- UCA International Users Group Open Smart Grid, International
- U.S. Department of Energy, Office of Electricity Delivery & Energy Reliability
- ZigBee Alliance Smart Energy

[11] NAESB: A Brief Description. http://www.naesb.org/pdf/naesb_brief_description.pdf
[12] Smart Grid Policy. Mar 19, 2009. FERC. http://www.naesb.org/pdf4/ferc031909_smart_grid_noi.pdf
[13] Activities in Smart Grid Standardization. Apr 2010. ITU.

1.2 Metering/Measurement

NIST

Of the eight NIST priority areas for the expedient creation of standards, four are related to metering/measurement:

- Demand Response and Consumer Energy Efficiency
- Advanced Metering Infrastructure
- Distribution Grid Management
- Cyber Security

Ten of the fifteen initial NIST Priority Action Plans also address metering/measurement:

- Smart meter upgradeability standard (completed)
- Common specification for price and product definition (early 2010)
- Common scheduling mechanism for energy transactions (early 2010)
- Common information model for distribution grid management (year-end 2010)
- Standard demand response signals (early 2010)
- Standards for energy use information (mid 2010)
- Guidelines for use of IP protocol suite in the Smart Grid (mid 2010)
- Guidelines for use of wireless communications in the Smart Grid (mid 2010)
- Interoperability standards to support plug-in electric vehicles (year-end 2010)
- Standard meter data profiles (year-end 2010)

Interoperable Device Interface Specifications (IDIS)

On September 23, 2009, three European companies: Iskraemeco, Itron and Landis+Gyr, founded IDIS, Interoperable Device Interface Specifications, in order to promote faster and broader deployment of advanced metering infrastructure (AMI) devices and services, by addressing interoperability concerns among their proprietary products. The scope of this organization covers a full end-to-end solution, from the Home Area Network to the Wide Area Network and the interface to utilities existing IT infrastructure.[14] The initiative is aimed mainly at Europe, the Middle East, and Africa.

Utility Communications Architecture International Users Group (UCAIug)

The UCA International User's Group is a not-for-profit corporation consisting of utility user and supplier companies that is dedicated to promoting the integration and interoperability of electric/gas/water utility systems through the use of international standards-based technology.[15] The OpenSG Users Group is a sub-working group within the UCAIUG, and AMI-SEC is a task force under the OpenSG Users Group. UCAIUG works with IEC to feed the standards development process where appropriate.

[14] http://www.idis-association.com/press.html
[15] http://www.ucaiug.org/UCAIug/default.aspx

The AMI-SEC is a special cyber-security-focused task force chartered to define common requirements for securing advanced metering infrastructure (AMI) system elements. [16] The **"AMI-SEC Task Force Roadmap"** outlines the organization's goals and future steps, while the **"AMI System Security Requirements, V1.01,"** published in December 2008, outlines the current security framework put forth by the task force. The goal of this Task Force is to define an exhaustive list of the potential security threats, threat agents and vulnerabilities to the systems, and to perform detailed to determine the risks they present. Also, AMI-SEC will produce the process by which a vendor can certify a device as a "UtiliSec Compliant Security Device," in assessing and procuring cyber-security functionality in their devices. This process will provide a mechanism to validate and endorse the certification methods associated with a given technology, enabling the industry to produce compliant and compatible security technologies.[17]

Another task force in the ICAIug is OpenHAN, which is designed to facilitate standards and technology development to enable dissimilar home-area network (HAN) protocols to interface and work interoperably. Southern California Edison, Consumers Energy, Pacific Gas and Electric, and American Electric Power, among others, are actively participating in UtilityAMI working group and task force meetings. Although focused on developing requirements from a utility perspective, vendors are actively involved in these activities to ensure that the requirements developed are technically and economically feasible in the marketplace.

Separately, in August 2008, American Electric Power, Consumers Energy, Pacific Gas and Electric, Reliant Energy, Sempra, and Southern California Edison announced they were working with the ZigBee® Alliance and the HomePlug® Powerline Alliance "to develop a common application layer integrated solution for AMI and HAN (Home Area Networks)" in order to enable HomePlug® and ZigBee® to work interoperably and integrally in HAN configurations.[18]

IEC

The IEC already has many electricity meter/measurement standards in place, and it is in the process of developing more through its IEC Smart Grid Strategic Group (IEC SG3) as part of its "one-stop shop" approach to smart grid standards.[19] The IEC AMI initiative, led by the UtilityAMI OpenHAN Task Force, published **"UtilityAMI 2008 Home Area Network System Requirements Specification"** in 2008 in order to specify a set of interoperability standards for HAN systems, as well as their communication interfaces

