WHITE PAPER
Smart Grid

Navigating the Road to Smart Grid: Modernizing the Critical Communication Infrastructure

By Kyle McNamara, Managing Principal, Verizon Business Energy & Utility Practice and
Alessandro (Alex) Meynardi, Managing Principal, Verizon Business Energy & Utility Practice

Introduction

Every day, utility industry employees deal with a frustrating, double reality. On the one hand, they work in an industry that powers the digital age. On the other hand, many utility operations and systems are dependent on old-fashioned, largely analog technologies.

Of course, much of this situation has been influenced by a regulatory environment that hasn't embraced modernization. But thanks to a new conviction in government and industry, change is coming in the form of smart grid—using digital technology to help create positive outcomes for all stakeholders in the utility industry.

Not only will smart grids help modernize utility infrastructure and services, they will reduce operating costs and offer customers better services. Early cases are demonstrating that customers are responding. One utility in the Western U.S. recently found success with advanced metering infrastructure (AMI), an important piece of the emerging smart grid. The company signed up more than four million AMI subscriptions in the first year while saving millions of dollars in field-service and energy production and distribution costs.

Smart grid brings intelligence and opportunity to the management and distribution of energy: improving demand scalability, grid reliability, new applications, and the ability for the consumer to better manage costs, as well as enabling a real-time energy market. However, the journey to smart grid is no easy road. Making this road tougher is a convergence where the power grid meets telecommunication and IT. Fortunately, there are proven solutions that solve challenges such as network connectivity, security, and the increase in data volumes. And, they do so in a way that not only supports existing legacy systems and architecture, but are also flexible and scalable enough to accommodate future changes.

Smart Grid's Critical Communication Layer

It's important to keep in mind the technical layers that make up smart grid when developing a strategy and roadmap for transformation. At the highest level, smart grid's technologies can be sliced into three layers:

- **Power Layer.** Power generation, transmission, substations, distribution grid, and energy consumption
- **Communication Layer.** Local area network (LAN), wide area network (WAN), field area network (FAN)/AMI, and home area network (HAN), supporting IT infrastructure
- **Application Layer.** Demand response control, billing, outage control, load monitoring, real-time energy markets, and a new range of customer services

While there will be requirements for changes in all three layers, the communication layer will likely change the most. Of the three layers, the communication layer is the real enabler for smart grid. It acts as a circulatory system to interconnect the variety of systems and devices, power layer to application layer, to communicate both up and down the energy supply chain. The communication layer leverages the same Internet technologies that have transformed other high-tech industries. These Internet technologies are now bringing intelligence to the grid.

Described simply, the communications layer includes both the communication network and the IT infrastructure that supports it. The communication network provides the two-way movement of data and voice from the utility company to the various points in the power layer, connecting them to the application layer. The IT infrastructure manages how the data and voice are used and secured. Yet it is the communication layer that will prove most challenging for utility CIOs who are dealing with legacy architecture, including private radio networks and disparate legacy systems.

Communication Drivers on the Smart Grid Highway

Smart grid is getting a lot of attention these days—and not just from the utility industry. There is a lot of enthusiasm from the government, environmental groups, and consumers in hopes that the flexibility smart grid will provide will create new energy options, better manage demand, and reduce dependence on fossil fuels and the need for other new generating facilities. Utilities are being asked to respond to these industry-shaping drivers in a number of different ways.

- **The smart grid is both an evolution and a revolution.** For years utilities have been adding intelligence to the grid where applicable. However it was a piecemeal approach with now-outdated early technologies. In many cases, transitioning from that approach with even better technologies compounds the challenges.
- **Momentum of Renewable Energy Sources.** Renewable energy sources are poised to go mainstream, and smart grid is a key enabler. Smart grid is helping to integrate wind power and solar energy into the power generation portfolio, while solving intermittency problems, which helps utilities meet increased energy demands.
- **Proliferation of Smart Grid Devices.** A number of new smart grid devices such as meters, substation monitors, and line load detectors, are available with embedded intelligence in order to detect and react to load issues. As situations occur, automated intelligence will send back instructions through a two-way communication system to resolve the issue. Other devices are being sold directly to consumers, empowering them to better manage their consumption.
- **Smart Grid Government Funding.** The Department of Energy has awarded $3.4 billion in smart grid Investment Grants as part of the American Reinvestment and Recovery Act.[1] Many utility companies have received grants and will be tasked with completing projects in short order, embarking on a range of smart grid projects.
- **NERC CIP Regulations.** In order to broadly protect the bulk electricity communication layer, the North American Electric Reliability Corporation (NERC) has called out eight cyber security requirements in the Critical Infrastructure Protection (CIP) standards. While implementation deadlines vary, organizations must be fully compliant and pass audits for most requirements in mid to late 2010.
- **Customer Empowerment.** Smart grid will create many new features and services that customers have been asking for. They will now be able to proactively manage energy consumption and even sell excess power from customer sites back to the utility company. In addition, intelligent smart meters can detect unusual energy demands and alert the consumer.

