The Opportunity and Peril of Smart Grid

*By Ray Gifford & Eric Gunning**

Last year witnessed "the smart grid" going from an arcane concept about updating the electric distribution system to a full-fledged public policy priority. The Obama Administration views the deployment of smart grid technologies as a linchpin to achieving its new energy economy objectives. These goals include: lowering energy costs for consumers, achieving energy independence, promoting clean and green technologies, and reducing greenhouse gas emissions. To that end, Congress allocated approximately $4 billion in stimulus grants and loans to smart grid deployments and tasked the National Institute for Standards and Technology ("NIST") to develop smart grid interoperability standards.

While smart grid deserves some of the hype that it has received, the reality of smart grid deployment is much more fraught. For smart grid deployment combines familiar challenges of information technology and communications network deployment—standards and interoperability problems, intellectual property issues, and privacy and security—with regulatory issues—prudent investment, rate design, competitive, and monopoly aspects of the service. In turn, this not quite harmonious stew of issues interrelates to present challenges to utilities, information technology vendors and regulators. How these challenges are answered will decide whether smart grid delivers the energy-saving, market-enabling efficiencies that proponents' promise, or if it becomes an industrial policy boondoggle where costs exceed the benefits.

The remainder of this article discusses the major policy issues facing smart grid deployment.

I. What is the Smart Grid?

'Smart Grid' is a general description encompassing distinct components of the electricity distribution network. Analytically, the electric system can be divided into three components: generation, transmission, and distribution. Generation involves just that, generation of electricity from central station power plants. These sources can be coal, nuclear, natural gas, or renewable resources. From there, the electricity is transported over the transmission system, which is an interconnected series of high voltage power lines.[1] In turn, the distribution system takes high voltage power into substations, steps down the voltage and delivers it to consumers.

This is a highly abstracted description of the electric grid system but will suffice for this discussion. The smart grid, for the most part, involves the final part of the grid—the distribution system. "Smart grid" involves creating robust communications paths between end-use consumers (industrial, commercial, and residential users) and upstream to the utilities, or other energy service providers. This communication path, in turn, can be used to manage and monitor voltage and the "cleanness" of power, communicate price to consumers, and customize energy management and usage by consumers.

Each of these smart grid capabilities promises potential benefits to consumers. Better monitoring and control of the distribution system increases reliability. Utilities can know and anticipate where outages occur or where transformers are stressed to the breaking point. In addition, "cleaner" power in the distribution system means less power needs to be generated in the first place.

The ability to communicate price in real-time (RTP) or time-of-use (TOU) promises increased efficiency and conservation. Currently, the vast majority of consumers pay for electricity on an averaged cost basis—an electron used at 4pm is priced the same as one consumed at 4am for the retail customer. Meanwhile, the underlying wholesale cost of generating that electron varies greatly depending on the time of day. During "peak demand," wholesale electricity prices can be five or ten times higher than "off peak" prices. Because there is no price incentive for consumers to conserve during peak demand periods[2] and utilities have a regulatory duty to meet demand, a substantial amount of investment must go to plan and build infrastructure to meet these peaks. Smart grid then, by communicating price to consumers, promises to "shave" energy demand during peak demand times. In turn, this should bring savings to consumers and the electric system by eliminating the need to build generation to meet demand peaks.

Smart grid then is very simple and very complex. It is simple because it involves creating communications paths on the distribution system where consumers have transparency into prices and generation mix; and where distribution operators have more information about demand and system status. It is complex because the architecture and regulatory treatment of this communications path presents many questions.

We turn to those now, beginning with standard setting:

II. NIST Interoperability Roadmap and Standards-Setting

On January 20, 2010, the National Institute of Standards and Technology (NIST) published its "*NIST Framework and Roadmap for Smart Grid Interoperability Standards, Release 1.0*." This report is the culmination of Phase I of NIST's three-phased approach for complying with the congressional mandate to coordinate development of interoperability standards for Smart Grid under the Energy Independence and Security Act of 2007 (EISA). From here, Phases II and III of the approach will be delegated to the newly-created Smart Grid Interoperability Panel (SGIP). This panel will be charged with refining proposed standards and developing new ones as the industry progresses.

