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The Knowledge of Power and the Power of Knowledge

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Imagine a future where the lights go out and, thanks to automated detection of the problem, it is corrected before any customer calls. Imagine all utilities having digital wallboards, enabling any office space to be a control center with real-time views of the operations from anywhere in the corporation. This degree of ubiquity and operational efficiency is still some time away, but this is one of the objectives of the smart grid: a grid that will meet the future need for power in a reliable and efficient way, a physically interconnected grid with wires, poles, transformers etc., as well as a grid that is interconnected with a common communications infrastructure including hardware, devices and monitors that are all interoperable.

We live in a world surrounded by digital devices from iPods¹ to Blackberries². We even have smart cable boxes that know when to record our favorite shows. We may inadvertently expect the same to be true for our electric grid. In fact, this is hardly the case today. While some larger utility companies have installed newer supervisory control and data acquisition (SCADA) systems, most

are operating with aging and increasingly outdated systems. For instance, when the lights go out in a block or neighborhood, we expect the utility company to be aware of the problem, isolate the cause and quickly mobilize to fix it.

But the reality is that the utility waits for calls from its customers to find out if there is an outage and only then begins to look for the problem. Aging transformers located throughout the network are subject to failure, but instead of having advanced monitoring or diagnostic devices, most utilities still depend on field personnel to collect oil samples from the transformers, send them to a lab and then, wait several days or even

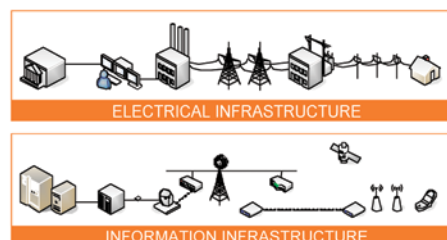
longer for the results – hardly a ‘real time’ assessment of asset condition.

The power industry today still is operating in many ways as it did during the industrial age; one characterized by:

- A large aging fleet of transmission and distribution (T&D) assets.
- Lagging construction of transmissions facilities as compared to new generation.
- Manual intensive outage planning and emergency management, requiring significant, time-consuming coordination between field crews and control-center staff.
- Increasing demand for power by all types of users.

Figure 1. Smart Grid Infrastructures

The integration two infrastructures



... to provide customer value

Increase energy productivity

Increase power reliability and quality

Reduce CO2 emissions

¹ iPod is a registered trademark of Apple Inc.

² Blackberry is a registered trademark of Research in Motion

Figure 2. Smart Grid Building Blocks



- Growing sensitivity to power quality and reliability due to increased dependence upon electronics and computers.
- A highly regulated industry with fragmented federal, state and local regulatory requirements.
- Growing environmental sensitivity to fossil fuel based power generation.

The Smart Grid

The digital revolution changed how consumers use information and allows them to continuously be ‘connected.’ It is now time for that digital revolution to address the electrical system where there is currently an information vacuum from substation operations down to the energy consumer. The smart grid fills the vacuum by overlaying the entire system from power generation to power consumption with a standards-based,

integrated information and communications infrastructure. (Refer to Figure 1 – Smart Grid Infrastructures)

A smart grid can better manage electrical power demand down to the residential level, network small-scale distributed energy generation and storage devices, communicate information on operating status and needs, collect information on prices and grid conditions and move the grid beyond central control to a collaborative network³. (Refer to Figure 2 – Smart Grid Building Blocks)

The smart grid will be composed of numerous automated T&D systems, each operating in a coordinated, efficient and reliable manner. It will be capable of handling emergency conditions with ‘self-healing’ actions and will be responsive to energy market and utility

needs. It will serve millions of customers and have an intelligent infrastructure enabling the timely, secure and adaptable information flow needed to provide power to the evolving digital economy. Simply put, the smart grid is going to be ‘intelligent’ and ‘integrated’ from end-to-end, from generation to consumption.

The challenge lies in taking the smart grid from a conceptual blueprint to cost effective implementation. This is not one size fits all. Each utility and territory will have a unique hierarchy of needs for the various elements of a smart grid. Some utilities might start with advanced meters while others might start with substation monitoring and diagnostics. The key is to gain support for large-scale demonstration projects to solve real problems and validate benefits.