[16] Advanced Metering Infrastructure Security Task Force. Jan 1, 2009. AMI-SEC. http://osgug.ucaiug.org/utilisec/amisec/Shared%20Documents/AMI-SEC%20Charter%20Statement%20-%20v1_1%20-%2020090101%20-%20drh.doc

[17] AMI-SEC Task Force Roadmap. Sept 30, 2008. http://osgug.ucaiug.org/utilisec/amisec/Shared%20Documents/AMI-SEC_Roadmap_Document_v0_4-20080930_NCG.doc

[18] http://www.homeplug.org/news/pr/view?item_key=6ddbf0d46d2156a8cb71f25199c02b2dfd20ce8b

[19] Smart Grid Policy. Mar 19, 2009. FERC. http://www.naesb.org/pdf4/ferc031909_smart_grid_noi.pdf

with the larger utility networks. Additionally, this paper outlines communication specifications for electricity meters including data exchange for meter reading, tariffs (enabling tiered rate structures), and load control (limiting or shedding load).

The **"IEC Smart Grid Standardization Roadmap,"** 1st edition, published in June 2010, outlines the strategy of the IEC SG3, bringing together experts from 14 nations to develop protocols and model standards to achieve interoperability of smart grid devices and systems. The IEC SG3 acknowledges the work down by NIST, and is actively offering NIST support on the PAPs where the work of the two organizations overlaps, with an international focus.

EPRI Intelligrid:

Consumer Portal: IntelliGrid's two-way energy portal transforms the traditional meter into a communications gateway that empowers consumers and helps utilities reduce costs and offer new value-added energy services including demand response, net metering, automated meter reading, energy management, real-time pricing, and appliance management.[20]

1.3 Monitoring Grid Conditions

NIST:

Of the eight NIST priority areas for the expedient creation of standards, three are related to grid monitoring:

- Wide-Area Situational Awareness
- Distribution Grid Management
- Advanced Metering Infrastructure

Five of the fifteen initial NIST Priority Action Plans also address grid monitoring:

- Smart meter upgradeability standard (completed)
- Common information model for distribution grid management (year-end 2010)
- Standards for energy use information (mid 2010)
- Harmonization of IEEE C37.118 with IEC 61850 and precision time synchronization (mid 2010)
- Transmission and distribution power systems models mapping (year-end 2010)

IEC

The IEC already has many substation equipment monitoring, operation and control standards in place, and it is in the process of developing more through its IEC Smart Grid

[20] IntelliGrid: Smart Power for the 21st Century. 2005. EPRI.

Strategic Group (IEC SG3) as part of its "one-stop shop" approach to smart grid standards.[21]

The **"IEC Smart Grid Standardization Roadmap,"** 1st edition, published in June 2010, outlines the strategy of the IEC SG3, bringing together experts from 14 nations to develop protocols and model standards to achieve interoperability of smart grid devices and systems. The IEC SG3 acknowledges the work down by NIST, and is actively offering NIST support on the PAPs where the work of the two organizations overlaps, with an international focus.

1.4 Communications Protocols

IEEE:

IEEE Standard 1815, ratified by IEEE in June 2010, represents a strong industry consensus and dictates a standard for smart grid electric power systems communications. The robust, multi-layered Distributed Network Protocol (DNP3) outlined in the standard outlines an agile, forward-looking architecture enabling better optimized and more secure information gathering, exchange, and use, particularly in Supervisory Control and Data Acquisition (SCADA) systems. Expanding on widely used industry protocols, the comprehensive standard also preserves previous significant infrastructure investments by remaining backward compatible with existing object models, but it also ensures adaptability to future technologies, a high level of device interoperability, and security of smart grid control/communication systems.[22] As this standard is being developed by IEEE, a highly reputable organization that builds standards on the basis of industry consensus, the final publication of IEEE 1815 will be a critical step towards the standardization of smart grid technologies, and the implementation of such systems.

IEEE 1815 has also garnered strong backing from leading organizations and institutions including the federally-chartered National Institute for Standards and Technology (NIST), which has been charged with the development of critical smart grid standards. IEEE 1815 supports NIST PAP12 DNP3 Mapping to IEC 61850 Objects under the NIST Priority Action Plans (PAP) established in 2009.

