At the pulse of power

ABB is never short of solutions for operating and controlling the grid

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As the global demand for power is growing, so too are the electrical grids. In growing economies, like those of China and India, the need for power is straining the existing system's capabilities, while in other parts of the world, ongoing regulatory efforts force a continuous restructuring of the vital infrastructure. Maintaining what can only be described as a very dynamic infrastructure involves many complex operations. However, irrespective of the complexity of this task, the reliable supply of energy must always be the prime goal of any provider of electrical energy system solutions.

As the world's number one provider in the field, ABB has been helping customers manage their grid and play a vital role in the operation of power systems for many generations. Continuous improvement and innovation have led to the development of modern and comprehensive solutions for controlling and operating the grid. ABB's Network Manager Platform, for example, provides the capabilities for traditional supervisory control and data acquisition (SCADA), solutions for generation and transmission management, distribution and outage management capabilities, as well as Business Management Systems for energy trading. However impressive these solutions may be, a company must never relax. An ever-changing market climate means that ABB is constantly adding to or upgrading their already extensive portfolio of energy operation solutions.

Every plug and outlet in a household, industry or in any consumer's facility connects to a myriad of lines and connections, which form a network similar to the veins of the cardio-vascular system. Distribution networks are constantly changing shape and size whenever consumers are added, appliances are connected and disconnected, or parts of the system undergo repair or maintenance. Built as star or ring structures, meshed or unmeshed, as cables or overhead lines, the distribution network finally connects to substations. Here, at the border of the transmission or sub-transmission system, the bulk of the power is fed into the distribution grid, converted, regulated and controlled. The transmission grid acts as the arterial lifeline in that it delivers energy to all parts of the system, and any disturbances will have a widespread impact. For example, millions of lights go out, public infrastructure may collapse, and the economy and people suffer. Therefore, the reliable supply of energy must always be the main goal of any company providing solutions for the electric energy systems around the world.

Transmission and distribution solutions

For many decades, ABB has been at the forefront of systems development – in particular, information technology (IT) systems development – for power transmission and distribution. Since the development of the first remote control system for power plants in the 1920s by ASEA and BBC, the company has come a long way with its IT systems of today that not only help customers manage their grid, but which also allow them to play a vital role in the operation of power systems. ABB solutions range from a pure SCADA system, to advanced transmission and distribution systems which ensure secure and stable operation and prevent blackouts. Furthermore, modern Energy Information Systems exist to help the operator ensure that the grid is operated in an economically optimized way. All the required business information is available at the click of a mouse.

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ABB's Network Manager offers a complete range of functions to fulfill the needs of transmission network operators and of combined network and power generation operators. These range from the analysis and optimization of day-to-day operations and short term scheduling to the real-time dispatch and control of generation.

ABB's Network Manager platform provides an open system architecture and versatile integration of ABB enterprise applications or third-party software. It provides the capabilities for traditional SCADA, solutions for generation and transmission management, distribution and outage management capabilities, as well as Business Management Systems (BMS) for Energy Trading.

BMS are market operations systems that provide complete software solutions for managing central energy markets for Independent System Operators (ISOs), power pools and Regional Transmission Organizations (RTOs). A typical BMS provides tools for day-ahead or real time generation scheduling, and is delivered on an open architecture platform that features state-of-the-art interfaces to other software systems. BMS also delivers an e-commerce platform to administer all aspects of a competitive energy market, and it provides settlements and metering interface.

The company's Generation Management System (GMS) allows for advanced operation and optimal scheduling and analysis of generating

Scope of supply for Network Management offerings

power plants. This includes load forecasting, in-flow forecasting, transaction evaluation, bidding, unit commitment, hydro-generation scheduling and optimal usage of generation resources with integrated scheduling and trading, multi area load-frequency and tie line balancing.

ABB's Energy Management Systems (EMS) extends SCADA functionality (to form the SCADA/EMS solution) with applications such as state-estimation, which provides a detailed and accurate picture of the network with a time resolution of seconds to minutes. Contingency analysis, also a part of EMS, helps operators to run "what-if" scenarios for different network conditions to determine, for example, what corrective actions are needed to enable overloads to be mitigated in an optimal way, or to assess reactive power balance and margins, or even to manage loading limits. In short, EMS allows utilities to support secure and efficient operations in regulated and deregulated markets by:

- Managing active power flows and voltage profiles
- Rapidly determining operational security
- Detecting and mitigating congestions
- Identifying voltage collapses
- Performing analysis on recorded disturbances and simulating restoration tasks
- Providing a training simulator

However, EMS applications are not ideally suited to modeling the details of the distribution level network. In fact, the network model size, in terms of power systems objects, is usually a factor larger in distribution systems than in transmission systems. To compensate for this, Distributed Management System (DMS) applications increase SCADA functionality capabilities (to form the SCADA/DMS solution) in fields where EMS applications fall short. DMS can handle feeder reconfiguration, reactive power component scheduling, and line cut modeling. It also supports constantly changing network topologies (due to extensions, maintenance or temporal local outages), and allows for a geographical view of the distribution network 1. An outage management function provides the capability of integrating customer information and trouble call management systems into the existing SCADA/DMS system, thus allowing operators to mange the distribution network with a fully integrated system.