These smart grid drivers place great demand on the communication infrastructure and will require utility companies to make sure their communication layer is up-to-date, scalable, and secure. However, there are challenges many utilities will face as they respond to these drivers.

Potholes on the Road to Smart Grid

The attention from stakeholder groups is putting pressure on utilities to keep the accelerator down and move quickly on smart grid initiatives. The level of change required to support smart grid and the new generation of energy can make even the most experienced utility executive uneasy.

Most utility companies have evolved their communication network and IT infrastructure incrementally. There is a combination of aging and legacy technology that lacks integration, making the move to a "connected" grid more challenging.

Outdated Communication Network

Utility companies serve markets in a variety of geographical terrains and often in combinations of both rural and urban customers in the residential, business, and industrial sectors. That same diversity extends to their communication assets, which have evolved over the past 50 years.

Many utility companies have implemented large communication networks that run both fixed and mobile voice and data and connect a variety of systems across the service territory. Each of these systems has different requirements for bandwidth, security, and performance, and may be built on different platforms using proprietary protocols. Some have fragmented architecture, which leads to higher operational costs, and may lack the bandwidth needed for the two-way, real-time communication of smart grid and the scalability needed to adopt an ever-changing array of smart grid devices and applications.

An Exponential Increase in Data

Utilities will soon experience an explosion in the amount of data due to the exponential growth of smart devices, meters, and monitors that will come online as part of smart grid. Most legacy data strategies and systems are not prepared to handle the volumes that will be generated. This new data will require increased storage, bandwidth and security. It also needs to be available to analytics functions that provide deeper analysis to understand new usage patterns and develop new pricing models.

Some utilities are already seeing this data boom. For example, before one utility began phase one of its smart grid rollout, their total information volume online was about 20 terabytes (TB), or 20,000 gigabytes. They are now capturing data from smart meters every 15 minutes which has increased their requirements to 200 TB of storage. The utility has predicted that moving to a five minute capture would increase the data volume from 200 to 800 TB.[ii]

With phase two and the addition of alternative energy sources like solar panels and fuel cells, the utility expects to enter the petabyte age. A petabyte is a thousand terabytes. Depending on where they are in the country, some utilities will need to store 36 months of meter readings. People are now talking about exabytes of data—equal to a million terabytes.

Information and Data Privacy Concerns

Customer data and privacy issues are current hot points of contention in the smart grid evolution. Who owns the data and for what reason is a question regulators are wrestling with. There is a growing concern that this data could be used in ways customers had never anticipated. The National Institute of Standards and Technology (NIST) has identified several potential data privacy concerns involving smart grid. They include identity theft, tracking customers' personal behavior, and real-time surveillance.

The information from these devices can be combined in unexpected ways that reveal things consumers may not want others to know. Consider for a moment a "smart" home. Data could be captured and sent that tracks which appliances are used and when, when someone becomes active in another room, when the water heater reveals a shower is being taken or even whether someone is home or not. While this is disconcerting, even worse is the potential to identify the use of health-related devices.

Increased Opportunity for Cyber Attacks

The utility industry faces very unique security challenges with the rollout of smart grid. Not only are there risks to the utility's own assets, but now there is the potential for threats to impact the greater energy supply chain. Interconnecting additional energy suppliers, adding new energy sources, and deeply connecting into the consumer's home create greater opportunities for harm.

In the past, utility companies have operated in mostly closed systems. Very little connectivity existed between the core control systems and the corporate network, let alone the Internet. However, as the industry moves toward smart grid, utilities will move toward a more open communication model. Not only will control systems, like SCADA (supervisory control and data acquisition), be connected to the network, but other points along the energy supply chain outside of the corporate firewalls.

Stephen Wostal, writer for *Intelligent Utility*, reports, "Various news outlets reported that senior government intelligence officials claim spies have already planted leave-behind software at strategic locations across the grid, giving new meaning to spyware."[iii] *Intelligent Utility* also reports that news sources recently reported that the CIA found evidence of successful cyber attacks against critical national infrastructures outside the United States. These attacks were specifically used to disrupt power equipment and cause a power outage that would affect multiple cities.

"The electric grid is highly dependent on computer-based control systems. These systems are increasingly connected to open networks such as the Internet, exposing them to cyber risks. Any failure of our electric grid, whether intentional or unintentional, would have a significant and potentially devastating impact on our nation."

