ACCELERATING STANDARDS AND MEASUREMENTS FOR THE SMART GRID

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ABSTRACT

The National Institute of Standards and Technology (NIST) has efforts underway to accelerate the international development of interoperability standards to support the future modernized "Smart Grid" electric grid or energy delivery network characterized by a two-way flow of electricity and information, capable of monitoring and responding to changes in everything from power plants to customer preferences to individual appliances. Through a high-visibility, rapid, and open process that brought together the Smart Grid community, including utilities, equipment suppliers, network providers, IT application developers and integrators, government and consumers of electricity, NIST has developed and published its Framework and Roadmap for Smart Grid Interoperability Standards, Release 1.0 [1], to create the basis for prioritizing, coordinating and accelerating the development of standards in private-sector standards setting organizations, including international standards development organizations such as the International Electrotechnical Commission (IEC) and the IEEE.

Index Terms— Smart Grid, interoperability standards, standards development organizations, phasor measurement units, calibration, and sensors

1. INTRODUCTION

By incorporating communications, distributed computing, signal processing and new measurement capabilities, the new Smart Grid will improve the reliability and efficiency of electric power grids while enabling integration of distributed renewable energy sources and electric transportation and reducing energy usage in buildings and industrial facilities through intelligence and automation. Under Title XIII, Section 1305 of the U.S. Energy Independence and Security Act of 2007, NIST is assigned the "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…" [2]. NIST also has responsibilities for coordinating the U.S. Government's use of voluntary consensus standards as described in the National Technology Transfer and Advancement Act of 1995 (NTTAA) [3] and the U.S. Office of Management and Budget (OMB) Circular A-119 [4].

1.1. NIST Smart Grid Program

In response, NIST has developed a multidisciplinary Smart Grid Program to provide visible national and international leadership and effective coordination of Smart Grid interoperability documentary standards efforts within the private sector, including by international standards development organizations, and to support new internal NIST metrology research and calibrations for measurement of power and energy and other electrical quantities important to revenue metering, wide area situational awareness, and the operation of the power grid. A significant challenge is to coordinate the efforts of the standards development organizations (SDOs) so that standards gaps are filled and overlaps are resolved. A range of conformity assessment processes including full interoperability testing is needed to assure that new equipment and systems are able to be integrated seamlessly into the power grid and provide needed functionality to enable the benefits of the Smart Grid to be realized. In addition, NIST leadership and technical involvement in numerous standards coordination efforts provides an opportunity to identify and develop programs to meet new research and measurement needs for the Smart Grid, as well as identify testing and certification issues to be resolved.

2. STANDARDS ACCELERATION

Recognizing the urgent need for standards to support Smart Grid interoperability and security, NIST developed a three-phase plan to (1) engage stakeholders to identify an initial set of standards that would promote the rapid development

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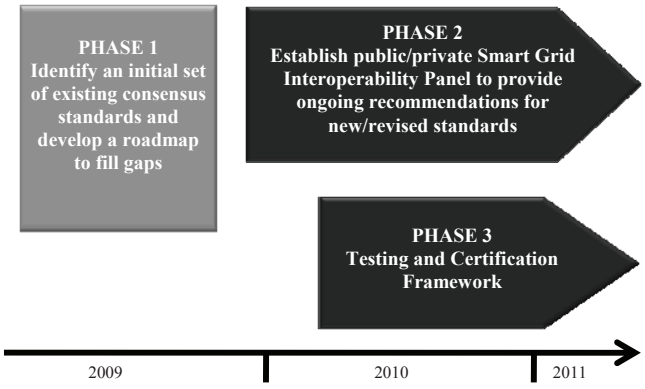

Figure 1. NIST Three Phase Plan

of the Smart Grid, (2) establish a robust framework for the sustaining development of the many needed additional standards through a public-private partnership, and (3) establish a framework for a strong conformity testing infrastructure. Figure 1 provides a visual diagram of the NIST Three Phase Plan.

2.1. NIST Framework

During the first phase, NIST held several public workshops and developed a NIST Framework and Roadmap for Smart Grid Interoperability Standards Release 1.0, published in draft form in September 2009 for public review and comment and finalized in January 2010 [1]. It describes a high-level conceptual reference model for the Smart Grid and identifies 75 existing standards that are applicable to the ongoing development of the Smart Grid. The document also specifies high-priority gaps and harmonization issues for which new or revised standards and requirements are needed, documents priority action plans (PAPs) with aggressive timelines by which designated standards-setting organizations will address these gaps, and describes the strategy to establish requirements and standards to help ensure Smart Grid cyber security and systems.