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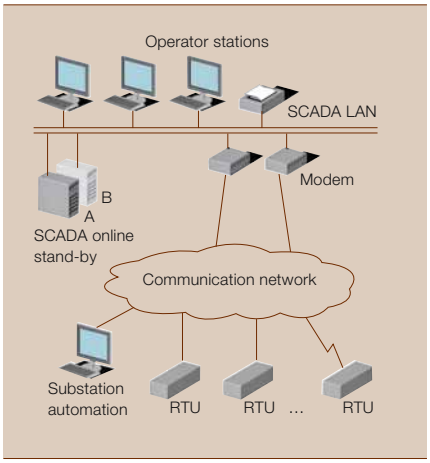
Finally, ABB's utility communications solutions complete the portfolio, providing functionality for operational and corporate communication networks. Broadband and power-line carrier solutions enable the transmission of voice, and vital control and protection signals for the operational needs of electric utilities.

Making the case

Market rules affecting business operation are constantly changing. Currently three factors have been identified which influence how power grids are operated, and the first of these focuses on the continuously increasing demand for power. Growing worldwide economies need more power, forcing utilities to operate their systems closer to their physical limits. This in turn reduces supply-margin security and puts more stress on the network equipment[1)].

At the same time, with growing networks and interconnections between countries[2)], the influence of economics on the supply of power, the second factor to be identified, is greater than it has ever been. In other words, in-

1 A geographically distributed process



Footnotes

[1)] Network expansion happens at a slower rate due to environmental and economic considerations.

[2)] The European UCTE network, extending from northern Denmark to southern Greece, and from the west of Portugal to eastern Romania and Bulgaria, currently supplies about 450 million consumers with an annual consumption of approximately 2,300 TWh.

stead of physics and safety influencing the behavior and plans of electric utilities, as they did in the past, market laws are now the driving force behind the flow of power in the grid. This change demands connectivity to many non-operational IT systems, such as ERP (Enterprise Resource Planning) and CRM (Customer Relationship Management) which carry business relevant data.

The third and final factor focuses on the environmental side-effects of increased power generation, especially the level of CO_2 emissions. The spotlight is now firmly on both the efficient use of energy, and the increased usage of renewable, distributed energy.

Companies like ABB can easily cope with these factors. The solutions described above go a long way in addressing the changing nature of the market. However, some technology initiatives were needed to further master these challenges, and these are described in the following paragraphs

Regulatory influence, economics and the growing use of standard IT infrastructure are fostering the integration of IT systems beyond their original boundaries.

Innovative solutions

While traditional substation automation solutions safeguard humans and equipment from operational failures in milliseconds, SCADA/EMS systems work on the minute time-scale when dealing with network operational conditions. However, with many global power grids already operating closer to their limits, the time to act and react to disturbances in the network has become shorter and more valuable. Traditionally, many power system applications report overloads or voltage sags on individual lines or nodes in the network. However in order to deal at speed with the system-wide consequences of such problems, a more complete picture is required. This picture can be supplied using ABB's Phasor Measurement Unit (PMU) based solutions. These provide a system-wide view of the network, thus enabling the operator to take corrective actions quickly in case of a critical system state. Highly accurate results are provided when PMU measurements are integrated into ABB's state estimator solution. These same PMU measurements are also used to assess the general power system condition as part of ABB's Wide-Area-Monitoring and Control portfolio. Operators can then take corrective actions (eg, use FACT devices to control the power flow) based on information concerning the entire network.

In a typical emergency situation, operators are usually overwhelmed with massive amounts of data and alarms. ABB is currently investigating different solutions to support utilities in this regard.

First of all, the operational awareness of the users in the control room is sharpened if more visual information about the power system state is provided. Usually power system collapses are a result of cascading failures in the grid, so it is important not only to view individual components, but also system-wide developments must be easily identified. The inclusion of voltage or frequency distribution contour maps 2, or of grid-wide power oscillations are examples of the extra information that could be supplied when observing the state of a system state before a critical event occurs.

With the meshing of large systems, not to mention the growing network sizes, the number of errors and alarms an operator has to deal with can be overwhelming. ABB supports its customers with an alarm management system capable of identifying root causes. This system helps to filter alarms and suppresses redundant events so the operator can react quickly on system failures at the right time.

