NIST Smart Grid Advisory Committee 2019 Report

June 2019

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June 5, 2019

Dr. Walter G. Copan
Under Secretary of Commerce for Standards and Technology &
Director, National Institute of Standards and Technology
100 Bureau Drive, MS1000
Gaithersburg, MD 20899

Dear Dr. Copan,

The Institute's Smart Grid Advisory Committee includes representation from the power industry, technology companies, industry associations, cyber security professionals, the academic research community, energy economists, and public interest organizations. The Committee reflects a broad consensus on the importance of ensuring that our nation's power system remains safe, reliable, efficient and secure; as well as resilient, sustainable and affordable for end users and consumers. The Committee recommends the continued and sustained support of the Smart Grid Program.

In the attached report, the Committee summarizes its findings on significant, ongoing public benefits of the National Institute of Standards and Technology (NIST) Smart Grid Program. The Program's coordination of the first decade of standards development from generation through to the end-use customer has been effective in supporting smart grid technology commercialization. NIST has led the development of an architectural framework for the changing future of the electric power system. In coordinating standards development and international harmonization, the program has accelerated the development of standards for smart meters, grid communications, and inverters. The Institute's Smart Grid Framework has led to recognition of the power grid as a cyber-physical system. The Federal Energy Regulatory Commission has supported NIST's work to develop interoperability standards. And, the National Association of Regulatory Utility Commissioners has encouraged state regulators to utilize NIST's work on interoperability standards, guidelines on protecting consumer privacy, and cyber-security framework.

Today distributed, intelligent, and responsive technologies are accelerating the pace of change in the power system. It is clear that coordination of a framework of interoperability standards will remain essential in addressing these on-going changes in the power sector and maintaining U.S. leadership in power systems and technologies. The Committee's experience supports the proposition that no other entity in the United States – public or private – other than NIST has the experience, scope and ability to bring together the key stakeholders at a common table for a necessary and publicly important common outcome.

We appreciate your consideration of the Committee's findings.

Sincerely,

Paul Centolella
Chairman, National Institute of Standards and Technology Smart Grid Advisory Committee

NIST Smart Grid Advisory Committee

2019 Report

The electric power system is in the midst of one of the most significant transitions the Nation's energy infrastructure has seen. Multiple, profound technological innovations are underway in each segment of the system: the generation, transmission, distribution, and use of electricity. A sustained NIST effort is required to complete the development of a framework and interoperability standards for such a distributed and dynamic power system. **Failure to support such efforts will likely place the security, reliability, and resilience of the power grid at greater risk.**

The deployment of distributed energy resources, including combined heat and power, photovoltaics, fuel cells, and storage, has stretched generation far outside the confines of the traditional utility model. Transmission and distribution are experiencing extensive penetration of sensors that monitor the state of the system while two-way communication among functional elements of the power system becomes the norm. The operation of the power grid is starting to become more dynamic, flexible, and capable with introduction of cost-effective technologies for dynamic ratings, real-time power flow control, transmission topology management, fault isolation in distribution circuits, microgrids, and the use of advanced power electronics for grid control and conservation voltage optimization. New as well is the increasing options customers have to respond to power system conditions as a result of their exposure to increasingly real-time pricing information while having the tools in hand necessary to moderate their demand. Within the next five to ten years, a single distribution system may be integrating millions of distributed, intelligent, responsive customer systems including electric vehicles, building management systems, smart thermostats, appliances, distributed generators, and storage units.[1]

In a 2011 analysis of national deployments of smart grid technologies, the Electric Power Research Institute (EPRI) estimated that a smart grid, requiring investments of roughly $17-24 billion per year, could produce **net economic benefits of $1.3-2.0 trillion over a 20-year period**.