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Briefly, the NIST Report:

- Identifies seventy-five existing interoperability standards that are applicable or likely to be applicable to Smart Grid;
- Specifies fifteen high-priority gaps and another fifty-five lower-priority gaps for which standards need to be adopted, receive industry consensus and NIST (or SGIP) approval;
- Establishes priority action plans to address and resolve the identified high-priority gaps;
- Introduces a Smart Grid conceptual model to create a common language for discussing the complex "system of systems"; and
- Passes the baton to the SGIP, a public-private partnership comprised of over 400 members and twenty-two stakeholder groups, to implement Phase II of the NIST interoperability plan which includes, providing a permanent process to "support the ongoing evolution of the Smart Grid Interoperability Framework, identify and address additional gaps, reflect changes in technology and requirements in the standards, and provide ongoing coordination of [standard setting organization] efforts to support timely availability of new or revised Smart Grid Standards." In addition, SGIP will also be responsible for Phase III: Smart Grid device conformity assessments and testing to ensure interoperability.

The issuance of the NIST report closes out on a frenetic year for the federal government in its efforts to spur development and deployment of Smart Grid technologies. These efforts included $3.4 billion in DOE grants awarded in October 2009 as part of the American Reinvestment and Recovery Act of 2009 (ARRA). Whether these efforts will actually catalyze real and substantial growth in Smart Grid remains an open question, and it may be many years before we can assess their success or failure. This determination with respect to NIST's efforts to "solve" interoperability will hinge on a number of practical, legal, and business issues, some of which are outlined below:

A. Federal-State Jurisdictional Issues.

The federal government has some laudable goals with respect to standard setting and spurring Smart Grid deployments. But its jurisdictional authority over the energy markets is more constrained. Through FERC, the federal government can only mandate standards for interstate transmission. It does not have authority over generation, middle-mile and last-mile distribution, or in-home energy management. Therefore, any federal standard setting efforts beyond interstate transmission must rely on condition-laden federal grants and loans (see the DOE grant program), fostering industry adoption (see the SPIG program) and pressuring/encouraging state regulatory commission to buy in. On the last point, there is no guarantee that state regulators will support the federal efforts. State regulators may even bristle on what are perceived to be federal intrusions into state regulatory turf. Standards adoption in large part will therefore depend on states' willingness to mandate NIST standards in state Smart Grid deployments.

Significantly, then, the federal push for standards rests on the hortatory ability of NIST, DOE, and FERC to convince the states and utilities that the federal standards should be followed, or in utility law parlance, would constitute "reasonable and prudent" investments.

B. Preventing Stranded Investments.

NIST's standard setting efforts must avoid, if possible, stranded investments in incompatible technologies. While the over 100 demonstration projects being deployed through the federal stimulus efforts all must incorporate NIST standards, there are hundreds more AMI (automated meter infrastructure) deployments that predate the Smart Grid push. It is inevitable that certain utilities will have deployed non-compliant technologies.

State regulatory commissions will have to face the unenviable task of deciding whether to: (a) allow ratepayers to assume the costs of the utilities' replacement of the stranded technology, or (b) allow the continued use of technologies that are not NIST-standard compliant and thus allow continued use of stranded technologies that will not be supported. Moreover, any utilities seeking cost recovery for AMI or other Smart Grid deployments that are NIST-standard compliant may face significant push-back from the state commissions.

C. What If NIST Gets It Wrong?

Mandating standards is always a tricky endeavor. If NIST focuses its efforts on bolstering a standard that turns out to be deficient or a subpar standard, the federal efforts may have the perverse effect of retarding innovation. It is not clear how nimble NIST and its Smart Grid Interoperability Panel will be in responding to these developments and being able to shift approved standards midstream.

D. Picking Winners and Losers.

Although NIST claims that its standard setting efforts are technology agnostic, there will invariably be winners and losers based on the standards NIST endorses. Again, these winners and losers may not be based entirely on merit but on business decisions regarding technology development, or on political economy factors having very little to do with the underlying technology.