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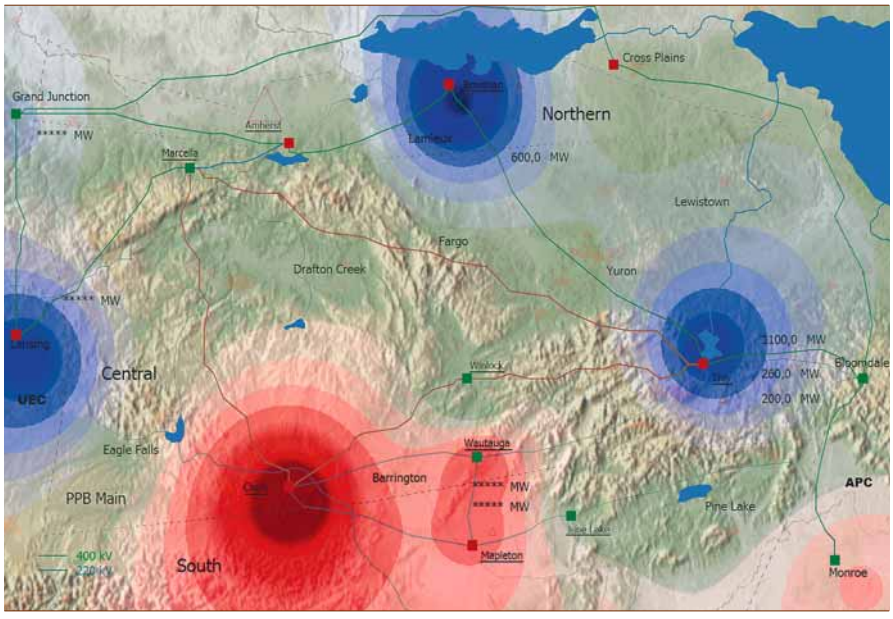
Regulatory influence, economics and the growing use of standard IT infrastructure are fostering the integration of IT systems beyond their original boundaries. However, the technical challenges of integration are significant. Cyber-security related issues further complicate the situation. With NERC/CIP cyber-security regulations[3)]

2 Dynamic Network coloring in Network Manager – Red/blue colors indicate a deviation from nominal voltage levels (high/low)



now in effect since the beginning of 2008, ABB Network Management is constantly developing or using a full set of tools to provide end-customers with the possibility to comply to these regulations within the scope of supply. With its SCADA/EMS solutions, the company ensures early in the development that: involved personnel are well trained on cyber-security standards; code access is logged and monitored; the software follows best practices in threat modeling; and the accompanying coding practices are followed. Compliance is also required during system deployment on activities such as restricting the number and types of services needed to fulfill operational requirements to the absolute minimum, and hardening the system by removing or disabling all unnecessary network connections, services and file shares, while ensuring that all remaining functions have appropriate security settings. However, it is important to understand that security is about risk management and that optimal security can only be achieved by maintaining close co-operation and contact with customers. ABB is also using internal (for example, ethical hackers) and independent facilities (eg, US Idaho National Labs) to test the vulnerability of its Network Management system. In short, ABB is developing its systems together with its customers with the aim of achieving two very challenging goals:

- Opening up the systems to met the ever demanding economic objectives, while at the same time
- Safeguarding the systems from unwanted intrusion or tampering

Energy efficiency and the increased use of renewable energy resources are very important factors in the development of transmission and distribution management solutions. On the high-voltage level, the integration of wind generation technologies is a major topic as confidence in wind power continues to grow. ABB's Network Management system helps to schedule and balance wind power's stochastic influence in an economically optimal way without jeopardizing system stability. On the distribution level, the influence of distributed generation (solar, biomass, combined-heat-power, etc.) is changing power flows in the network. In former times, power flow was uniquely directed from the generation level to the distribution level via the transmission level. Nowadays, the growing in-feed of renewable energy at the low-voltage level needs to be dealt with. At the same time, the installation of more "intelligent" devices in the field produces a vast amount of varying data. The analysis of this data helps to determine the most optimal ecological and economical solution for dispatching distributed generation. In the future, ABB's solution will help to determine the potential for adding distributed energy resources. The utilities can then concentrate on finding suitable network extension solutions.

ABB is adding capabilities for emissions trading to the "market infrastructure support" software that forms part of its BMS. BMS' "Market Operations" applications are designed to manage bids and offers (including energy, reserves, congestion, etc.) from market participants, and emissions trading (CO_2, NO_x, etc.) is a natural extension to the capabilities of these systems, given that the practice of trading emissions is now common in Europe under EU directives and NO_x is actively traded in the US.

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Final thought

With societies so increasingly dependent on the reliable delivery of energy, a secure, affordable and ecologically sustainable supply is top of the agenda for all utility companies. Behind the plug, ABB is well prepared to take on these challenges with a full range of transmission and distribution solutions.

A typical control room

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Footnote

[3] See http://www.nerc.com/~filez/cip.html (NERC /CIP webpage) (December 2007).