National Institute of Standards and Technology
Smart Grid Advisory Committee
Summary Discussions – July 2016 Meeting

This report summarizes discussions at the meeting of the National Institute of Standards and Technology (NIST) Smart Grid Advisory Committee (SGAC or Committee) for on July 13-14, 2016, in Gaithersburg, Maryland. The meeting agenda set aside time for general discussion on two key topics — "Role of the Electric Sector in Community Resilience" and "Grid 3.0 Drivers for Change and Architectures for Interoperability." During those discussions, and throughout the rest of the meeting, committee members made a number of comments on a wide variety of smart grid topics. Because the wide-ranging discussions touched on a number of issues, those comments have been captured, grouped, and synthesized under the key topic headings found below.

The role of NIST Smart Grid Advisory Committee is to provide input to NIST on the smart grid standards, priorities, and gaps—and on the overall direction, status, and health of the smart grid implementation by the smart grid industry—including identification of issues and needs. With this report, the Committee is providing strategic input to NIST on emerging issues that will drive significant change over the next five to ten years.

Rapid Pace of Change in Industry

The changes now being experienced in the electric industry are not merely transitional—they are transformational. The transformation is happening at a quickening pace, faster than many had anticipated even just a few years ago. The electric industry, which used to change slowly, is now transforming so quickly that "industry scares us with the speed at which they are changing."

Within the industry, some organizations are embracing the changes, while others are taking a more "wait-and-see" approach. In addition, organizations not traditionally considered part of the electric industry are getting involved, are taking risks, and may introduce disruptive technologies and business models that radically change the shape of the industry. The Committee urged NIST to be cognizant of and interact with the full spectrum of stakeholder organizations across the sector.

Several committee members expressed the view that NIST may need to move faster and be more agile to keep pace with industry. As a result, members urged NIST to focus, look beyond normal boundaries, and maintain close interactions with industry.

Consumers as a Driver

A key driver of industry transformation is increased customer/consumer/citizen engagement at all levels—individual, commercial, industrial, and governmental. Important trends driven by increased customer choice include greater use of renewables, greater customization, a desire for greater resilience, and a desire for greater energy autonomy and self-management. All these trends introduce challenges and the need for changes, especially at the distribution level. The

Committee recommended that NIST should facilitate information exchange and collaborative planning between consumer and third party assets and utilities.

Examples cited by committee members include the following:

- At the individual level, especially in certain geographic areas (southern California and Hawaii were mentioned several times), increasing adoptions of rooftop solar and electric vehicles introduce significant challenges at the distribution level (e.g., variable loads, visibility of assets, planning).
- At the commercial level, some "big-box stores" are increasing the percentage of renewable energy in their energy footprint. Some office towers are realizing significant energy savings by "pre-cooling" the building several degrees when electricity rates are lower. For some small businesses, who have not in the past been thought of as "critical loads," energy costs and reliability are among their most critical concerns.
- At the industrial and campus level, some organizations are "greening themselves," putting a major focus on sustainability, climate change, and resilience. Among technologies being considered, microgrid technology is of special interest to these organizations.
- At the governmental level, some states (e.g., New York, California, and Hawaii) are using legislative and regulatory processes to drive change. At a more local level, "community choice aggregation" is allowing communities to take greater control over their energy footprint.

New Technologies as a Driver

Recently introduced new technologies, as well as those still being pioneered, are dramatically changing the landscape and are requiring the need for new architectures, especially at the distribution level. Power supplies are becoming increasingly decentralized, and there is a proliferation of new technologies at the grid edge. New layers/levels of control, with escalating complexity at each level, are creating new challenges for those organizations—including NIST—trying to understand the big picture.

Accompanying the growing complexity of the distribution system, there will be associated challenges for control, automation, and optimization. The evolving distribution system will have many more end points and generators, far more dynamic load, a consistently morphing topology, and issues with real and reactive power that have to be accounted for. This makes distribution operations far more complex than ISO operations. Because of these challenges, operating a DSO the same way as an ISO works (e.g., through dispatch) is computationally intractable.

Among the important new and emerging technology trends and their characteristics discussed by committee members are the following:

- Electric vehicles and EV charging—very significant adoption in some geographic regions and by some demographic segments, including through short-term rentals, is contributing to greater variability in local loads
- Rooftop PV solar—costs keep dropping, nearing saturation in some regions, can create problems for utilities wanting/needing to have visibility over all assets in the system,

current rate designs may not be adequate, and approaches that can match price with the value provided by various elements of the overall system are needed

- Smart inverters—rapid introduction, with California as a leading example
- Microgrids—increased interest because of issues such as resiliency, smart cities, and distribution management
- Battery storage—costs keep dropping, could lead to new business models (especially when combined with rooftop solar)
- Buildings—being used for energy storage, increasing number of net-zero and high-performance buildings
- Smart meters—now with over 65 million installed nationwide, a source of useful data that is not yet well understood or developed
- New sensors—another source of big data that will bring new analytical opportunities and challenges; how can sensor, meter, and other data from the grid edge be integrated, aggregated, and "mashed-up" to provide useful new information (e.g., PMUs and fault detection); using sensors (rather than "instrumenting the grid") can be more cost effective
- IoT devices installed behind the meter—how can they be recognized (e.g., auto-discovery) and accounted for (e.g., "visibility" issue); this trend is also bringing new players into the energy sector
- Distribution-level automation and controls—tools and technologies from the transmission domain now being introduced to the distribution domain (e.g., distributed energy resource management systems, also known as DERMs)
- Standards—in the smart grid area, there are many, many small players; they don't have the money for the more expensive standards and that is limiting.