³ Grid 2030 – A National Vision For Electricity’s Second 100 Years – US Department of Energy

This requires a cooperative effort between utilities, technology providers and regulators to fund and implement these projects. American Electric Power (AEP) has already taken a step in that direction by partnering with GE Energy, a business unit of General Electric, to pursue the development, integration and deployment of advanced energy delivery infrastructure and metering technologies. GE Energy is aligning its efforts with AEP to define operator and consumer benefits and attain regulatory support for their implementation plans.

Benefits to the Utilities

The integrated smart grid is going to provide many short-term and long-term benefits to the utilities. Together with better returns on investments (ROIs), and increased revenues in the long run, there are going to be many intangible benefits that cannot be measured in absolutes, like greater job satisfaction and improved customer relations. However, the core benefits to a utility are significant, as summarized below:⁴

Operational Efficiency

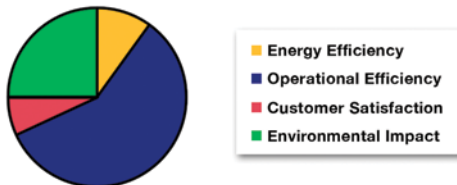
Through complete integration of the system, all assets and resources of the utility can be managed more efficiently. The T&D systems will provide a real-time view of operations and will be able to detect and correct problems at very early stages, thereby avoiding costly power interruptions.

Environmental Impact

Utilities will be able to manage peak load times by leveraging information coming from meters; thus, facilitating better use of distributed energy resources and demand side management. The integrated grid also will reduce field trips by crews by automating detection and switching actions, quickly reducing the outage size and helping to return the grid to service with fewer dispatched vehicles.

Energy Efficiency

Smarter energy usage data management will enable more optimal use of existing assets, improving the rate of return on capital investment and lowering utility operating costs.



Customer Satisfaction

A 'smarter grid' will enable power to be restored with minimal downtime and enable customers to receive timely updates on the status. Customers will be 'connected' to the utility through home area networks and will get a more complete breakdown of their energy usage, allowing them to operate certain appliances at times when electric rates are lower and optimizing their overall energy utilization.

The Building Blocks of the Smart Grid

The smart grid is not going to happen overnight. The various elements of the smart grid will be implemented over time to meet the changing needs of each utility. The building blocks of the Smart Grid are going to be:

Advanced Metering

Currently, most existing meters simply report the aggregated consumption of power by the customer over a specific time period – usually about 30 days. However, with smart meters fitted with two-way communications, the utility will know consumption patterns down to each individual household, commercial or industrial customer level, and interval readings – as frequently as every 15 minutes or less – are also possible. The inclusion of smart meters in the networked smart grid will enable the utilities to know how to manage load at any given time. The meters also will allow utilities to:

- Connect or disconnect power remotely
- Read the meters remotely and accurately
- Report time-of-use data and send real-time pricing signals, so the customers can make smart energy choices on an informed basis
- Provide additional competitive power offerings like broadband over power lines (BPL) and home area network (HAN) capabilities
- Encourage consumers to reduce power consumption during peak load times

Utility Enterprise Asset Management

The power industry is a capital-intensive industry, with expensive equipment. To squeeze the ultimate performance from its myriad vital assets, many utilities employ enterprise asset management (EAM), which focuses on achieving the business benefits of lowering the lifecycle costs of physical assets. EAM also improves asset utilization and ROI by increasing the effectiveness of capital investments and operation and maintenance work planning.

In the smart grid environment, custom legacy IT systems will be replaced over time by modern EAM systems built on open-standard platforms and conforming to interoperability standards, reducing implementation and maintenance costs. These systems will share information on each asset, down to recording the historical cost of maintaining and operating these assets and enabling the utilities to maximize ROI for the assets. Moreover, the geospatial applications of the EAM will allow utilities to optimize the geographic location of assets and provide service crews with more efficient access to the assets as well as reducing travel time and costs.

