Integrated Network Management improves
the Services of Utilities

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Summary

The paper addresses the changing objectives that the electricity market impose on the power
industry, as a result of openness, competition and market orientation. A consequence being a
tremendous restructuring of power companies and their ownership, all over the world. The paper
further discusses the new roles that emerge for generation, transmission and distribution
companies and points at the changing focus towards fulfilment of business objectives and
importance of increasing customer services.

Information is taking a new role, bridging technical, administrative and economical aspects. As
such the importance of an enterprise-wide Information Technology (IT) Strategy is growing,
taking all company objectives into consideration. The development of new integrated network
management solutions have become state-of-the-art, but now under the common IT standards that
are part of the company strategy. This is also true for the communications infrastructure. The
operations department has become an integrated part of the corporation and its overall
objectives and not the "island" of operation that it often was before.
1. Introduction

The power industry is in a phase of transition - openness, competition and deregulation are being introduced at breakneck speed. As a result, the use of information is taking on a new role, bridging technical, administrative and economical aspects. The operational focus has moved to fulfillment of business objectives and increasing of customer services. The importance of an Information Technology (IT) strategy which takes account of all company objectives is growing.

Traditionally, there has been a strong belief that centralized control provides the most efficient solution to any nations energy supply. Generators and network operators have worked closely together to find an optimum for the minute-to-minute operation, while developing resource scheduling programs that optimize generation and network supply in a medium-term to long-term perspective. This has been fulfilled in a large number of projects where advanced EMS (Energy Management System) and DMS (Distribution Management System) are installed.

However, the new electricity markets are characterized by open access networks, competition in power generation and establishing an energy market place for trading of energy. Electricity consumers become customers signing contracts with the producers. Network operation is regarded as a monopoly with its services paid by transfer tariffs.

Operators continue to focus on security, i.e. reliability of supply, while minimizing transfer losses. Quality, in terms of voltage and frequency, are key factors to reach customer satisfaction.

A need for information applies also to network management, on all voltage levels. The development of network management systems to meet with the new market demands offers an opportunity to avoid the “island-of-operation” that was common only a few years ago. Opening up the electricity market introduces competition which demands cooperation between operation, trading and risk management. The need for integration rapidly evolves.

ABB brings integrated industrial IT solutions to the market with our Panorama for the utility industry (figure 1). Panorama assists power companies with efficient tools to cope with the transformation into open markets. The S.P.I.D.E.R. product represents ABBs offering for energy as well as transmission and distribution network management. Panorama offers integration in a multi-application environment, a new spectrum of decision support tools as well as fulfillment of the needs for business management orientation. Its vertical integration implies the coordinated monitoring and control between control centers and the local plant equipment. It involves local plant controllers, protection devices etc. as well as centralized software functions for optimization and enhanced monitoring. The horizontal integration meets the needs of an integrated utility-wide computing environment. This facilitates optimal solutions for the coordinated monitoring and control, from power generation to power distribution and load management, bridging the tasks of planning, operation, follow-up and maintenance departments of any power company.

2. A power industry in transition

The power industry is in a rapid change. The usage of information and control for operation receive a new role. Focus is placed on operation in relation to business objectives. The increasing competition and the requirements for improved overall economy and quality of services is accelerating the demand for more accurate and up-to-date information. Many new IT-based systems for improving and even making a rational operation possible are put into effect on different levels of the power system. Information and control systems are a life nerve for the power industry. The information technology has become the critical means to be successful on a competitive market. Information is a strategic resource.

Figure 1 Industrial IT - Panorama for integrated solutions
With the increasing interdependence of operational and planning functions for generation, transmission and distribution, and the possibilities of their integration with commercial and service functions, the importance of an IT-strategy taking account of all power company business units is growing. The traditional EMS, and DMS, has, until recently, remained fairly isolated from other utility information systems.

Today, Information Technology (IT) can offer efficient and cost-justified solutions for the integration of these resources. The integration aspects of operation in a broad sense, both within the control center itself, as well as in the operation, all the way from generation, to transmission and distribution, down to consumption, is the challenge for the future (figure 2). Such an integration has economical as well as organizational repercussions.

The new integrated information system may be realized in the same technical system or in different computer systems that are, strongly or weakly, connected to each other. Open systems, client-server technologies and standardized, componentized systems facilitate these solutions.

