NIST Smart Grid Framework Status Report

This summary report provides a status update on the NIST smart grid interoperability framework. The NIST smart grid framework is a NIST special publication document (NIST SP-1108, NIST Framework and Roadmap for Smart Grid Interoperability Standards, Releases 1, 2 and 3) that addresses NIST's primary responsibility under the Energy Independence and Security Act (EISA) of 2007 to coordinate development of a framework that includes protocols and model standards for information management to achieve interoperability of smart grid devices and systems.

Over the past six years, NIST has worked cooperatively with industry to develop and refine this framework, resulting in a solid foundation and standards-based platform to support continued modernization of the national and international electrical grids. The title of the document includes the words "Framework" and "Roadmap" in recognition of the dual characteristics of this work, (1) to provide interoperability-focused guidance, organizing structures and tools to advance smart grid architectures, cybersecurity, and testing and certification and to support industry implementations and deployments (Framework) and (2) to establish processes and priority action plans to identify, prioritize and address gaps in standards and testing and certification to improve standards-based smart grid interoperability (Roadmap). To support these goals, NIST established a robust consensus-building stakeholder engagement process and organization—the Smart Grid Interoperability Panel, or SGIP 1.0—and has facilitated its transition a non-profit membership-based organization (SGIP 2.0, Inc.), which is expected to provide for continued development and implementation of standards to meet the needs of industry and consumers, to promote best practices for interoperability, and to keep pace with the rapid advance of technology.

For historical perspective, it is useful to briefly describe different phases of NIST's smart grid activities and the associated development and revision of its Smart Grid Framework and Roadmap document.

- In 2008, NIST began its response to the EISA mandate by engaging a broad range of smart grid stakeholders, and working with the Department of Energy (DOE)-sponsored GridWise Architecture Council (GWAC) to create and co-lead several working groups composed of industry experts organized by smart grid domains.
- In early 2009, with the identification of smart grid as a national priority by the Obama Administration and with the investment of over $4.5 billion in the American Recovery and Reinvestment Act (ARRA)-funded smart grid demonstrations and deployments, NIST accelerated its smart grid activities and coordination with the Department of Energy (DOE) and the Federal Energy Regulatory Commission (FERC) to address the urgent need to develop smart grid interoperability standards.
- In March 2009, NIST identified a senior executive to lead the NIST-wide smart grid program, and dramatically increased its collaboration and coordination with industry stakeholders, who committed to support NIST coordination efforts at a kickoff meeting of smart grid industry CEOs and other leaders at the White House.
- With contracted support, three NIST-led smart grid stakeholder workshops were held in the spring and summer of 2009 to identify key standards, interfaces, gaps, use cases, and to develop

priority action plans to address key gaps. NIST and its contractors used the results of these workshops and continuing industry input as the basis for the development of the first draft NIST Smart Grid Framework and Roadmap, which was released for public comments in October 2009 and finalized as Release 1.0 in January 2010.

- In November 2009, NIST launched the Smart Grid Interoperability Panel (SGIP 1.0) in keeping with NIST's EISA goals and to provide a forum for smart grid interoperability stakeholder coordination, with an initial membership of over 370 organizations, an elected Governing Board representing 22 stakeholder categories, and several Committees and Working Groups.

- With NIST leadership and NIST-funded Administrator contracted support, the SGIP ramped up its activities in 2010-2012, growing to 800 organizations with more than 2,000 volunteer representatives, and making significant progress in developing a Catalog of Standards, completing many priority action plans, and other activities. During the same time period, NIST was able to increase its smart grid program technical activities with additional appropriated funding.

- Based on SGIP and industry progress, including work in SGIP Committees and Working Groups and other sources, NIST revised its framework and roadmap and released its Draft Release 2 for public comments in October 2011. The final Release 2.0 framework and roadmap was issued in February 2012, and included advances in architecture, cybersecurity, and testing and certification, and detailed information on SGIP activities and priority action plans.

- With a goal to promote industry leadership and broaden the base of support for SGIP, NIST encouraged and facilitated the transition of SGIP to become an independent membership-supported nonprofit 501(c)3 organization, Smart Grid Interoperability Panel 2.0, Inc. (SGIP 2.0). SGIP 2.0 was legally established in 2012 and became operational in April 2013. NIST has supported SGIP 2.0 activities through continued NIST staff leadership and through a cooperative agreement.

