



ITC Holdings Corp.

Ensuring Reliability and Increasing Efficiency Through an Intelligent Transmission Grid

White Paper

Introduction

Today, more so than any time in recent history, great focus is being placed on the electric industry and how it operates and impacts our society. Renewable energy, demand response, energy conservation, climate change, transmission and distribution infrastructure enhancements, and modernization are all part of the new debate on how we create, deliver, and consume electricity in the 21st Century. Decisions are being made regarding the development and enhancement of the transmission and distribution grid so that it can meet extraordinary economic challenges, critical needs for energy security, and essential requirements for a sustainable way of life.

This is a defining moment in terms of our nation's commitment to providing an electric energy system, including the transmission network that meets societal needs of the 21st Century and beyond. A major evolutionary step in the grid's design, planning, and operation is needed. These include new design concepts and innovative technologies that can be integrated into a modern infrastructure. While much of the focus is on customer-level Smart Grid devices in current Smart Grid discussions, we should also focus on the development and implementation of Smart Grid technologies at the transmission level.

Planning for Smart Grid investments should explicitly recognize that Smart Grid technology is not a panacea for an aging infrastructure. Rather, Smart Grid is the application of advanced technologies that enhance the operation of the hard assets of the transmission grid. These investments are not a substitute for developing the transmission infrastructure to maintain reliable service and provide open access and non-discriminatory transmission service, including the integration of renewable resources.

To date, ITC Holdings Corp.'s ("ITC") Smart Grid investments have focused on improving the reliability, security, and functionality of the transmission system. ITC's strategy has leveraged both the capability of the existing communications network and a strategic view of the types of data required to improve operation and analysis of the system. The availability of bandwidth enabled ITC to leverage off-the-shelf technologies to improve reliability and enhance disturbance analysis. Years of planning were dedicated to ensuring that ITC could integrate security and communication needs into a robust data network with flexibility for upgrades in the future.

ITC Holdings Corp.

ITC is the first and only fully independent transmission company in the U.S. With transmission systems in Michigan's Lower Peninsula and portions of Iowa, Minnesota, Illinois, and Missouri serving a combined peak load in excess of 25,000 megawatts (MW) over 15,000 transmission line miles, ITC is the eighth largest transmission-owning company in the U.S. based on transmission load served.

ITC's business strategy has many components including a focus on our customers, employees, communities, and shareholders. Our strategy is focused on ownership, operation, maintenance, and construction of transmission facilities as a single line of business. There is no competition for capital; it is dedicated for prudent transmission investment. With this singular focus, ITC's goals are clearly defined to:

- improve reliability;
- reduce congestion and improve efficiency;
- increase access to generation, including renewable resources; and,
- lower the overall cost of delivered energy to consumers.

With this in mind, ITC recognizes that the development of a "Smart Grid" will provide opportunities for the company to achieve its goals for the benefit of consumers.

Section 1301 of the Energy Independence and Security Act (the "Act") sets forth ten goals and characteristics of a Smart Grid. The Smart Grid as envisioned in the Act contemplates not just the application of digital technologies to the transmission grid, but a technological upgrade to electric distribution and electric generation as well. Because ITC is engaged exclusively in construction, ownership, and operation of electric power transmission systems, our interest is focused on the Act's identified goals and characteristics that are applicable to the transmission grid, including:

- Increased use of digital information and controls technology to improve reliability, security, and efficiency of the electric grid.
- Dynamic optimization of grid operations and resources, with full cyber security.
- Development of standards for communication and interoperability of appliances and equipment connected to the electric grid, including the infrastructure serving the grid.
- Identification and lowering of unreasonable or unnecessary barriers to adoption of Smart Grid technologies, practices, and services.

ITC's singular focus on construction, ownership, and operation of electric power transmission systems places it in a unique position to support these goals. Specifically, the company's Smart Grid vision is to actively invest in new technology when it:

1. Makes business sense to do so (i.e., when the benefits of the new technology outweigh the costs, and the assets are used and useful);
2. Improves reliability of transmission service, for example, by upgrading transmission assets with more effective monitoring and control technology;

3. Retains flexibility for the future because the technologies to be deployed are flexible enough to accommodate innovation over time; and
4. Enables a smarter future, as the use of Smart Grid technologies in the transmission system can serve as an enabler for Smart Grid applications related to generation and distribution.