The future and challenging trends within the entire area of power system information and control can be viewed from four different vantage points:

1. *The power industry in a new role.* The utilities will become energy companies, not simply power companies. They will be market-oriented. Deregulation, local producers (cogeneration), common carrier networks, will follow as a result. Focus will be placed on operation. All these will require many new demands for information and control systems working in real-time.

2. *From administrative computing to instantaneous operation.* The administrative computing tasks of today, such as design, maintenance, spare parts, customers, etc., will be the base for common computer based tools, including even the instantaneous operation. Technology will make it possible to use the similar base, all the way from design to maintenance.

3. *Vertical and horizontal integration* will dramatically broaden the power system information and control area. One example of integration is the co-operation between the control center and the local protection devices. Another example is the introduction of controllable objects, static VAR-compensators. Cooperation with asset management, graphical information systems and tools for trading are other examples.

4. *Information system technology.* The basic technology, will be more and more of industrial standard types, available on the market. The system will be open in nature, which means that components can easily be added or taken away, depending on actual need. These may originate from different suppliers. Examples of components are workstations, databases, SCADA, communications, advanced applications, etc.

The "traditional" electricity market is characterized by national, regional and local monopolies for power supply. For generation as well as for distribution companies there have been structural changes in the past and this is expected to continue in the future. In the past companies that were in possession of concession of a distribution network more or less owned the customers. In reality, there was no alternative supplier of electricity to a customer. Still there were a lot of mergers taken place to improve efficiency and economy. In the future more mergers and a more distinct
separation between network companies and power producers/retailers are expected to come.

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Figure 3 New roles on an electricity market

Network operators appear on three levels:
1. Main grid, where a national grid company is assigned overall responsibility for the national interconnected power system, including the power balance.
2. Regional network, with operators responsible for subtransmission in their corresponding area.
3. Distribution network, responsible for the widespread network giving services to end-customers.

A new set of specialized roles on the electricity market is emerging (figure 3). The functions needed by each company may differ depending on the actual role. But the requirements on efficient IT-support systems for power system operation are basically the same.

3. New IT structures for Network Management

The new IT-demands can be viewed from three directions. First, support of all aspects of the company’s business processes. Second, the traditional operational support systems, like production control, network analysis and operation enhancements, which will become more important and undergo an adaptation to fit into the new demands. Third, customer information and metering because contractual agreements need to be followed up for subsequent accounting and final billing (figure 4).

The network operator (transmission and/or distribution company) is required to provide information to those customers connected to its network and who trade across it. That same operator must ensure efficient use of its installed base (the wires, transformers and substations). The generation company must offer its power to the market in such a way as to meet with its commercial objectives as defined by its contracts for sale of electricity (short-term and long-term) and in compliance with secure operation of the transmission and distribution networks.

Operational support includes the traditional power applications needed to support business decisions in the new electricity market. They include network operational capacity calculations and assistance in determining the most cost-efficient power generation, both short-term and long-term. The set of functions being used depend entirely on the role each company has on the electricity market.

Load forecasts and its coupling to scheduling are crucial for business decisions and need to be seen in relation to other market analysis activities. These forecasts need to include present as well as potential customers for any supplier.

The physical limitations for transporting power within acceptable levels of security are of prime importance in determining the feasibility of simultaneous bulk power transactions. This becomes an even greater concern in open access power networks, and in a market where accurate capacity evaluation is needed for decisions on short-term business transactions. The ability to evaluate power transfer capability is, therefore, invaluable for
decisions on short-term energy transactions and planning. An open, inter-connected transmission network substantially increases the volume of wheeling transactions. These and other transactions significantly impact the cost and reliability of the operation of the power system. To evaluate the feasibility of any such wheeling transaction is a difficult task without the help of application software. The module permits the analysis of simultaneous transfer in a model with full non-linear accuracy. It can analyze multi-area problems and obtain a maximum security in MW transfers between any number of companies, power pools or even individual buses.

The new market requires tools for each of the generators seeking their own optimal solutions. This function is designed to assist utility operational planners in making mid-range decision related to fuels, emissions, thermal and hydro generation as well as power/energy transactions.

