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The Smart Grid: Frequently Asked Questions for State Commissions

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Introduction

The electric transmission and distribution system is on the verge of a transformation that may integrate some of the network capabilities of the information technology sector with the traditional electricity delivery capabilities of the existing transmission and distribution grid. Called the "smart grid," this advance in the electric system promises improvements in how we deliver and use power. Commissioners, companies, customers, and other electricity-sector stakeholders are asking questions about the smart grid – what it is, what it can do, what value it brings, and what potential pitfalls should be avoided when considering moving forward. This frequently asked questions (FAQ) factsheet seeks to explore some of these questions and provide brief answers.

What Would Make the Grid a "Smart" Grid?

For the purposes of this factsheet, the smart grid takes the existing electricity delivery system and makes it "smart" by linking and applying seamless communications systems that can:

- gather and store data and convert the data to intelligence;
- communicate intelligence omnidirectionally among components in the "smart" electricity system; and
- allow automated control that is responsive to that intelligence.

What Are its Components?

The components of the electric grid, and the ways that smart grid technologies and activities are integrated into it, are depicted in Figure 1, below. The diagram distinguishes between the generation bulk transmission side of the system, the distribution elements of the system (up to the customer meter), and the appliances and devices in the consumer's home, business, or facility. As will be discussed later, the predominance of smart grid systems are likely to be deployed on the distribution system and on the end-user side of the meter.

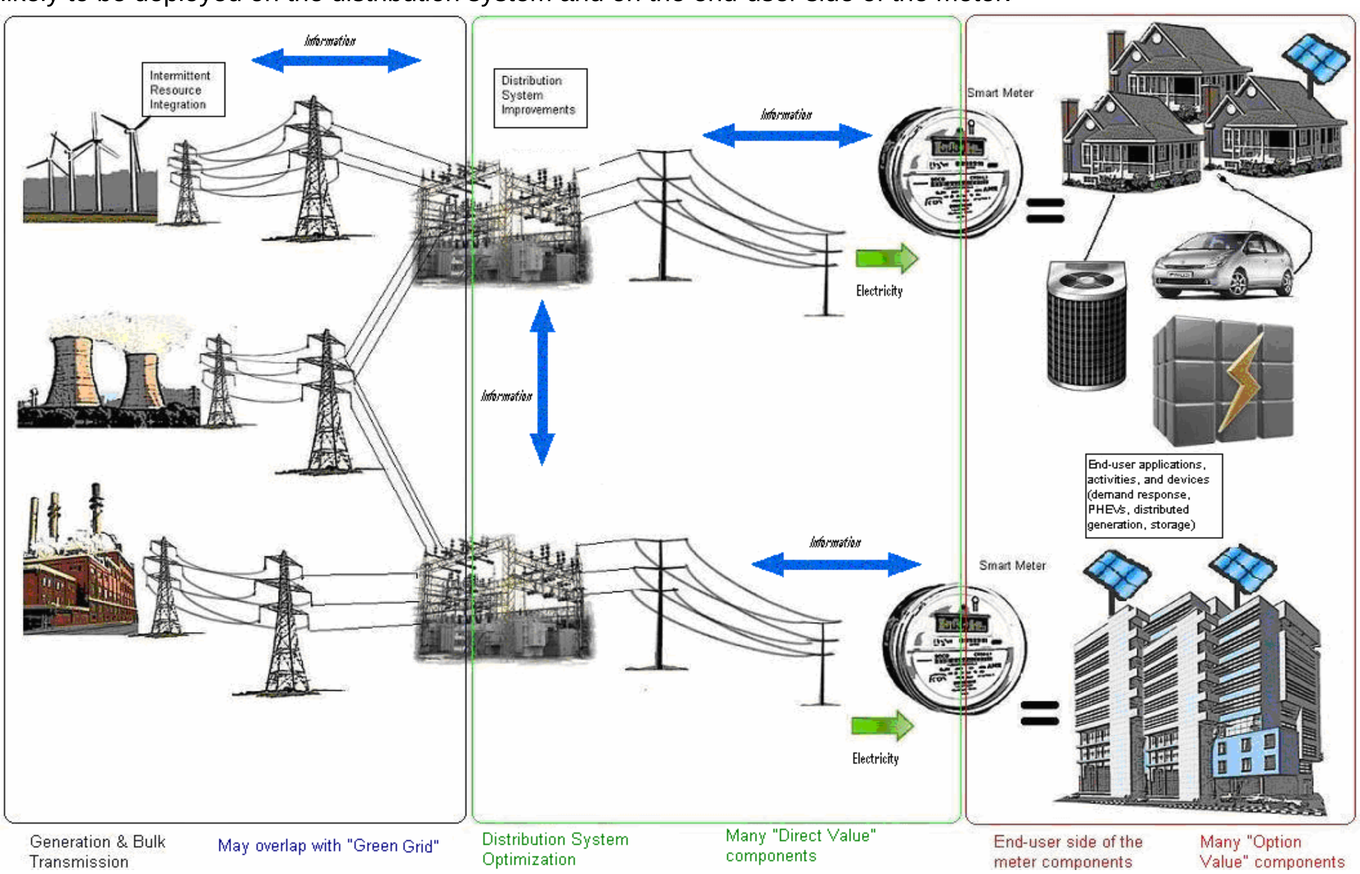

Figure 1. Smart Grid Components.