For example, there has been a significant push by technology companies to ensure that Internet protocol (IP) standards are incorporated into the NIST-approved standards. Taking the cue, the NIST includes the IP suite as potential standards and defers to the Internet Engineering Task Force (IETF) to identify the suite of protocols applicable to Smart Grid. Adopting IP will benefit existing technology providers in the Internet space and allow quicker integration to other technologies and sectors. In addition, IP does provide a number of benefits; notably, it is a mature standard with widespread adoption, it enables bandwidth sharing and quality of service measures, and it is easily scalable. NIST also strongly suggests the adoption of IPv6 (as opposed to IPv4) in developing Smart Grid standards. And yet, non-IP-based standards vendors and advocates raise security concerns about IP-based infrastructure because its very pervasiveness makes it more vulnerable.[3]

E. Privacy Issues.

The NIST report accurately noted that privacy, including the collection of energy consumption data from consumers and the ownership of such data are issues of significant concern to state regulators. As the state regulators strive to enact rules on these issues, it is possible that these decisions will negatively impact the standard setting efforts. This could occur if there is a disconnect between state privacy and ownership rules and the standards regime adopted at the federal level. Although the National Association of Regulatory Utility Commissioners (NARUC) adopted the "Resolution Urging the Adoption of General Privacy Principles for State Commission Use in Considering Privacy Implications of the Use of Utility Customer Information," it is unclear how state regulatory commissions will respond or, as noted by the NIST report, whether state regulatory commissions have statutory authority to make privacy rulings.

With respect to standards setting, the Smart Grid industry is still in its infancy, with a number of hurdles to overcome before it has a comprehensive set of standards that will enable interoperability, plug-and-play interoperability, and stability. The NIST report constitutes a huge initial step—it is hoped—in the right direction.

III. Federal and State Tensions and the Role of the State Governments

The federal smart grid push (through the NIST interoperability mandate) and the $3.4 billion smart grid stimulus package in American Recovery and Reinvestment Act of 2009 ("ARRA") has created tension between federal and state regulators as the majority of the regulatory, cost recovery and policy issues related to grid modernization will occur at the state level. While the Federal Energy Regulation Commission ("FERC") regulates the wholesale energy markets and interstate transmission, state regulatory commissions have jurisdiction over public utilities and intrastate energy distribution and generation. FERC's and NIST's federal authority with respect to standards therefore can only directly impact interstate transmission, not distribution, the last mile, or home area networks, all of which are within the purview of the states. Therefore, the success of smart grid depends in large part on the actions taken by state regulators with respect to, among other things, cost recovery of smart grid investments, market structure, competitive issues, and establishing dynamic retail energy pricing (a necessary component of demand response). Despite the significant role of state regulators, they have been noticeably underrepresented in many smart grid policy discussions and debates.

This is problematic because the states are going to have the primary role in approving smart grid investment.[4] Significantly, state regulators will evaluate:

– Cost recovery and prudent investment tests for utilities' deployment decisions of smart grid technologies;

– Revising the regulatory structure for utilities to more closely align utilities' incentives with smart grid benefits. This could entail decoupling the utilities' profits from the amount of kilowatt-hours (kWhs) consumed and shifting to another regime that compensates utilities for adopting energy efficiency measures, akin to price cap regulation used to regulate telecommunications;

– Dynamic pricing and retail rate structures that enable, among other things, variable retail pricing based on wholesale energy prices;

– Ownership and sharing of customer data generated as a result of the smart grid; and

– Competition issues such as interoperability, unbundling, market regulation and electric network neutrality.[5]

Although it is the Obama Administration's clear belief that grid modernization is a key component to many of the country's energy problems, state regulators will actually need to evaluate the value to energy consumers. Simply put, the benefits of smart grid must prove to be greater than the costs of building out this new communications path. This is public utility law 101—investment in the smart grid must show itself to be reasonable and prudent. And that cost/benefit equation may have different answers in different utility systems.

The federal promotion of smart grid creates tension with states, as it is the state commissions that will be asked to approve utility expenditures on projects partially funded by federal stimulus dollars. Moreover, state regulators may perceive the federal efforts as an attempt to usurp some of the state powers with respect to the prudence of grid investments, interoperability mandates, and grid management.