The integration of these new technologies at the distribution level is a subject of great interest and concern. As a result, a number of new ways of doing business are being proposed and are under consideration, including the following:

- Distribution system operators (DSOs)—a foundational element of the State of New York's "Reforming the Energy Vision" process (NY REV), also increasing in California, will require new grid architectures
- Need for new architectures—grid will be controlled very differently in the future (e.g., autonomous control of voltage, frequency, and other aspects of power flow)
- Grid as platform—platform economics create a larger ecosystem (connecting different providers and customers) that facilitates other products and allows new players to enter market; platform connects new services in new ways and will require new types of information exchange
- Partnerships between utilities and other organizations—provides a way for utilities to adapt and evolve in new environments; raises new issues related to contracts, collaborative planning, and regulation
- Transactive energy—of great interest to some, but still in very early stages; poorly understood by many; may provide customer choice and customization without jeopardizing grid; an area where NIST smart grid program is playing a leading role

There are several important international aspects to new technologies as a driver:

- Developing countries will require sustainable energy technologies in order to play their critical role in the global issue of climate change. As one member said, "smart grid has to be for the world, not just developed countries."
- Because of the lack of legacy systems, some international countries are effectively "green fields" and accommodate rapid innovation cycles. In the future, there may increasingly be more "reverse innovation," where innovative technologies are developed abroad and then introduced to the United States.

Resilience,[1] Trustworthiness,[2] and Cybersecurity[3]

These three subjects are grouped together in this report, because they contain some overlap.

The Committee listened to a presentation—"Resilient Infrastructure: Context, Functionality, and Dependencies"—by Dr. Therese McAllister, Manager, NIST Community Resilience Program.

In the discussion about resilience that followed the presentation, the committee members made the following observations about resiliency, trustworthiness, cybersecurity, and the smart grid:

- Going forward, it will be important for NIST to coordinate efforts on community resilience, smart grid, and smart city.
- Interdependencies between different sectors (e.g., between electricity and gas, or electricity and transportation) are very important.
- Resiliency must be considered at many different levels/layers. Systems thinking is important in considering strategies for resilience.
- In the modernized grid, privately owned organizations will play an important role in the overall grid (e.g., microgrids, DER). There must be collaborative planning conversations between these organizations and utilities. Because of liability issues, it will be important to get commitments in advance from these privately owned organizations to make well-maintained resources available. (This is another reason why utilities need to have visibility over assets in the system.)
- Distributed energy resources (DER) can have real value with respect to resilience. Key questions include: How can these be appropriately valued? What kinds of incentives will encourage owners of DER to assist in case of emergency?
- Partnerships can work better than contracts (MOUs, options, etc.) in many situations, because both parties have "skin in the game."
- With respect to "critical infrastructure," there are many different perspectives on what might be considered "critical." It will be important to consider optimization functions on many different levels.
- Similarly, with respect to "critical loads," there are many different perspectives on what might be considered "critical."

[1] "Resilience," as defined in NIST's "Community Resilience Planning Guide for Buildings and Infrastructure," is the ability to prepare for anticipated hazards, adapt to changing conditions, and withstand and recover rapidly.
[2] "Trustworthiness," as defined by the CPS Public Working Group's "Cyber-Physical Framework," includes security, privacy, safety, reliability, and resilience.
[3] "Cybersecurity," as defined by NIST's "Glossary of Key Information Security Terms," is the ability to protect or defend the use of cyberspace from cyber attacks.

- What lessons about resiliency can be learned from other sectors (e.g., health care or finance)?
- What metrics can be developed for resiliency?
- It is important to consider resilience from a larger geographical perspective than just the perspective of a single community. What is the capacity for resilience within regions of the country?
- For the electric industry, the biggest risk is a major cyber intrusion (e.g., an attack that could result in electricity outages lasting months). To be better prepared ("we are currently unprepared"), it will be important to identify a team of experts across all industries—a cyber SWAT team. This "human capital" must be able to be mobilized quickly and effectively.
- It is very difficult to discern NIST's recommendations on the cybersecurity framework; it is 200 pages and is unclear about specific recommendations.
- When considering communications in real systems, it's important to remember that communications (e.g., timing, latency, etc.) may be poor. It may not be possible to move large amounts of data quickly.
- As the electricity industry adopts new and different models and/or architectures (e.g., DSOs, connected microgrids, or transactive energy), how will these provide a different way to look at resilience?