In *The Smart Grid: An Introduction*, the Department of Energy notes five technologies that will drive the smart *grid*:

- Integrated communications
- Sensing & measurement technologies
- Advanced components (superconductivity, storage, power electronics & diagnostics)
- Advanced control methods
- And improved interfaces and decision support

What Are Applications of the Smart Grid?
End-use applications such as automated demand response, use of on-site storage and generation, and smart charging of plug-in hybrid electric vehicles (PHEVs), are often the first that come to mind when discussing smart grid. Smart meters, price-sensitive "smart" appliances, energy storage, and distributed generation are the components of these applications. While these are potentially important customer-side applications, some of the highest value applications are likely be on the distribution system-side. One of the highest-value early-stage smart grid applications is system visualization, using networked systems to allow system status monitoring to occur. Currently, for example, outage management is often triggered by a call from a customer who has lost power. With system visualization, outage management does not depend on customer outage reporting, and in some cases can report overhead vegetation contact before a tree actually falls on the line. More importantly, once you can see how your system operates, you can better optimize its performance, for example, through transformer and conductor overload detection, volt/var control, phase balancing, abnormal switch identification, and a host of ways to improve peak load management. Distribution automation will allow for more efficient use of the electric distribution system, and may lead to highly resilient systems able to route around trouble spots in emergencies. Finally, on the transmission system side, better visualization of system status allows for improved integration of intermittent resources like wind and solar. So, while the smart meter may have become the "poster child" for the smart grid, advanced sensors, synchro-phasors, and distribution automation systems are examples of equipment that are likely to be even more important in harnessing the value of smart grid.

What's the Difference between Smart Grid and Green Grid?
An Interstate "Superhighway" Transmission System Connecting Renewables and Supporting Policies are Not Necessarily the Smart Grid: Some have called for the development of a nationally-funded and federally-regulated Extra High Voltage transmission grid as an overlay to the existing transmission grid, connecting remote areas rich in renewable resources to population centers, and calling it a "National Clean Energy Smart Grid". While some may argue that this is smart policy for the existing electric grid, unless it incorporates data and communication systems consistent with the definition above it should not be confused with "Smart Grid" policy. For the purposes of this factsheet, we distinguish it from "smart grid" by referring to this idea as "Green Grid."

The Smart Grid is Mostly on the Distribution Side: Data, control, and omnidirectional communications systems can be applied to improve the operation of the bulk transmission system, but 80% of the smart grid components and activity are likely to be deployed on the distribution system (although this changes if one considers home appliances as part of the smart grid, in which case the customer side of the meter may play a much larger proportional role in time.)

What's the Case for the Smart Grid?
Integrating data network characteristics with the electric grid may have important benefits in each of the three areas identified in Figure 1:

Generation and Bulk Transmission: renewable energy integration; system efficiency; improved performance and reliability.
By integrating communications into transmission, the system can be more reactive to accommodate intermittent power sources like wind and solar, and in times of large-scale system failures (like those that affected the Northeast in 2003) can be more responsive to isolate failures, or self-heal by bypassing the failures, before they cascade into broader events.

Substation to Meter: system visualization; performance optimization; improved reliability and resilience.
While the electricity system brings power with tremendous reliability to 330 million Americans, outages cost between $80 billion and $150 billion every year. One of the key value-components of the smart grid is how

system visualization can improve outage prevention, detection, and response, dramatically improving reliability.

Meter to Appliance: "smart" rates and information; resulting behavior – demand response – "prices to devices;" new devices.
Because of electric demand spikes, economics may argue that there are times of scarcity when electricity is more valuable than at times of liquidity. Older metering architecture does not enable an easy path to communicate price signals to consumers enabling price-based demand-response. While demand response may have a strong value case, new devices and applications may hold unquantified promise (such as distributed energy, energy storage, and the sector-transforming potential of plug-in electric vehicles).