Several key focus areas were identified in NIST's Framework document, including standards for advanced metering infrastructure; interfaces between the grid and the customer domain to support demand response and energy efficiency applications; phasor measurement units and other sensors that increase wide area situational awareness; distribution grid automation and integration of renewable resources; interconnection of energy storage; communication with electric vehicles to manage charging; data communication in the smart grid; and cyber security. In addition, complementing and expanding the cyber security section of the NIST Framework document, NIST issued its Guidelines for Smart Grid Cyber Security [5] on September 2, 2010. These guidelines include nearly 200 high-level security requirements and identify an initial set of 137 Smart Grid interfaces.

2.2. Smart Grid Interoperability Panel

To launch the second and third phases, in November 2009 NIST established a Smart Grid Interoperability Panel (SGIP), a public-private partnership composed of organizations organized into 22 stakeholder categories, including categories covering multiple kinds of utilities, power equipment manufacturers, standards development organizations, state and local regulators, R&D organizations and academia, and many others. The SGIP provides a more permanent organizational structure to support the continuing evolution of the NIST Smart Grid Framework, including for conformity testing and certification of Smart Grid devices and systems.

The purpose of the SGIP is to unify the many Smart Grid stakeholders by bringing them together to develop consensus on the approaches to standardization and on the standards themselves. The SGIP has a Governing Board that serves to ensure fairness and balance in the SGIP standards activities and outputs. The SGIP has grown to involve over 620 organizations and over 1500 member representatives, with significant and growing international participation. Within the SGIP are several standing committees and working groups, including the Smart Grid Architecture Committee, the Testing and Certification Committee, and the Cyber Security Working Group, as well as domain expert working groups in areas such as Transmission and Distribution, Home-to-Grid, Business-to-Grid, and Business and Policy.

2.3. SGIP Priority Action Plans

Many of the standards identified in the NIST Framework are still undergoing development and require modifications, some of which are being addressed through priority action plans (PAPs) being carried out within the NIST SGIP. As described in the NIST Framework [1], with consideration of stakeholder input, NIST identified an initial set of priorities for developing and improving standards necessary to build an interoperable Smart Grid based on immediacy of need, relevance to high-priority functionalities, availability of standards to respond to need, and the state of technology deployment. A NIST Smart Grid workshop then engaged more than 20 standards-setting organizations (SSOs) as well as user groups to address these priorities through the establishment of 15 PAPs. Standards organizations and other Smart Grid stakeholders agreed on many individual and collaborative responsibilities for addressing standards issues and gaps, and defined tasks and set aggressive timelines for accomplishing many of them. These PAPs are led by NIST staff and include efforts to support transmission and distribution, metering, enhanced customer interactions with the Smart Grid, communications, and new technologies such as electric vehicles and electric storage

integration. The initial PAPs represent the beginning of an accelerated development and sustained standardization effort that will continue for a number of years. Over the past year, additional PAPs have been approved by the SGIP Governing Board to address standards gaps for wind power and facility information; it is anticipated that more PAPs will be initiated as existing efforts are completed over the next year.

2.4. Standards Ready for Consideration by Regulators

National Institute of Standards and Technology (NIST) has worked closely with U.S. energy regulators including the Federal Energy Regulatory Commission (FERC) and state public utility commissions (PUCs) to coordinate efforts and ensure that energy regulators have technical summary information to support potential rulemaking that regulators may choose to initiate involving consensus standards to support the Smart Grid.

As part of this effort, NIST has identified five foundational families of standards as ready for consideration by regulators. These standards are fundamental to Smart Grid interoperability overall and, specifically, to several FERC priority areas as identified in the Commission's July 16, 2009 Smart Grid Policy Statement. As described in the October 6, 2010 letter from NIST to FERC [6], this initial set of consensus standards, developed by the International Electrotechnical Commission (IEC), help to enable efficient and secure exchanges of information within and across Smart Grid domains. NIST identified these standards are being essential to uniform and interoperable communication systems throughout the grid; they will also accommodate the evolution of the grid and the integration of new technologies, and focus on the information models and protocols important to efficient and reliable grid operations. Additional sets of standards ready for consideration by regulators will be identified by NIST in the future.

4. CONFORMITY ASSESSMENT

The establishment of the SGIP also addresses the third phase of the NIST Three Phase Plan, developing a compliance testing and certification framework, through creation of the Smart Grid Testing and Certification Committee (SGTCC) within the SGIP. The SGTCC is working to develop a framework to support coordination of multiple testing and certification programs across the Smart Grid ecosystem, needed to ensure that products based on Smart Grid standards function as specified and provide seamless end-to-end interoperability from within the utility infrastructure and to the industrial, commercial and residential devices and applications supported by the Smart Grid. The level of effectiveness and robustness of this interoperability experience will depend on the characteristics of the underlying standards, the processes to validate configuration requirements for systems and devices under test, and the thoroughness of interoperability testing under real world conditions.