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[1] For Electric Vehicles, see Institute for Electric Innovation. 2018. *Electric Vehicle Sales Forecast and the Charging Infrastructure Required Through 2030.* Washington, D.C.: Edison Electric Institute; Bloomberg New Energy Finance. 2017. *Electric Vehicle Outlook 2017*. For Smart Buildings, see S. Kejriwal and S. Mahajan. 2016. *Smart Buildings: How IoT technology aims to add value for real estate companies, The Internet of Things in the CRE industry.* Deloitte University Press; S. Raschke. 2017. *IoT Enables Smart Building Technology for the Other 90%*. For Smart Thermostats and Appliances, see Wang, F. 2018. *Residential Flexibility Potential in the U.S.* New York, N.Y.: Wood Mackenzie. For Distributed Generation and Storage, see Vrins, J. 2016. *Take Control of Your Future, Part II: The Power of Customer Choice and Changing Demands.* Navigant Research; Wood Mackenzie Power & Renewables and Energy Storage Association. 2019. *U.S. Energy Storage Monitor*.

Investment in such a smart grid modernization program would yield a benefit-to-cost ratio of between 2.8:1 and 6.0:1.[2]

Equally significant, falling costs and growing public support of renewable generation will require a smart grid capable of integrating these technologies. A 69% decline in the unsubsidized levelized cost of wind and an 88% reduction in the unsubsidized levelized cost of utility-scale solar from 2009 to 2018 are making new wind and solar generation increasingly competitive with the operating costs of many existing fossil fuel generators.[3] Market research and polling commissioned by the Edison Electric Institute in 2018 found that 74% of the public thinks the country should be using renewables "as much as possible," and 70% believe that in the near future, 100% of our electricity should come from renewables like wind or solar.[4] In the same study, 51% of respondents believed that 100 percent renewables is a good idea even if it raises their energy bills by 30 percent. Accommodating such growth will require an increasingly smart and dynamic power grid.

A 2018 Pacific Northwest National Laboratory report highlighted the need for interoperability throughout the electric system from generation and delivery to the millions of customer devices that are being equipped with processing power and communications. The report described the multiple ways in which interoperability provides value in the power system:

> "**Interoperability has important economic consequences.** Systems that integrate simply and predictably have lower equipment costs and transactions costs, higher productivity through automation, better conversion of data and information into insight, greater competition between technology suppliers, and more innovation of both technology and applications. Those systems propagate faster, use resources more efficiently, and create more value for their users. Such systems consistently prove that interoperability standards and supporting integration mechanisms enhance user choices, because they create a framework within which vendors and their competitors can innovate to provide new products that deliver new functions that were previously unattainable or even unimaginable."[5]

The National Academies in their report, *The Power of Change: Innovation for Development and Deployment of Increasingly Clean Electric Power Technologies*, noted that "to ensure that grid

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[2] Gellings, Clark. "Estimating the costs and benefits of the smart grid: a preliminary estimate of the investment requirements and the resultant benefits of a fully functioning smart grid." *Electric Power Research Institute (EPRI), Technical Report (1022519)* (2011).

[3] Lazard. 2018. *Lazard's Levelized Cost of Energy Analysis, Version 12.0*.

[4] David Roberts, "Utilities Have a Problem: The Public Wants Renewable Energy, and Quick," Vox, October 11, 2018,https://www.vox.com/energy-and-environment/2018/9/14/17853884/utilitiesrenewable-energy-100-%-public-opinion.

[5] Widergren, Steven E., Mark R. Knight, Ronald B. Melton, David Narang, Maurice Martin, Bruce Nordman, Aditya Khandekar, and Keith S. Hardy. *Interoperability Strategic Vision*. No. PNNL-27320. Pacific Northwest National Lab. (PNNL), Richland, WA (United States), 2018.

modernization works effectively, secure interoperable standards are necessary. Efforts to develop standards and protocols to ensure that different systems and devices can communicate and operate with each other are being undertaken by the National Institute of Standards and Technology."[6] The Academy further identifies four activities that can accelerate innovation in energy technology: (1) simulating, (2) testing, (3) accelerating (or paralleling) the development of standards and specifications for related physical, information, and/or control architectures and implementation or integration templates, and (4) certifying products using appropriate proof-of-system test protocols.