IV. Network Design and Market Structure

Despite stimulus funding and the rush to develop interoperability standards, significant questions remain regarding what is "smart grid" and what the grid of the future will look like. Debates are ongoing regarding whether the utility grid should have intelligence at the core, be based on an end-to-end architecture similar to telecommunication networks, or take on some hybrid architecture. It is likely that utilities will prefer having the control, intelligence, and innovation located within the core of their networks, as opposed to the edge of the network. This is because utilities' current regulatory model rewards it for increasing the costs of providing electricity by investing in infrastructure, as opposed to seeking efficiency-enhancing benefits from innovative products and services provided over the network. Conversely, IT vendors such as Cisco and IBM favor more intelligence at the edge with Internet protocol being their preferred communications protocol. For now, the regulatory model pushes toward utilities increasing their capital stock, and controlling the communications path and network attachment. Until regulatory institutions like price caps or other efficiency-encouraging regulatory plans are instituted, the distribution utility will seek to control the smart grid communications path.

In addition to network design, the smart grid industry is puzzling over answering the question: What is the business case for smart grid? For example, demand response depends on solving a number of problems: (a) creating incentives for customers to participate through price or other signals; (b) establishing the appropriate regulatory regime regarding market structure, privacy, etc.; and (c) identifying the "killer application" that will ultimately spur demand response. Beyond demand response, near-term success of grid modernization efforts could probably focus on grid optimization and efficiencies, an area where existing broadband networks could play a role by serving as the middle-mile communications network for the utilities.

For now, no one knows what the smart grid business model looks like. Utility rate design historically biases toward average cost pricing; smart grid makes real time, marginal cost pricing possible. Utility cost recovery biases toward increasing capital stock and selling more electrons; smart grid, if built on existing broadband systems at the least cost, should mean fewer electrons are sold and lower utility capital stock. Utility cost recovery encourages integration forward into the home for energy management; smart grid enables modularity and unbundled access where consumers have more choice of providers, energy management systems, and can monetize their own data.

IV. Conclusion—"Smart Enough Grid"

The core challenge of smart grid is a regulatory one. At the initial level, smart grid is the not-so-simple, but done-before construction of a communications path across the electricity distribution system. At the deeper level, smart grid unsettles the current cost recovery, pricing and business model of distribution utilities. Further, the benefits of smart grid are not uniform across all electric systems, and smart grid must satisfy cost/benefit criteria before regulators are going to authorize cost recovery. There remains great promise to smart grid—its market-making, efficiency-enhancing, and consumer-empowering possibilities are real and profound. In the end, smart grid transformation will have to be an evolution where "smart enough" solutions are tried, and missteps have to be tolerated.

Endnotes

1 The interconnectivity of the transmission grid varies across the nation, and it is not a single, interconnected national grid. The East, West, and Texas constitute separate interconnected transmission grids. Interconnection between these grids, which operate at different frequencies, can only be accomplished through a direct current (DC) tie.

2 In most parts of the country, the peak demand occurs during the summer when demand for cooling is at its greatest. As air conditioning becomes more pervasive, utility summer peaking issues have become more acute.

3 This is exactly the same phenomenon as affects computer platforms. The Windows OS systems face more security threats than, say, a Mac OS or Linux system, in part, because there are so many more machines running Windows. In turn, virus and malware attacks are more likely to focus on the most pervasive platforms because they have more potential victims.

4 Though there are exceptions, state public utility/public service commissions regulate the natural monopoly distribution systems of investor-owned (private) utilities. Publicly owned distribution systems exist in many parts of the country, and rural America is usually served by user-owned distribution co-operatives. Public power and co-operative distribution systems do not usually face a state regulatory approval process for investments like smart grid. That said, investor-owned utilities serve the largest number of customers in the country and stand to gain the most from smart grid investment. Accordingly, the state commissions remain the most important institutions that will evaluate the prudence of smart grid.

5 For example, in Colorado PUC Chairman Binz's comments at a Gridweek conference in September 2009, he specifically indicated that in approving Xcel Energy's SmartGridCity project, he was very interested in privacy; data ownership; market structure (whether utilities would be able to provide services in the home); unbundling of the meter; interoperability and network neutrality issues. *See* Comments of Chairman Ron Binz, Colorado Public Utilities Commission, GridWeek, State and Local Collaboration: Enabling a Recipe for Success Panel, September 22, 2009.