How Should Commissions Consider the Value of Smart Grid?
As economic regulators, Commissioners are likely to immediately ask questions about the potential costs and benefits of smart grid. The estimated costs for smart grid vary widely, but perhaps less important to State policymakers than the overall price-tag nationwide are the costs and benefits to ratepayers in their State's utility service territory. While the costs and benefits will vary depending on the State and utility where a proposal is made, it may be useful to consider two variables in valuing a smart grid proposal.

Direct Value: This represents the quantifiable value of components that, when introduced, will immediately improve the efficiency of the system and create cost-benefits such as distribution optimization and visualization. Benefits begin to accrue upon deployment rather than waiting for customer behavior or further component deployment.

Option Value: Some applications rely on additional activities before their value can be fully realized. In certain cases, like demand response enabled by smart prices and smart meters, realizing the value depends on consumers changing their behavior including responding to price signals. For other applications, such as distributed generation and PHEVs, consumers must purchase, install, and utilize them before their value can fully be realized. The addition of smart grid components creates the option for these technologies and activities to be deployed. This "option value," while not directly quantifiable, is nonetheless measurable and should be considered along with "direct value" components as applications for smart grid warrant.

The total cost of deploying smart grid may change depending on which smart grid components are deployed first. It may make sense to prioritize distribution system automation components with immediate, demonstrable, and direct value over smart meters if the meters rely on components that have yet to be deployed on the distribution system or undeveloped on the customer side to bring value.

What Federal Law is Driving Commission Consideration of Smart Grid?
Title XIII of The Energy Policy and Security Act of 2007 (EISA) sets goals for modernizing the nation's electricity transmission and distribution system through a smart grid, and authorizes funding for smart grid development and demonstration projects and matching funds for smart grid investments. The American Reinvestment and Recovery Act (ARRA) appropriated $4.5 billion for Title XIII projects and other efforts to modernize the grid. The federal funds may impact rate cases when eligible entities, including utilities, pursue demonstration projects or matching funds. In addition,

Is Rate Reform a Prerequisite to Smart Grid?
For distribution system functions, (such as distribution system optimization) rate reforms that introduce peak electricity pricing signals are essential. One argument for smart grid is that it empowers consumers with information that they can employ to reduce their energy use during peak periods. Without rates that differentiate how much you pay during peak periods from how much you pay for electricity during low-usage periods, there is little incentive to conserve at peak. Even if appliances are programmed to reduce at peak automatically, there are some who argue that "smart devices" without "smart prices" are meaningless. However, to encourage time-of-use savings, "Time of Use" (TOU) rates can be used that price electricity higher not during actual peak times, but during predictable times of higher peak, like summer afternoons. With that in mind, a formulaic TOU approach is likely to be less economically efficient than raising electricity prices during actual peak periods of electricity use, rather on potential peaks that may or may not actually materialize.

TOU rates are not the only rate design that is compatible with smart grid; State policymakers should explore how any smart grid proposal would interact with existing and potential future rate designs.

EISA requires the State Regulatory Authorities (and non-regulated electric utilities), under Public Utilities Regulatory Policies Act (PURPA), to consider smart grid investments; and smart grid information standards.

There are two federal funding opportunities for smart grid investments, both established by EISA and amended and funded by ARRA: demonstration projects and matching funds. The bulk of the funding will go toward matching grants for the implementation of digital upgrades to the electric grid. Electric utilities, distributors and marketers, distributed power generators, grid operators, and others are eligible for smart grid matching funds of up to 50% of qualifying investments. Demonstration projects are designed to promote smart grid demonstrations in different regions of the country that embody the salient characteristics of each region and to collect information for a suite of use cases that will assist in national implementation and replication. DOE will provide financial assistance, of not more than 50% of the cost of qualifying investments, to utilities and others to carry out demonstration projects. Demonstration projects do not qualify for matching grants.

Given the federal role in developing standards and funding deployments, some have questioned the role for State regulatory personnel. In addition to approving any non-federal – in other words, ratepayer-funded – expenditures on smart grid, some have suggested that State regulators should be ready to approve, condition, or disapprove a huge number of new investments by the electric utilities deploying smart grid. In order to facilitate expedited review, precertification standards have been suggested as one approach.

How Can We Ensure that Smart Grid Investments Avoid Obsolescence?