This Committee concurs with the National Academies' assessment, and we find that the **NIST Smart Grid Program conducts a robust program of research, development, and innovation that help define the important relationships and technology standards that form the foundations of the Nation's future electric grid**. The Committee recommends this effort continue and expand in response to the accelerating pace of change in the industry. NIST's program has been influential in having the power industry and utility regulators plan and operate the grid as a cyber-physical system.

The Smart Grid program is supporting work in these four areas identified by the National Academies as necessary to accelerate innovation in energy technology:

- The *NIST Framework and Roadmap for Smart Grid Interoperability Standards*, now in its third edition with development of a fourth well underway, which is one the program's most significant contributions. Working with stakeholders and partners from industry, government, and academia, NIST has built an important framework and roadmap for smart grid interoperability standards; and
- The NIST Transactive Energy Modeling and Simulation Challenge for the Smart Grid (TE Challenge), which spanned from 2015 to 2018, identified simulation tools and expertise that might be developed or combined in co-simulation platforms to enable the evaluation of transactive energy approaches;
- The IEEE 2030.8 Standard for Testing Microgrid Controllers published in August 2018 ensures that these essential pieces of equipment enable the microgrid as a system that can manage itself, operate autonomously or in a grid-connected mode, and seamlessly connect to and disconnect from the main distribution grid for the exchange of power and the supply of ancillary services;
- The Smart Grid Program supported development of the 1588 power profile conformance test suite by the University of New Hampshire InterOperability Laboratory, which is used to certify performance of a product's ordinary and boundary clocks. The need for the new test suite was revealed by testing the Smart Grid Program did

[6] National Academies of Sciences, Engineering, and Medicine. 2016. *The Power of Change: Innovation for Development and Deployment of Increasingly Clean Electric Power Technologies*. Washington, DC: The National Academies Press, p. 187. doi: 10.17226/21712.

demonstrating the failure of eight commercial phasor measurement units for conformance to an IEEE standard for managing leap seconds.

The effort to coordinate and accelerate standards development needs to engage at a higher level of intensity. We envision this would entail a multi-sector partnership coordinated by NIST.

The Smart Grid program and its parent organization, the Smart Grid and Cyber-Physical Systems Program Office, are special within NIST in that they draw on expertise from across the breadth of the NIST organization, including the Engineering Laboratory, the Physical Measurement Laboratory, the Information Technology Laboratory, and the Communications Technology Laboratory. This integrating function of the Smart Grid program, we believe, is central to NIST's ability to play the distinct and important role it does in the Smart Grid ecosystem. Regulatory bodies have recognized this role. For example:

- The Federal Energy Regulatory Commission July 2011 Order Smart Grid Interoperability Standards Docket No. RM11-2-000: "…the Commission encourages 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";
- The National Association of Regulatory Utility Commissioners' July 2011 Resolution on Smart Grid Principles: "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 "There are many resources on privacy policies that will guide NARUC's efforts, including the NIST Guidelines for Smart Grid Cyber Security (NISTIR 7628)"; and
- The NARUC February 2010 Resolution regarding cyber security: "encourages commissions to regularly revisit their own cyber security policies and procedures to ensure they are in compliance with applicable standards and best practices, such as those of the National Institute of Standards and Technology."