The initial testing and certification framework includes qualification criteria, use cases and example processes documenting best practices through an Interoperability Process Reference Manual, and identification of testing and certification gaps [7]. In addition, candidate certification programs supporting several NIST-identified standards are being identified that match the foundational processes outlined by the SGTCC, as a first step in implementing a comprehensive testing and certification framework for the Smart Grid.

4. MEASUREMENTS

As part of the NIST Smart Grid Program, additional research and development of new or expanded calibration services is being supported, including in the areas of phasor measurement units, smart meters, building automation, networking, cyber security, and industrial control systems. Many new sensors and measurement devices need to be developed and deployed in order to realize the new capabilities envisioned for the Smart Grid. The NIST programs will provide the research necessary to support the development of the devices and standards, and address device performance and communication to ensure that the requirements are met. Additionally, testbeds will be developed to assess the interoperability and reliability of these devices and systems, as well as how they conform to the requirements of the standards. An example of NIST research to support Smart Grid measurements as well as improvements to documentary standards is presented below.

4.1. Phasor Measurement Unit Measurements

With funding support from NIST and the U.S. Department of Energy (DOE), NIST developed a SynchroMetrology Laboratory [8] to address the need for calibration of electric power instrumentation that links power measurements to Coordinated Universal Time (UTC). NIST offers special test calibration of Phasor Measurement Units (PMUs) and is currently the only National Metrology Institute in the world to provide traceability for PMUs. A phasor is the complex form of the ac waveform of the grid; synchronous measurements of phasors by PMUs (using GPS reference to UTC) are made at multiple geographically separated locations and provide great improvement in the visibility of the state of the power grid. Over 870 new PMUs will be installed in the U.S. over the next few years as supported by American Recovery and Reinvestment Act funding through the DOE Smart Grid Investment Grants Program. With the great interest in expanding the use of PMUs in power grids for Wide Area Situational Awareness [9], many manufacturers are now offering PMUs. NIST has calibrated

PMUs from different manufacturers, including for use on the Brazilian power grid, and has provided feedback to manufacturers to support product improvement needed to meet performance requirements, as well as feedback to improve the IEEE C37.118 standard for PMUs.

5. SUMMARY

Through timely development of the NIST Framework and Roadmap for Smart Grid Interoperability Standards, Release 1.0, NIST is coordinating and accelerating the development of interoperability standards within national and international standards development organizations to support the new modernized Smart Grid [10]. NIST research programs will help to support the development of standards, devices, and systems, and ensure their interoperability to accelerate the deployment of the Smart Grid.

6. REFERENCES

[1] "NIST Framework and Roadmap for Smart Grid Interoperability Standards, Release 1.0," NIST, January 2010, http://www.nist.gov/public_affairs/releases/smartgrid_interoperability_final.pdf

[2] Energy Independence and Security Act of 2007, http://frwebgate.access.gpo.gov/cgi-bin/getdoc.cgi?dbname=110_cong_public_laws&docid=f:publ140.110.pdf

[3] National Technology Transfer and Advancement Act of 1995, https://standards.gov/NTTAA/agency/index.cfm?fuseaction=documents.PL104113

[4] U.S. Office of Management and Budget Circular A-119, "Federal Participation in the Development and Use of Voluntary Consensus Standards and in Conformity Assessment Activities" https://standards.gov/NTTAA/agency/index.cfm?fuseaction=documents.A119

[5] Guidelines for Smart Grid Cyber Security, NISTIR 7628, http://csrc.nist.gov/publications/PubsNISTIRs.html#NIST-IR-7628

[6] NIST letter to FERC Chairman Jon Wellinghoff and "NIST-identified Standards for Consideration by Regulators, Release 1.0" http://www.nist.gov/public_affairs/releases/upload/FERC-letter-10-6-2010.pdf

[7] The Smart Grid Testing and Certification Committee website provides access to working documents and final products: http://collaborate.nist.gov/twiki-sggrid/bin/view/SmartGrid/SmartGridTestingAndCertificationCommittee

[8] G. Stenbakken, and T. Nelson, "Static Calibration and Dynamic Characterization of PMUs at NIST," Power Engineering Society General Meeting, 2007, IEEE, 24-28 June 2007.

[9] Z. Huang, B. Kasztenny, V Madani, K. Martin, S. Meliopoulos, D. Novosel, J. Stenbakken, "Performance evaluation of phasor measurement systems", Power and Energy Society General Meeting - Conversion and Delivery of Electrical Energy in the 21st Century, 2008, IEEE, 20-24 July 2008.

[10] The work presented here represents the efforts of many NIST staff members working as part of the NIST Smart Grid team, led by Dr. George Arnold, the U.S. National Coordinator for Smart Grid Interoperability.