Indeed, the initiatives that ITC has undertaken in Michigan already have resulted in a realization of technological improvements that align with the Federal Energy Regulatory Commission's Smart Grid vision. These initiatives address Smart Grid elements such as cyber security and reliability, inter-system communication and coordination (or interoperability), and integration of renewable resources into the electric grid. ITC's initiatives offer a model for the electric power industry for cyber security and reliability, interoperability, and renewable resources integration.

Nevertheless, to achieve the promise of a Smart Grid, several hurdles must be overcome including the continued development of technology and the resolution of interconnectivity and standardization issues of the various devices and protocols to ensure interoperability.

Defining the Smart Grid

One of the impediments to the development of the Smart Grid is the lack of a consistent, cohesive definition. A precise definition of the Smart Grid remains elusive as organizations invest in the idea that the development and application of technology to the electrical grid has value today and in the future:

"Grid advancements will apply digital technologies to the grid and enable real-time coordination of information from both generating plants and demand-side resources."¹

"A smarter grid applies technologies, tools, and techniques available now to bring knowledge to power – knowledge capable of making the grid work far more efficiently..."²

"The Smart Grid is in essence the marriage of information technology and process-automation technology with our existing electrical networks."³

"The term 'Smart Grid' represents a vision for a digital upgrade of distribution and transmission grids both to optimize current operations and to open up new markets for alternative energy production."⁴

"A Smart Grid delivers electricity from suppliers to consumers using digital technology to save energy, reduce cost, and increase reliability."⁵

"The Smart Grid is a combination of technologies deployed throughout the electricity generation, transmission, and distribution system that will turn today's

¹ Federal Energy Regulatory Commission, News Release, "FERC accelerates Smart Grid development with proposed policy, action plan," March 19, 2009.

² United States Department of Energy, "The Smart Grid: An Introduction," October 28, 2008.

³ Gillian, Robert, Plug Into the Smart Grid Conference, Washington, DC, February 17, 2009.

⁴ IEEE Power and Energy Magazine, "From the Editor: Beyond the Gridlock," March 2009.

⁵ Wikipedia, http://en.wikipedia.org/wiki/Smart_grid, June 25, 2009

rudimentary grid into something more akin to the Internet, with real-time, two-way communications capabilities throughout.”⁶

“The perfect power system will include both a major technological update to the existing generation, distribution, and transmission systems as well as the building and interconnecting of smaller systems, or smart micro-grids, enabled by digital controls and distributed generation facilities all over the country.”⁷

From these definitions, ITC has concluded that the Smart Grid is simply the convergence of electrical and new “intelligent” infrastructure. This convergence includes the two-way flow of information that strengthens reliability and resource management; data, control, and automation providing increased efficiencies, responsiveness, flexibility, and resiliency; “time-based” decisions and transactions between energy suppliers, buyers, and markets; market-side resources operating with traditional supply-side resources as a portfolio; and, sustainability (environmental compliance and resource stewardship benefits).

However, several hurdles must be overcome to reach this future. Technology, state and federal policies, cost recovery, interconnectivity and standardization will all play a critical role in the development of the Smart Grid. For example, many of the technologies needed to reach the full promise of the Smart Grid are only in the early stages of development or are not yet commercialized. Similarly, the Federal Energy Regulatory Commission recently issued a preliminary policy statement, but has yet to decide on a final course of action for the Smart Grid. Just as important are the various state utility commissions that will ultimately decide what is appropriate for consumers at the retail level.

Finally, it is important to recognize that technology is not a universal remedy for an aging infrastructure (i.e., the Smart Grid does not replace the “real grid”). The real grid is the hard assets that make up the traditional infrastructure (i.e., wires, substations, etc.). The Smart Grid is simply the application of advanced technologies that enhance the operation of the real grid.

The ITC Approach: ITC’s Smart Grid Strategy

ITC plans to continue to actively invest in new technology to the extent it adds value for our customers and investors, improves the reliability of our service, and retains flexibility for the future.

Smart Grid at the transmission level has led ITC to focus on three fundamental areas. These include:

1. The development of a robust communications network using a secure broadband logical network;
2. A real-time monitoring and control system that utilizes sensors and intelligent devices to enhance real-time observation with rapid analysis and response to system disturbances; and
3. Event analysis that incorporates enhanced monitoring and data analytics for a robust analysis of system events.