- Based on continued industry and SGIP 2.0 collaboration and international coordination, in April 2014 NIST released its draft Release 3.0 framework and roadmap for public comments, and a final Release 3.0 is planned to be issued in September 2014. NIST anticipates that future releases will be timed to reflect significant changes in the state of progress of smart grid improvements.

The impact of the NIST smart grid framework and roadmap has been significant. It has served as the primary reference document for smart grid interoperability protocols and standards, not only for the U.S. but also internationally. It has been used by Japan, Korea, China and the European Union in developing their roadmaps, and by utilities and vendors as overall guidance to support interoperability of systems and devices. In addition, SGIP 1.0 and SGIP 2.0 have become the leading national and international smart grid organizations to visibly align and coordinate smart grid stakeholders to accelerate smart grid standardization and deployment. In FERC's 7/19/2011 Order on Smart Grid Interoperability Standards under RM11-2, FERC stated that, "We believe that the best vehicle for developing smart grid interoperability standards is the NIST interoperability framework process, including the work of the SGIP and its committees and working groups…The Commission recognizes and appreciates the comprehensiveness of the smart grid interoperability framework process developed by

NIST… we encourage utilities, smart grid product manufacturers, regulators, and other smart grid stakeholders to actively participate in the NIST interoperability framework process to work on the development of interoperability standards and to refer to that process for guidance on smart grid standards." In addition, the National Association of Regulatory Utility Commissioners (NARUC) passed a Resolution on Smart Grid Principles (July 2011) which included the statement, "When evaluating smart grid investments, State commissions should consider how certified smart grid interoperability standards may reduce the cost and improve the performance of smart grid projects and encourage participation in the Smart Grid Interoperability Panel, a public-private partnership that is coordinating and accelerating the development of interoperability standards for the smart grid."

Understanding the Key Elements of the NIST Smart Grid Framework and Roadmap

Reflecting the breadth and technical complexity of smart grid, NIST's Smart Grid Framework and Roadmap is a comprehensive, technically rich document with many interrelated chapters and components. A brief description is provided below of the key elements of the smart grid framework. The smart grid is a system of systems, and so it is natural for it to be characterized by a framework of frameworks. It is important to note that the underlying frameworks often refer to additional key reference documents and processes.

Before describing these key elements, it can be noted that frameworks are conceptual structures that organize and make clear the collective wisdom – vision, principles, underlying structure, functions, requirements, practices, and more – that is needed to provide insight on the interrelated systems of systems to coordinate and inform all participants and to help organize communities of practice. There is flexibility in what is considered a framework; EISA did not specify a particular format or outcome. EISA did provide guidance that the NIST smart grid framework should be technology neutral, and enable all electric resources, including demand-side resources, to contribute to an efficient, reliable electricity network, and EISA also described other attributes such as ability to incorporate regional and organizational differences and provide sufficient manufacturer lead time for development of relevant products and systems. These attributes collectively inform the overall vision for the future of the smart grid, which is the first key overarching framework element. The vision is built upon and supported by references to national and international energy policy goals, identification of key concepts and definitions, and prioritization of goals.

It is also important to note the human organizational element within frameworks, which are created by the stakeholder community – people working within a variety of organizations – with their technical expertise and process. This expertise is collective knowledge that is informed by experience, infused with creativity, and marshalled using effective processes and organized methodology developed within the active stakeholder community.

With this human element in mind, a second key overarching framework element is the SGIP organization, established by NIST to be an effective forum for cooperation and coordination with stakeholders. Because SGIP 2.0 is now an independent non-profit organization, it is more appropriate for the NIST smart grid framework and roadmap 3.0 to describe the SGIP at a higher level with less specific

detail on structure, processes, committees, and work products, which are now SGIP's own internal responsibilities. As will be described later, many of the activities of the SGIP may be thought of as being included in the roadmap portion of the NIST Smart Grid Framework and Roadmap.

Another key element of the smart grid framework is an interoperability standards framework, following the EISA mandate which included identification of protocols and standards. The NIST framework provides a list of identified standards that support interoperability of smart grid devices and systems. There are now more than 65 identified standards or families of standards in the NIST framework, enabling the diverse array of smart grid elements such as solar panels, wind turbines, conventional generators, batteries, transmission and distribution sensors, smart meters, smart appliances and electric vehicles to work together reliably and securely. The standards have undergone a cybersecurity and architectural review process before inclusion, and one primary source of input for these standards is the SGIP Catalog of Standards process including its membership vote on evaluated standards.