BENNIE G. THOMPSON (D-MS), CHAIR OF THE U.S. HOUSE COMMITTEE ON HOMELAND SECURITY, WITH THE INTRODUCTION OF THE "CRITICAL ELECTRIC INFRASTRUCTURE PROTECTION ACT" (APRIL 30, 2009)

Accelerating on the Communication On-Ramp

Even though communications is not the primary focus of utilities, smart grid requires a strong communication network that can support the traditional utility functions in the power layer. It must also have the flexibility to adapt to the new requirements in the application layer. It must support demand response, advanced metering devices, and distributed energy sources. The communication network must provide seamless integration, real-time communication, and manage the flood of data being produced by the components of smart grid all while maintaining security.

> Integrated communications networks connect components of smart grid for real-time information and control, allowing every part of the grid to both talk and listen.

Bridging Communication Technologies With MPLS

The utilities communication network handles traffic for data acquisition, metering information, and corporate voice and data. The requirements for these different types of traffic vary, making it more complex to manage and secure. Much of that traffic runs over private and proprietary Layer 2 protocols while a fully integrated and optimized grid network will run over IP Layer 3 protocols. Most utilities aren't ready to fully replace legacy communication systems with IP-based communication so a hybrid approach is needed. Bridging that gap is a technology called Multiprotocol Label Switching or MPLS.

MPLS is a technology that consolidates multiple communication protocols by creating virtual circuits, allowing it to manage both Layer 2 and Layer 3 traffic. The virtual circuits allow Layer 2 traffic to flow through devices with IP addresses but on a separate segment with no IP connectivity. This integration is critical to preserve still valuable legacy assets while enabling smart grid's broader communication needs.

MPLS provides flexibility in how traffic is handled across the network by allowing it to be prioritized, giving priority to mission critical traffic. For example, SCADA traffic can be tagged for priority delivery to the master controller. MPLS also provides resilience. By segmenting AMI, SCADA, and substation traffic, each component is still protected even if another is compromised. Traffic can be quickly rerouted as needed.

MPLS can also be configured to logically separate private and public data. Where public and private data travels over the same physical circuits and routers, additional security should be provided at the provider edge to protect those elements from attacks.

MPLS consolidates disparate traffic into a single network, reducing both capital and operating expenses. In addition, MPLS can help utility companies meet NERC CIP standards managing the Layer 2 assets while providing full Layer 3 routing as the assets evolve. Not only can MPLS integrate legacy communication networks, it is also capable of connecting IP networks, providing an easy migration path to incorporate additional IP-enabled components in the future.

Lifting Data into the Cloud

It will be difficult to predict just how much to scale the current infrastructure to meet the data growth from smart grid. With some utilities keeping as much as 36 months of meter reads, storage requirements can quickly reach exabytes of data. Like the energy systems of yesterday, many utilities will build out data centers to handle peak-level demands. This could often leave periods of underutilization due to an overbuilt infrastructure, and create an unfavorable return on investment.

Many companies are now embracing cloud-based services for managing data. Cloud-based services help reduce capital expenditure on hardware, software, and services, by paying the cloud provider for only what is used. This leaves critical capex dollars available for other smart grid initiatives. Usually, there are little or no up-front costs and contracts can be terminated at any time, avoiding potential return-on-investment risk. The services are backed by Service Level Agreements (SLAs) with financial penalties for noncompliance. Other benefits include:

- Shared infrastructure costs
- Real-time scalability on a pay-for-use model
- Offsite and managed disaster recovery
- High levels of availability
- Reduced maintenance and energy costs

Probably the biggest advantage is that cloud computing is often more secure than today's enterprise. Cloud providers have specially trained security teams, top-notch equipment, and security protocols that stay current with the latest threats—something most IT organizations, not just utilities, struggle to keep up with.

A more incremental approach is to consider managed services. Outsourcing data management to an expert vendor allows IT resources to focus on essential new business and technical initiatives. Vendors with expertise in data management can improve data center efficiencies through server virtualization. Virtualization helps consolidate multiple applications onto a single server in what is called "virtual instances," which then reduces the total number of servers needed.

In addition, data management experts can help implement a multi-tiered storage strategy that offloads "less-active" or archived data to less expensive storage media, yet keeps the important and active data close to the system that needs it. These same experts often have a deep understanding of data and system security, including identity management protection methods.

Securing Smart Grid's Future

Threats can materialize as either malicious attacks or outright stealing of corporate data, including sensitive customer information. When developing a security strategy, meticulous care needs to be taken, as smart grid's interconnections create increased exposure to the utility and the network nodes on the greater grid.