Simply stated, our customers benefit from ITC’s intelligent transmission system. The use of select Smart Grid technologies provides customers with increased reliability resulting in fewer

⁶ GridWise, Letter to Senators, February 5, 2009.

⁷ Galvin, Robert, Galvin Electricity Initiative, www.galvinpower.org, June 25, 2009.

interruptions to business and improved customer satisfaction. Similarly, enhanced event analysis leads to quicker response times and identification of corrective actions. In addition, many of the Smart Grid technologies ITC has deployed assist in compliance with North American Electric Reliability Council (“NERC”) mandatory reliability standards for transmission system monitoring, operating, analysis, and security.

Smart Grid Technologies

Communications

The Smart Grid is often assumed to be a single technology. In reality, the Smart Grid is a collection of key technologies that supplement our existing electric utility infrastructure. A robust communications network is the key to achieving the interoperability of these technologies.

As ITC has acquired and separated transmission assets from previously vertically integrated utilities, the company incorporated a robust communications network to support the increased data transmission requirements of Smart Grid technologies in the field. Previously, communications were provided over a variety of technologies that were cobbled together and poorly maintained. These were low speed, non-networked, point-to-point lines with limited bandwidth that restricted the amount of data that could be transmitted. They were very expensive with some circuits costing thousands of dollars per month. These legacy systems were incapable of transporting the increased data and connecting with new sensor devices that are now part of the Smart Grid. ITC conducted an extensive study that led to the adoption of an Internet Protocol-based network running on AT&T frame relay network technology.

The frame relay network is based on 25 year-old, proven technology, which meets all ITC requirements for speed, bandwidth, reliability, and security. Additionally, it provides virtually unlimited bandwidth network availability at the head-end facilities and up T1 bandwidth at transmission substations – all backed by innovative security and customer support capabilities. ITC substation facilities are logically networked to redundant ITC operating control rooms through the AT&T network. This provides ITC with reliability, speed, redundancy, and leading technology, all taking advantage of AT&T’s economies of scale. The use of open-industry protocols and standards provide the fundamental building blocks for interoperability.

Future Smart Grid upgrades at ITC are enabled by a standardized, advanced network architecture that provides security, reliability, and virtually unlimited bandwidth. ITC made a fundamental decision to create a communication network that had TCP/IP capabilities using standard, off-the-shelf hardware. In this regard, as technological advances occur, new products are easily incorporated into the existing infrastructure. The uniformity of ITC’s architecture facilitates upgrades to the most advanced commercial components available.

Cybersecurity

ITC has planned for, standardized, and implemented high levels of security in its network communications system that enable it to easily comply with evolving Critical Infrastructure Protection (“CIP”) standards. Cybersecurity is achieved at the ends (data are prioritized and encrypted prior to entering the AT&T network). Up to 12 virtual local area networks (“VLANs”) may be created, separating and prioritizing data for transmission. The data are then secured by establishing a virtual private network (“VPN”). A state of the art Cisco Monitoring Analysis and Response System (“MARS”) and Cisco Secure Agent (“CSA”) centrally monitor traffic at all remote terminal units (“RTUs”), providing detection and mitigation of multiple cyber-threats. Because communications are provided by a third-party telecom provider, security is established inside the ITC network. The advantages of robust network architecture include central monitoring of all RTUs at critical substations, scalable bandwidth that allows addition of features such as

broadband video feed, and future enhancements and upgrades that can be handled easily and quickly.

Physical Security

The communications network also enables ITC's physical security, which was recently recognized by NERC as an Example of Excellence. Critical ITC substations are centrally monitored 24 hours a day, seven days a week by a sophisticated physical security system that is supported by the communications network. Closed-circuit television cameras provide video to ITC's Security Command Center through a simple remote upgrade of bandwidth. Intrusion monitors and alarms are linked back to central monitors which are all integrated into a single central security monitoring system. In addition, cyber locks and electronic access controls communicate with central databases to ensure access privileges are current and authorized.