Support for distribution network operations include another set of functions. Improving end-user services to keep them as the customer in a competitive market is gaining importance. At the same time minimizing cost and streamlining of processes for the design and maintenance of the assets is also coming to focus. All this leads to integration needs between distribution network operation systems with customer information systems as well as with asset management and graphical information systems. And the distribution network management systems themselves model the networks all the way to end-users and supports the work flow in the distribution company by for example providing crews with direct interface to all the data and work procedures that exist.

The design of the SCADA/EMS/DMS systems of today is going through a dramatic change. New architectures and tools built on standardization results will offer new integration possibilities. The existing systems have been tightly integrated. The extensive functionality in today's SCADA/EMS/DMS results in many and large software modules making software maintenance a large undertaking. The tight integration also makes functional extensions difficult. New functionality has to be backwards integrated to installations in operation. Integration with software from other vendors or with other systems is also a challenging effort.

ABBs S.P.I.D.E.R. SCADA/EMS/DMS system is evolving into a componentized system based on standards, as they evolve. The evolution results in a system with successively more fine-grained software components integrated through applications that form self contained products comprising one or more components, separately developed and maintained.
Software components require a platform to plug into (indicated by the middleware box figure 6). The platform is defined by a set of APIs (Application Program Interface). Such an “API” platform enables installation of components without source code changes and hence independent release cycles for the component. The platform of a component-based system is built on top of some middleware, e.g. a CORBA (Common Object Request Broker Architecture) based product, Microsoft COM (Component Object Model), a message oriented middleware (MoM), a database or any mixture of them.

The open SCADA/EMS/DMS platform also support easy communication with external systems enabling work processes to exchange data in different stages of refinement. An open SCADA/EMS/DMS will make increasing use of the web for the Human Machine interface (HMI) giving new user categories easy access to data. It will integrate with, office applications, vertically with devices having increasing intelligence, other SCADA/EMS/DMS and with other IT-systems. As WANs will be used in this integration the security becomes important.

The standardization efforts in the world are also evolving, certainly true also for utility IT-solutions. IEC, EPRI, OMG are some of the institutions, CIRED and CIGRÉ are also moving the objectives forward. ABB is active in the standardization groups. Examples of the results so far are the CIM (Common Information Model), the CCAPI (Control Center API), the DAIS (Data Acquisition for Industrial Systems).


4.1 ENEL, Italy; nation-wide multi-center EMS/TSO

ENEL, Italy was formerly a state-owned power company responsible for almost all of power supply in Italy. The Italian power system serves around 57 millions of people with a power consumption of 280 billion kWh. ENEL having an installed generating capacity of 57,000 MW.

ENEL is at the moment going through a heavy restructuring in that the operations are split into separate companies and some of the new units are being privatized. In this process the power system control schemes are being revised in a new project. A new national control center is established with three regional network operational centers. This constellation is aimed at operating as the Transmission System Operator (TSO) of Italy when deregulation comes into effect.

Three regional control centers are established for the detailed network supply and three generation control centers are also established for the privatized generation companies. Refer figure 7.
ENELs new control system is built on 30 S.P.I.D.E.R. SCADA/EMS systems. The systems will communicate with the process using standardized communication protocols and via an ENEL owned TCP/IP network. The data acquisition consists of 245 new ABB RTU 560 and 200 existing RTUs, together with protective devices and other IEDs (Intelligent Electronic Devices) that will be connected to 22 communication nodes using the IEC 60870-104 and -101/-103 protocol standards. The information is fed to the control centers on an IEC 60870-6 Tase.2 network (ICCP). The URTICA (UCTE Real Time Information Communication Architecture) is used for transferring information between control centers and also interfacing with the European coordinating center in Switzerland.

Among the advanced network functions can, besides more traditional network monitoring and security analysis functions, be mentioned packages to detect transmission bottlenecks (TRACE - Transfer Capability Evaluation) but also intense use of Operator Training Simulators. Also to mention the establishment of a utility data warehouse for statistical information available to all connected users, built on ABBs UDW 200. Integration to existing IT-systems is also implemented, e.g. to a system for load-frequency and voltage control as well as connection of a disturbance analysis tool that is used by ENEL today.

By adopting to these international standards ENEL creates the openness for the future connection of new substations and operational systems throughout the country. The amount of transferred information accumulates to around 200,000 points of data with a continuous data flow of 7000 measured values per second. The network calculations are designed for approximately 6,000 network nodes.