With the increasingly complex information overlay on the grid, requirements for cybersecurity grow – and here the benefit of the multi-laboratory span of the Smart Grid program is clear. NIST's coordinating function, coupled with its multi-program span of expertise, is the basis for a holistic view of the electric power system as a cyber-physical system. This position enables them to influence the agendas of other agencies and industry, including for data privacy and cyber security. The Department of Energy's DataGuard Energy Data Privacy Program to protect data use by third parties is motivated by NIST 7628 Guidelines for Smart Grid Cyber-Security (2010). As an example of the continuing regulatory and industry use of NIST 7628, a June 2017 document from the Seattle Information Technology Department titled "AMI Privacy Considerations" notes that: "[Seattle] City Light relied extensively on the Department of Energy's Voluntary Code of Conduct for Data Privacy and the Smart Grid (VCC), and the National Institute of Standards and Technology Guidelines for Smart Grid Cybersecurity, Volume 2 (NIST

Guidelines) in the original development of the required Privacy Impact Assessment (PIA) as well as when completing the responses to the privacy suggestions above."

The NIST role in the development of the highly visible and widely successful Green Button initiative is emblematic of how we expect the Smart Grid program's contributions will continue into the future. In the Green Button case, delivering energy usage information to consumers with security and privacy built in was identified by NIST as a key strategic benefit early during the development of the first NIST Framework and Roadmap for Smart Grid Interoperability Standards as mandated by the Energy Independence and Security Act of 2007. In their case study of the 2011 Green Button initiative as an example of successful data disclosure policy, Sayogo and Pardo found that one of the major factors "that enabled the rapid implementation of Green Button in California is the availability of an industry standard to support Smart Grid development in the U.S."[7] Sayogo and Pardo point to NIST working with the Smart Grid Interoperability Panel to develop the industry standard format known as the Energy Service Provider Interface (ESPI) in support of Smart Grid development as an example of where government has a role as an identifier of opportunity.

The Committee is mindful of the importance of maintaining a balance of country participation in international standards bodies. For example, NIST's previous work demonstrated success in influencing international standards harmonization. NIST's convening power creates an important opportunity for industry participants to raise concerns should it become apparent that one country (or coordinated group of countries) is upsetting the balance of these standardization activities by gaining undue influence. We note, for example, that China's Green Belt and Road Initiative includes a long-term effort to transfer technical standards to recipient countries, China's significant investments in power system research and development, and the objective of the State Grid's China Electric Power Research Institute to be "the main formulator of standards for power grid technology."[8]

The Committee notes that the Energy Independence and Security Act of 2007 provides that, "The Director of the National Institute of Standards and Technology shall have primary responsibility to coordinate the development of a framework that includes protocols and model standards for information management to achieve interoperability of smart grid devices and systems."[9] The Committee finds that the Smart Grid Program has effectively executed this authority by working cooperatively with industry to coordinate the development of standards that have guided a decade of U.S. investment in grid modernization and a framework that has created opportunities abroad for U.S. technology. The Smart Grid Program is currently

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7 Sayogo, Djoko Sigit, and Theresa A. Pardo. "Understanding smart data disclosure policy success: The case of green button." In *Proceedings of the 14th annual international conference on digital government research*, pp. 72-81. ACM, 2013.

8 K. Sims Gallagher and Q. Qi, *Policies Governing China's Overseas Development Finance: Implications for Climate Change.* Medford, MA: The Fletcher School Tufts University; China Electric Power Research Institute at: https://sites.tufts.edu/cierp/files/2018/03/CPL_ChinaOverseasDev.pdf. (Downloaded May 19, 2019.).

9 Energy Independence and Security Act, Pub. L. 110–140, title XIII, § 1305 (42 U.S.C. 17385).

completing an update to its Interoperability Framework and Roadmap that reflects the significant developments in grid modernization occurring in the last five years.

As the power system continues to change from a largely centralized to a distributed architecture, the requirements for coordinating the further development of interoperability standards for the grid are expanding. The Committee believes that the NIST Smart Grid program, with its broad view of cyber-physical systems across multiple domains, multiple disciplines of technical expertise, relationships with standards setting organizations, and unwavering focus on developing standards that can improve the efficiency, reliability, and security of energy systems, has positioned NIST so that the agency remains an essential contributor to power systems standards development and vital to the future of the Nation's power system.