Real-Time Monitoring and Control

Smart Grid technologies provide enhanced monitoring and control capabilities. Accordingly, a system based on information technology has been developed to monitor and control equipment in the field from a central location. Key functionality includes intelligent alarms and self-diagnosing sensors to direct subject matter experts to potential equipment failures, analytical tools that filter data and only provide critical information for observation by engineers, and advanced annunciators that allow field crews to interface with systems at the substation. In addition, data are provided in real time to the Operations Control Room, enabling System Operators to remotely observe events on the transmission system.

Grid Intelligence

When the transmission assets were separated from the previously vertically integrated utilities, ITC installed new RTUs and intelligent electronic devices ("IEDs") to provide Supervisory Control and Data Acquisition ("SCADA") data to ITC's state-of-the-art emergency management system ("EMS"). The new RTUs provide a wealth of information from substations that is prioritized and monitored by the control room. The robustness of the data allows quicker analysis of events and efficient response. System Operators are able to remotely operate equipment in the field, when appropriate, to quickly restore service.

ITC also utilizes dynamic displays to provide visualizations of the transmission system data increasing the company's situational awareness. The EMS is used to provide the System Operator with a variety of displays at their desktop with key information to assess system integrity including equipment voltage and thermal parameters versus established operating limits, magnitude and direction of power flow, reactive dynamic reserves and interconnection status with neighboring transmission operators. PowerWorld software is used to create a wide-area graphical view of the entire ITC system providing simultaneous visualization of related information on line and breaker status, line flows and voltage magnitude.

Assessing System Security

To assess the security of the transmission system, ITC utilizes analysis tools as part of the EMS that constantly search for potential overloads and voltage issues. The State Estimator and Contingency Analysis tools help System Operators assess transmission system reliability. The State Estimator acts as a filter for raw SCADA data; it runs once every minute and provides thousands of data points reflecting the entire system state.

Contingency Analysis uses a real time State Estimator snapshot to analyze hundreds of contingencies at least once every ten minutes. It tests system integrity by simulating failure of

individual grid components and provides results of contingencies and their impact, in order of severity for both voltage and thermal limits, on tabular displays. These analytical tools provide “up to the minute” information about the security of the grid and alert System Operators to system instabilities that might otherwise go unobserved.

Critical Equipment Monitoring

The monitoring of critical equipment is extremely important to ensuring the reliability of the transmission system. To do this, ITC has deployed IEDs that are capable of self-diagnosis. Data on the status (i.e., temperature, oil analysis, etc.) of key pieces of equipment are provided in real time to analysis programs. These programs identify where trending changes and anomalies in the data may indicate problems in specific pieces of equipment. These devices and online monitoring of equipment make it possible to take preventative measures based on changes in key indicators. In the field, where once only general status alarms were provided to System Operators, IEDs allow intelligence to be distributed beyond the Operations Control Room and RTU and into the device itself. IEDs are able to self diagnose their condition and report back to the Operations Control Room, virtually eliminating the need for field calibration and inspection to ensure the device will operate reliably when needed. In the case of protective system relays, when a fault is detected, the relay sends a signal directly to the circuit breaker to trip with no delay.

One specific example is the Transformer Monitoring Project which provides protection for transformers by analyzing system conditions and sending alerts to ITC engineers for further analysis. These include dissolved gas in oil analysis, power factor bushing monitor, full range of temperature monitoring, current monitoring of fans and pumps, active cooling control as primary control system, and traditional fans and pumps.

Inter-Control Center Communications Protocol

Inter-Control Center Communications Protocol (“ICCP”) is an international industry standard protocol that is utilized extensively by transmission owners to exchange data with other control rooms, local distribution companies, RTOs and ISOs, and non-utility generators. The protocol is usable with EMS made by different vendors, regardless of database structure and is completely independent of any protocols used to communicate with field devices.

Event Analysis

In addition to enhanced real-time monitoring and control, Smart Grid technologies facilitate analysis of system events after they take place. In the past, engineers were required to access relays and fault recorders to download data associated with a system event and attempt to piece together what transpired. In those situations, dial up access was not always reliable and modems were not secure. Additionally, the lack of any time data made sequencing events very difficult. Today, devices in the substations have IP addresses and are accessible via the secure frame relay system enabling faster, more accurate, and more reliable analysis. RTUs are also supplemented by microprocessor relays with digital fault recording capabilities.