As anyone familiar with information technology can attest, the speed of technological change in this sector is dramatically faster than in the electric sector: a laptop may be obsolete in three years, while many electric grid components have a useful life of half a century. Moreover, the time horizons for information network investments are much faster than for electric grid investments. How can we ensure that our investments don't lag? How can we keep smart grid investments from becoming obsolete? Three key terms, familiar to those in the data networks world, will be key areas for decision-makers to understand and investigate before approving a smart grid investment:

> *Firmware upgradeability:* One important way to avoid obsolescence is through firmware upgradeability. Firmware is the embedded software in a device (such as a smart meter or sensor equipment) that controls and implements network and security protocols for that device. As new capabilities are required or vulnerabilities are discovered, remote, or "over-the-air" upgradeability, represents a method for ensuring that the device enjoys the most up-to-date capabilities, and that security threats are patched quickly on a widespread basis. (Some have argued that over-the-air firmware upgrades can also pose a cybersecurity threat, an issue decision-makers will need to investigate in any smart grid proposal.)
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> *Latency:* Refers to the speed with which network data is transmitted or processed. A system with low latency communicates more quickly, while a high latency connection generally communicates less frequently and has longer delays. For smart grid proposals, some components will be more latency-tolerant, such as meters which may need to communicate once an hour at most. Other applications are less latency-tolerant, such as distribution optimization systems whose response time needs to be less than a second. Smart grid networks need to be built for systems that may be deployed that are the least latency-tolerant, so that the system does not need to be upgraded to accommodate these in the future.
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> *Bandwidth:* Represents the size of the data packages that can be sent via a network connection. The greater the capacity, the more likely that greater performance will follow, though overall performance also depends on other factors, such as latency. As with latency, bandwidth should accommodate the expected application that has the highest bandwidth needs to prevent the need for future upgrades.

It is important to note that these are only three of a host of data network-related terms and concepts that Commissions will need to become familiar with in evaluating a smart grid proposal. They are among the most important examples, but far from comprehensive.

What Remains Under Development for Smart Grid?

These are a number of areas that remain under development for the smart grid. Technologies on the transmission, distribution, and customer side are widely discussed. For regulators, it is important to monitor and participate in the development of standards and protocols in three unresolved areas:

- Physical Communications: such as the media over which components will transmit and receive information;
- Networking: the language that components will use to address, route, and share information; and
- Applications and devices: including standards for consumer electronics, distribution system equipment, and visualization system mapping, among many others.

Since the smart grid is broad in its scope, the potential standards landscape is also very large and complex. Utilities, vendors, and policy-makers are actively engaged. There are already mature standards that are applicable to some aspects of the smart grid; much of the new work on emerging standards and cybersecurity can be leveraged from what already exists. A number of organizations, including the National Institute of Standards and Technology (NIST), the GridWise Architecture Council (GWAC), the American National Standards Institute (ANSI), the Institute of Electrical and Electronics Engineers (IEEE), and the ZigBee Alliance have been in partnership for standard, protocol, and agreement development. Open standards and a long-term plan for incorporating interoperability are most likely to remain durable as communications and security requirements evolve.

Security is the cross-cutting theme in standard-setting, affecting communications, networking, and applications. Commissioners may be familiar with the cybersecurity protocols being set by the North American Electric Reliability Corporation (NERC), which has by requirement, tended to focus more on the cybersecurity of existing electricity distribution systems, and less at the implications of joining the properties of data networks to these systems and to the applications that will be linked to it.

What about Cybersecurity? Does Smart Grid Make Us Less Secure or More Secure?
In concept, smart grid provides so many improvements in situational awareness, prevention, management, and restoration that in spite of new vulnerabilities introduced; it fundamentally makes the electric system more secure. However, new vulnerabilities and new points of access to create intentional disruption should be taken extremely seriously. "Guns-gates-and-guards" analogs of password protection and "security through obscurity" must be augmented with a framework of maximum system resilience and next-generation safeguards that allow the network to be impregnable, even if devices connected to it are compromised. Three areas are worth considering in principle:

- Hardware improvements in performance should not be mistaken for improvements in security; likewise obscurity does not provide security;
- Firmware must be updateable to prevent quick obsolescence, but must be protected, for example with encryption, certification and authentication; and
- Software must be deployed in a way so that even if an attack is successful, it will be unproductive, unappealing, unprofitable, and traceable.

Even with these protections, the network must be designed to assume data is interceptable, and have an overall design with resilience as a core principle.

Are Smart Meters a Prerequisite?
Not for everything above the meter level: you can do a lot with distribution system visualization, optimization and automation without knocking on doors. However, many of the applications that have been highlighted by those management tools promoting smart grid deployment, such as PHEVs, distributed generation, energy storage, smart devices and demand response, are "option value" applications that may depend on additional meter infrastructure.

Where can I find out more?
The intent of this factsheet has been to introduce basic concepts. A great deal of sophisticated research has been undertaken on the smart grid, its components, its potential direction, its economics, and potential vulnerabilities. These should be consulted for a more in-depth investigation of the smart grid. NARUC's Grants & Research Department has compiled an annotated bibliography of essential research reading as a companion piece to this factsheet, Titled "Smart Grid: An Annotated Bibliography of Essential Resources for State Commissions." It is available on the NARUC website at www.naruc.org/grants.

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