With this growing list of standards identified as key building blocks, a framework needs to provide the ability to design, secure and test implementations and deployments desired by practitioners. This ability is achieved with the development of architectural, cybersecurity, and testing and certification frameworks as key elements within the overarching NIST smart grid framework.

The architectural framework includes the NIST smart grid conceptual domain architecture developed in collaboration with the SGIP's Smart Grid Architecture Committee (and its liaison partners including the EU Smart Grid-Coordination Group) and builds on work by the DOE-sponsored GWAC. The architectural framework presents an architectural process and methodology that includes views (diagrams) and descriptions that facilitate the discovery of appropriate characteristics, uses, behavior, interfaces, requirements, and standards of the smart grid. Because the smart grid is an evolving networked system of systems, one benefit of the high-level model is that it provides guidance for standards-setting organizations (SSOs) that are developing more detailed views of smart grid architecture. The architectural framework also prioritizes key interfaces, in particular identifying those for which standards are most urgently needed.

The cybersecurity framework provides a description of standards, guidelines and practices to ensure the confidentiality, integrity, and availability of smart grid information systems, and how these can be leveraged in the context of an organization's risk-management program. The cybersecurity framework is more comprehensively described and developed in the NISTIR 7628 Guidelines for Cyber Security (Volumes 1, 2, and 3) publication, and other publications, including those developed in partnership with DOE and other groups. NISTIR 7628 has achieved wide recognition and use for utilities, vendors, and regulators, and is cited internationally.

The testing and certification framework provides structure and guidance for testing and certification programs needed to support demonstrated end-to-end interoperability in smart grid systems. It is more comprehensively described in the underlying SGIP Interoperability Process Reference Manual (IPRM) Version 2.0. The IPRM provides information, guidelines and best practices for test programs and

guidance and recommendations for test laboratories and certification bodies. Several organizations have implemented test programs based on the IPRM.

The smart grid framework also provides the ability to expand as needed to incorporate additional structure and guidance for smart grid systems. In another framework element, cross-cutting issues and future topics are introduced for further development in areas such as electromagnetic interference, implementability, safety, reliability, and resiliency.

In addition to coordinating the development of a smart grid framework, NIST recognized the importance of organizing the smart grid community for action and creating time expectations for when critical gaps would be addressed. During its initial series of smart grid workshops, priority action plans (PAPs) were developed in cooperation and coordination with industry and standards setting organizations and included requirements identification, planned action steps and coordination, responsible parties and time schedules. These PAPs and other activities represent the roadmap portion of the NIST Smart Grid Framework and Roadmap. Included in this roadmap portion is continuing scheduled work to develop and enhance framework elements, such as in architecture, cybersecurity and testing and certification.

In the future, NIST may focus effort on the framework components of the overall document, which would then become the NIST Smart Grid Framework for Interoperability Standards, and enable the smart grid community to take primary responsibility for the associated Roadmap components of the overall effort. This concept is aligned with the continuing evolution of the SGIP and the overall goal of enabling an industry-led longer-term organizational platform capable of driving continued progress in smart grid interoperability. NIST would continue to lead and participate in Roadmap activities through collaborative efforts with multiple organizations. In addition, NIST would be able to increase its research and development smart grid activities including through its smart grid testbed, and extend its focus and activities to support integration with additional infrastructures and advance the broader field of cyber-physical systems.

Finally, it is useful to note that the general approach developed by the NIST smart grid program (convening workshops, organizing stakeholders, developing frameworks, initiating priority action plans, establishing consensus-developing organizations, and identifying R&D opportunities) has become an example playbook for use by others, including the critical infrastructure cybersecurity framework effort, disaster resilience effort, and many more. Smart grid is a key case study cited by the NSTC Subcommittee on Standards in its "Federal Engagement in Standards Activities to Address National Priorities" and was instrumental to inform policy development resulting in the OSTP/USTR/OMB "Principles for Federal Engagement in Standards Activities to Address National Priorities" guidance to federal agencies.

Author: Dr. David Wollman, NIST
Date: 28 July 2014