Threats and Vulnerability

Securing smart grid to reduce threats and vulnerabilities requires a combination of protective measures. Today's hackers, who are often part of an organized crime group or even terrorist networks, look for vulnerabilities in targeted areas of the network.[iv] It becomes more imperative that security is complete, strong, and up-to-date. Fortunately, the networks on which most smart grid applications are being targeted to run are not new and there are already protection methods that address the various security risks.

Security activities are broad and require a solid team of experts to manage. Anti-virus and anti-spyware systems need to be implemented and monitored. Controls need to be put in place, including firewalls and VPNs to detect and prevent intrusion. Authentication measures need to be added to help prevent systems from being tampered with, and ensure that only trusted metering assets are added to the network and only approved metering firmware updates are allowed to be applied.

> All personal data moving across the grid should be encrypted to safeguard the data from unintended use.

Identity and Access Management

Whenever personal data is collected, particularly sensitive data, it should be stored and transmitted securely. All personal data moving across the grid should be encrypted to safeguard the data from unintended use. Two way "handshakes" will be required to uniquely identify devices and allow appropriate interactions to occur. Identity and access management (IAM) strategies aim to secure applications and data from fraudulent use of personal information. IAM encompasses user management, authorization, and authentication functions.

IAM becomes a more complicated challenge when access is extended to vendors, suppliers, and even customers. A new process called federated identity enables the portability of authentication across domains, allowing disparate systems inside and outside the company to be seamlessly joined from a security perspective.

Summary

Utilities face some very real challenges implementing smart grid. Not only will overall intelligence of devices continue to evolve and new energy sources be added, like wind and solar, new applications will also be added that allow proactive energy management by consumers. This places a heavy burden on the communication layer that supports the integration of the power layer and the application layer.

In order to quickly and cost-effectively meet smart grid's new requirements, the communication layer requires an infrastructure that not only supports legacy systems and architecture, but will also be flexible and scalable enough to accommodate future changes. And, it must do so in a secure manner, meeting CIP compliance requirements.

Fortunately, technologies and services exist today that can help utilities meet the communication infrastructure challenges they face. Bridging network technologies like MPLS, hosted data services, and comprehensive security programs are viable options that can be implemented relatively quickly to provide a high level of service.

This is new territory for most utilities. Upgrading core components for smart grid is a complex and lengthy process and will not be accomplished overnight. Utility executives should approach communication infrastructure upgrades with care and thoughtfulness, understanding where the edge of their own expertise lies and when to rely on outside experts.

Verizon Business Can Help You Navigate the Road to Smart Grid

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Now, we're ready to assist you with your growth. We've assembled a team of experts from the energy and utility industry ready to help you manage all aspects of your smart grid transformation, including one of the most critical components of smart grid—the communication infrastructure. Our wireless and global IP network, managed data services, and advanced security applications can help you quickly advance your technology infrastructure.

Want to get started? Contact us. We know technology transformation, and we're ready to help you move confidently and securely down the road to smart grid. For information, visit www.verizonbusiness.com and contact your Verizon Account Manager.

About the Authors

Kyle McNamara, Managing Principal, Verizon Business Energy & Utility Practice

Kyle McNamara is a Managing Principal with the Verizon Business Energy & Utilities practice. He has more than 10 years of management consulting experience in the electric utility and other industries, and he has worked for clients in the U.S., U.K., Canada, China, and South Korea. He has extensive experience working with electric utilities to solve customer service challenges, including helping several Midwest utilities implement deregulation and solve issues resulting from the implementation of new billing systems. He has also led efforts to design customer and billing strategies for major international companies, and helped develop the customer analytics practice for a management consultancy. His other core competencies include business process improvement, business continuity management, and revenue assurance.

Alessandro (Alex) Meynardi, Kyle McNamara, Managing Principal, Verizon Business Energy & Utility Practice

Alessandro (Alex) Meynardi is a Managing Principal in the Verizon Business Energy & Utility practice. In the utility industry, he is a trusted advisor and thought leader responsible for providing strategic guidance and developing innovative solutions. In this role, he works with several utility companies, technology partners, and multiple organizations and disciplines across Verizon to develop and deliver key utility market capabilities that leverage the strengths of Verizon and provide market-changing solutions. Meynardi focuses on smart grid solutions, outage management, substation automation and protection, physical and cyber security, and communications infrastructure.

Prior to joining Verizon Business, Meynardi was an accomplished executive at Accenture with 15+ years of experience. During this time, Meynardi acquired a broad range of industry, technical, and security experience and led the designing and deployment of large and complex multi-million dollar business, technology, and security solutions to support business objectives at key utility companies in North America.

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