ITC has also deployed Global Positioning Satellites (“GPS”) clocks in its substations to provide a common time stamp enabling sequence of events analysis across multiple locations and time zones on the grid. Data streams into the central monitoring stations from the substations while GPS are used to synchronize all substations to a common clock with no variation between substations. This is very important since an unanticipated event can trigger a cascading series of equipment operations that ripple through the grid in milliseconds. To determine the root cause of an event, data must be recorded and retrievable and must be sequenced in order to logically map the root cause. ITC system engineers are then able to “piece the puzzle together” quickly and with confidence. The availability of reliable sequenced data allows ITC to respond rapidly to

unanticipated events, determine the root cause of the failure, and implement corrective actions in the field to restore normal operations.

ITC's communications network provides a reliable means to collect data across a wide area. However, to realize the full benefits of ITC's Smart Grid investments, the organization's analytic capabilities must evolve still further over time.

Summary

More so than at any point in recent history, we have a great opportunity to affect how we generate, transmit, and consume energy. An extraordinary interest exists to:

- generate electricity from renewable sources;
- transmit power more efficiently and reliability over vast distances;
- reduce the impact to the environment and our health and well-being; and
- consume energy more intelligently and efficiently.

A major evolutionary step in the grid's design, planning, and operation is needed using new design concepts and innovative technologies that can be integrated into a modern infrastructure.

To date, ITC's Smart Grid investments have focused on improving the reliability, security, and functionality of the transmission system. ITC's strategy has leveraged both the communications capability of the existing communications network and a strategic view of the types of data required to improve operation and analysis of the system. Years of planning were dedicated to ensuring that ITC could integrate security and communication needs into a robust data network with flexibility for upgrades in the future. ITC will continue to upgrade the transmission system with appropriate Smart Grid technologies as their value to the operation of the grid is proven. This approach ensures that ITC will retain interoperability with various Smart Grid applications as they are deployed.

Case Study – Critical Equipment Monitoring

The cost to replace a transformer on the ITC system can exceed four million dollars. The lead time to construct and acquire a new transformer is close to two years. Due to the critical importance of these assets in the transmission system, ITC deployed an advanced monitoring and diagnostic system on its transformer fleet in Southeast Michigan. The monitoring and diagnostic systems for the remainder of Michigan will be completed by early 2010.

On July 10, 2008, ITC avoided a potentially catastrophic failure when a transformer bushing alarm was received by the ITC Transmission System Coordinator on the 345/120kV, 370MVA autotransformer located at the St. Clair Power Plant. This transformer is a key system interconnection between ITC Transmission and the Independent Electricity System Operator in Ontario, Canada. After a controlled shutdown and inspection, a bushing was confirmed to be deteriorating rapidly, and the decision was made to replace it and one other bushing showing similar degradation. ITC believes the bushing in question would have likely failed in service causing extensive damage to the transformer and the assets in its proximity, or possibly a complete transformer failure.

By continuously monitoring key assets, ITC can detect abnormalities and prioritize maintenance on the system. Accordingly, the advanced monitoring and diagnostic system pays for itself quickly with a small number of avoided failures.

Case Study – Event Analysis

ITC Transmission operates 106 miles of High-Pressure Gas-Filled underground cable systems in and around the city of Detroit. These cables are pressurized with over 200 pounds of nitrogen and have been in service for approximately 50 years. These cables have been proven to be very reliable and low maintenance systems.

ITC upgraded all of the nitrogen pressure monitoring systems in 2006 to a remote monitoring system, replacing out-dated paper chart recorders. The remote monitoring allows the pressure levels in the cables to be monitored in real-time rather than only during periodic on-site maintenance inspections. Additionally, data is archived in an electronic warehouse for analysis of history with accurate time stamped data.

In September 2007, ITC noticed a significant drop in pressure on one of the HPGF cables and deployed technicians to investigate. Analysis of the data revealed a sudden, but steady, pressure loss. The investigation revealed that the day the pressure loss began, a water utility contractor was performing work in the vicinity of the underground transmission line. Excavation of the underground cable was performed that quickly revealed evidence of an attempt to install a water saddle valve on the underground cable pipe which initiated the leak. The gas monitoring system allowed ITC to quickly identify and repair the problem which minimized downtime of an important transmission line for the city of Detroit.