Distributed Operations and Automation

Distribution management systems (DMS) and associated SCADA systems will have a more comprehensive visualization of the entire system, integrating all relevant network information from various sources in a dynamic system topology model. They

⁴ Mazza, Patrick, "The Smart Energy Network: Electricity's Third Great Revolution," c. 2003

will also have the self-healing functionality to instantly detect and react to power disturbances with minimal customer impact.

SCADA systems will have monitors or sensors built with real-time data acquisition capabilities to capture and analyze voltage sags and swells, high frequency impulses, transients, and various other power distortions. Fault detection, isolation and recovery and volt/VAR management by switching in capacitors and voltage regulators can be managed remotely, enabling timely action to minimize down time and improving the quality of service.

These improvements would, in turn, result in less coordination with field crews to manually operate switching actions, thereby reducing the number of vehicles on the road and lowering harmful emission levels. Field crews will be directed to the specific problem area with a preliminary diagnosis and the appropriate resources to complete the repair in a single trip. Over time, the first generation of trouble call type outage management systems (OMS) will gradually give way to smart grid DMS/OMS platforms that are linked to the advanced metering infrastructure (AMI).

The smart grid will have a combination of a centralized strategy complemented by a local strategy. Distribution operations software would control the overall system and set the parameters at the grid level, and the substation controllers – along with distribution controllers – would contain a sufficient level of control logic to support the overall grid control scheme.

Substation Automation

In the smart grid, automated substations provide capabilities that have been unavailable in traditional substations to link in new, smart information and control technologies. Power saving and energy efficiency can be realized by installing voltage control technology that improves overall substation efficiency. Automated substations will have

inter-device communication, interoperability and early alarm notification systems. Sensors will monitor transformers (e.g., temperature, moisture, gases, etc.), relays, digital fault recorders, breakers and station batteries to ensure all are working efficiently. A single automation platform will perform the roles of security gateway, SCADA, data concentrator, hardwired I/O, sequence control logic, communication processor, port switch, protocol converter, sequence-of-events (SOE) recorder, alarm annunciator, local data warehouse and substation human machine interface (HMI).

Systems Integration: Unlike the traditional grid, the smart grid will need to be built on an enterprise service bus (ESB), which is a distributed, message-based integration solution based on open standards. The role of an ESB is to facilitate reliable communications between IT resources such as applications, platforms and services that are distributed in multiple systems throughout a utility enterprise. It provides foundational services for complex architectures, is event driven and incorporates a standards-based messaging system and also allows IT personnel to exploit the value of messaging without writing code.

The (Obvious) Future

The smart grid is no longer just a concept. A number of utilities have initiated pilots or large-scale demonstration projects of various smart grid solutions. A common factor for all of them is recognition that successful programs require significant business process change in addition to technical program execution. This is about changing the way utilities operate and the way they interact with their consumers. The smart grid requires utilities to:

- Adopt a top-down strategy that is comprehensive and includes the entire system and operations instead of looking at individual functions in isolation.
- Commit significant budgets and leadership talent to smart grid projects.

- Bridge the gap between IT and operations.
- Adopt industry standards-based systems with demonstrated interoperability, to ensure easy sharing of information across the enterprise.

The future smart grid is going to be a fully integrated system from generation to consumption. The smart meters will provide constant status updates at the point of use, and utilities will be immediately aware of potential disruptions or other issues, vastly improving overall reliability. Customers will call only to report dangerous conditions and obtain estimated restoration time. There will be proactive monitoring of networks to avoid outages and incidents and self-healing restoration tools to provide dramatic reductions in customer outage durations.

Automated advanced distribution infrastructure and outage management system (ADI/OMS) integration will significantly reduce the field trips required to investigate 'single customer' outages. The net result will be a better understanding of the state of customers and the ability to analyze and overall grid health and operational reliability and stability at any point in time.

About the Author

Bob Gilligan is the Vice President for GE Energy's transmission and distribution business. In this role he is responsible for delivering integrated network reliability solutions to the T&D, Oil & Gas and Telecom sectors. The business includes a diverse group of products and services including intelligent electronic devices, meters, transformers, GIS software, distribution management systems software and energy management systems software. He was appointed to his current position in January 2004. ■