Testbeds, Modeling, and Human Factors

As the grid is modernized in response to the drivers described above, many new elements are being introduced, leading to much greater complexity. To understand this increased complexity, it will be very important to use testbeds, modeling, and simulations. The Committee believed that this is an area where NIST can play an important role.

The grid-as-platform has a stream of values (attributes), and it is important to do a much better job of describing them, characterizing them, and explaining them to others (including regulators and consumers). The Committee recommended that NIST support this area of modeling as well as education especially for regulators.

An important new element that must be incorporated into modeling for the smart grid is the human factor. This is an area where NIST has begun building its capacity. The increased role of consumers—and their priorities and decision-making processes (i.e., behavioral economics)—must be included in the modeling and simulation work. For example, can user models and scenario planning help us understand how best to align local optima with global optima in a transactive energy environment?

The work that NIST has begun in transactive energy modeling and simulation is very important and timely. It has been challenging (and slower than anticipated) to help various stakeholders develop a common language so testbeds can be integrated and/or federated.

While stressing the importance of systems thinking, modeling, and simulations for NIST research, committee members added some important caveats:

- Modeling must be validated, using real system data whenever possible.
- Uncertainty modeling is essential.
- Modeling and testbeds are tougher than anticipated; don't expect results overnight.
- Designing and working with different architectures is very important but also very challenging.
- Don't underestimate the complexity of controls at the distribution level.
- It is essential to choose questions wisely and systematically, with an emphasis on careful experimental design.
- Include social equity (e.g., vulnerable populations, small businesses) as a concern.

Business Models, Markets, and Regulation

As the grid is modernized, aspects of the business models, markets, and regulations of the last several decades are becoming increasingly outdated. The committee members highlighted a number of areas where changes and innovations are urgently required. Although changes have begun in some regions and with some organizations, the breadth and pace of innovation must quicken.

Among the needed changes and emerging trends related to business models and markets are the following:

- Rate design—current rate designs are inadequate; the rapid growth of rooftop solar and electric vehicles is not handled well by current rate structures (e.g., the "net metering" issue).
- Grid attributes and associated values—The grid has a stream of various attributes (e.g., reliability, voltage stability, balance of active and reactive power). If the values associated with these various attributes could be unbundled from today's bundled rates, then more rational and equitable rates could be designed. This is an urgent need.
- Time-of-day variability in true prices is not handled well by today's rate designs.
- Transactive energy approaches may be useful in the future, but they are still in their infancy at the distribution level. ("Transactive energy is arriving just in time.")
- Customization (i.e., meeting diverse needs of different consumers through customized solutions) must be an important consideration in new business models.
- With more stakeholders/organizations/players expected to be involved at the distribution level, there is a need for more collaborative planning.
- As new technologies are introduced (e.g., lower-cost battery storage), a number of new business opportunities will arise.
- New players may bring new business models and new approaches for using existing and new infrastructure. Examples of how other sectors have been disrupted and changed by new models include Uber, AirBnB, Netflix, and Google.
- The wholesale market (ISO) and the distribution market (DSO) are very different. Nonetheless, some lessons and approaches from the wholesale market can be usefully applied to the distribution market,
- There is a need for coordination across wholesale and distribution markets.
- Because of the diversity in states' and regions' approaches to markets and regulations, there will be a diversity in business models from state to state and from region to region.

- It is critical to consider business models as the context for scientific solutions.

Regarding regulators and the regulatory process, the following issues were raised:

- Regulators can be a barrier to innovation or an enabler of innovation and new opportunities.
- The NY REV process is an example of how regulators and the regulatory process may bring many opportunities for innovations.
- Many regulators are seeking better insights into the scale and pace of the transformations now under way (i.e., “Grid 3.0”).
- There is a strong need for educating regulators. NIST can play a role in this process, using its experience as a convening authority.
- What is the role of NIST in the development of new business models in the Grid 3.0 world? NIST can serve a convening function and bring together stakeholders working on these issues
- An important question raised by the Committee centered around the changing role of regulators in the future. (As a comparison, the role of regulators and regulation has diminished over time in the telecommunications sector.)

NIST Roles in Convening and Research

The Committee discussed two different roles played by NIST: as a convener (i.e., bringing together stakeholders on neutral ground to discuss important issues) and as a research institution with a focus on measurement science.

Committee members felt that these two roles, while sometimes in tension with each other, are each very important.

As a convener, NIST has the leveraging authority to encourage people voluntarily and through consensus mechanisms. However, there can an inefficiency in the process if the stakeholder participation process becomes so time-consuming that senior people with great expertise and experience are unable to continue participating. NIST should continue to find ways to access and leverage these senior experts (e.g., tiger teams, “technical champions,” resilience fellows).

As a research organization, it is important that NIST be able to take risks, even though some failures will be experienced whenever risks are taken. A “portfolio” approach to research projects can ensure that both short-term and long-term projects/goals are addressed.

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