International Telecommunication Union (ITU-T)

ITU-T announced a smart grid standards initiative on May 12, 2010. ITU experts have already agreed on specifications for Smart Grid products for home networks. The specifications include a 'low complexity' profile that will allow multiple manufacturers to develop products that deliver the low power consumption, low cost, performance,

[21] Smart Grid Policy. Mar 19, 2009. FERC. http://www.naesb.org/pdf4/ferc031909_smart_grid_noi.pdf
[22] http://smartgrid.ieee.org/ieee-smartgrid-news/89-ieee-delivers-critical-1815-dnp3-standard-in-record-time

reliability, and security that is required for Smart Grid and other lower bit rate applications.

Members of HomeGrid Forum, an independent body set up to promote ITU-T's home networking standard, G.hn, are active participants in Smart Grid standardization efforts worldwide, including those led by NIST, IEEE, ISO/IEC, and SAE. In 2009, HomeGrid Forum formed a Smart Grid initiative group, which will help to bring a range of G.hn-based devices to the Smart Grid market and home energy management applications.

The G.hn standard, which enables gigabit home networking over any existing wire systems, was earmarked as a technology with "strong stakeholder consensus" by NIST until it was removed from their final report issued in 2010, entitled "Standards Identified for Implementation."

IEC

The IEC already has many utility communications security standards in place, and it is in the process of developing more through its IEC Smart Grid Strategic Group (IEC SG3) as part of its "one-stop shop" approach to smart grid standards.[23] Additionally, the IEC is in the process of developing standards for distribution automation using distribution line carrier systems.

The **"IEC Smart Grid Standardization Roadmap,"** 1st edition, published in June 2010, outlines the strategy of the IEC SG3, bringing together experts from 14 nations to develop protocols and model standards to achieve interoperability of smart grid devices and systems. The IEC SG3 acknowledges the work down by NIST, and is actively offering NIST support on the PAPs where the work of the two organizations overlaps, with an international focus.

A core group of standards initiated by the Electric Power Research Institute provide the basis for addressing the need for a cohesive communication system- these standards are IEC 61970 and IEC 61968 (together often referred to as the "Common Information Model" standards) and IEC 61850. These standards have been cited by recent papers on the subject, including NIST's recent "Smart Grid Issues Summary." This group of standards was designed to allow different systems to talk to one another as well as to provide software development tools for more efficient system integration. This suite of standards is already in use by a number of utilities for enterprise system integration (enabling integration across "intrasystem" interfaces).

NIST:

Of the eight NIST priority areas for the expedient creation of standards, five are related to communications involving metering and measurement:

[23] Smart Grid Policy. Mar 19, 2009. FERC. http://www.naesb.org/pdf4/ferc031909_smart_grid_noi.pdf

- Wide-Area Situational Awareness
- Advanced Metering Infrastructure
- Distribution Grid Management
- Cyber Security
- Network Communications

Seven of the fifteen initial NIST Priority Action Plans also address communications protocols:

- Common information model for distribution grid management (year-end 2010)
    - This has driven a modeling effort that used data developed by the Utility Communications Alliance (UCA) OpenSG Communications Working Group with a NIST- and IEEE-developed analytic model of IEEE 802.11. This effort has demonstrated the adequacy of that wireless technology for Smart Grid use cases in Advanced Metering, Distributed Energy, and Distribution Operations. [24]
- Standard demand response signals (early 2010)
- DNP3 Mapping to IEC 61850 Objects (2010)
- Harmonization of IEEE C37.118 with IEC 61850 and precision time synchronization (mid 2010)
- Guidelines for use of IP protocol suite in the Smart Grid (mid 2010)
- Guidelines for use of wireless communications in the Smart Grid (mid 2010)
- Harmonize power line carrier standards for appliance communications in the home (year-end 2010)
    - This PAP has been successful in validating co-existence requirements for both broadband and narrowband PLC technologies, getting Standards Defining Organizations (SDOs) and vendors to agree on many details of co-existence standard specifications and accelerating timelines for their implementation.

EPRI Intelligrid:

Communications Protocols for Distributed Energy Resources: IntelliGrid will encompass highly automated smart distribution systems including small generators and storage devices located near customer loads. An open communications architecture will allow these devices to be added to the system over time without custom redesign of the communication and control system at every incremental addition.

[24] http://www.smartgridnews.com/artman/publish/Technologies_Communications_News/Smart-Grid-Standards-Wars-Battle-over-Communications-Heats-Up-2590.html