**Figure 7 ENEL System architecture**

Statnett is the power grid company in Norway acting as a TSO (Transmission System Operator) in the country. At the same time Statnett is the part-owner of the NordPool market arrangements in the Norwegian-Swedish electricity market (figure 8).

Statnett is responsible for keeping the Norwegian main grid at its goals and at the same time cooperating with Svenska Kraftnät to keep the grid ready for a seamless open transmission access to the actors in the market. To further improve the operational situation Statnett is now installing a new energy management system.

The new EMS is built on four redundant S.P.I.D.E.R. EMS configured in a distributed fashion throughout Norway. Statnetts TSO-system comprises four control centers, one national and three regional. In total 110 substations are monitored. Interface to 54 existing control centers, exchanging both operational data and schedules, has been built. In total 105000 points are included in the database.

The system is highly distributed around a wide area network under the ownership of Statnett. This is true for data processing, the man-machine interface as well as operator training and system development. In addition, the TSO-system will be interconnected to existing Statnett systems, e.g. for forecasting and for maintaining a record of power system split and interchange between regions and to Sweden.

### 4.2 Statnett, Norway; A study of a multi-center TSO/EMS
The TSO functionality comprises an extensive set of SCADA-functionality for monitoring and control of own and adjacent substations. With the distributed man-machine interface it is possible to view any information point according to defined authorities and priorities. A utility statistics warehouse is built using ABBs UDW, where operational statistics data are stored for reporting and analysis purposes according to a legal framework in the marketplace. This information may also be used for information exchange with other systems and control centers. As well other systems may store information in this warehouse available for all users of the integrated system. The TSO-system also integrates functions for maintenance and personnel resource scheduling.

The set of power applications shows naturally the standard set for network monitoring of today including state estimation, dispatcher’s power flow, contingency analysis, short circuit calculations etc. All these to maintain the security in the network.

Additional functions included are dynamic security analysis, voltage collapse analysis in real-time as well as in study mode and other mid-term transient stability calculations. All these are needed to both offer the grid open to every actor in the NordPool market and also to maintain the interconnected Norwegian - Swedish main grid.

4.3 China Light & Power, Hong Kong; a study of a large DMS

China Light & Power (CLP) in Hong Kong has been running a large distribution automation project built on a full fledged S.P.I.D.E.R. SCADA/DMS system with advanced network analysis applications. The regular system control center is equipped with an emergency back-up control center at another location. The system integrates with many other systems, e.g. a customer information system, a trouble call & outage management system and further on an automated mapping & facilities management system (figure 9).

CLP services comprise 2,200,000 customers and the company has a staff of 4,500 persons. The network is huge with 160 primary substations and 20,000 secondary substations. The total sales is 23,000 GWh with a maximum demand level of 5,000 MW. The system will administer more than 250,000 data points.

In 1994 the Government made an audit review of CLP performance which resulted in a strategic project where objectives are to reduce long outage times, improve the lack of accurate and timely information for operations and also fill the gap of lacking remote switching facilities. In 1995 the project was established and ABB was awarded a substantial part of the contracts in 1998. The new distribution management system, built on has become fully operational during the fall of year 2000.

The integration between maintenance planning, customer information and the systems having documentation of the distribution networks forms a basis to improve customer service. E.g. the outage management is fed with information on fault location, fault isolation and restoration as well as an automatic estimate of number of interrupted customers, which may lead operations in prioritizing the maintenance efforts. And the enhanced distribution operations analysis will model the loads of distribution transformers, the customer substations as well as the distribution network connectivity. The power flow calculations give results of best operational state as well as performing loss analysis. The implementation of a utility data

Figure 8 Statnett, Norway TSO System Configuration
warehouse, built by ABB's UDW 200, will help CLP to follow-up operations as well as achieving a precise and detailed base for scheduling of operations. The enhanced network functions include e.g. a fault location, isolation and service restoration for overhead and ring main unit circuits. A load modeling and allocation function adjusts the load values at network load points. And also a distribution load flow in both real-time and study modes, with a full set of operator changes during a study. Such a large system involving a huge network and integration of many systems sets forward challenges where both parties of the installation are affected, e.g. developing of staff knowledge and preparedness to take over the system. Handling of rapid technology development during the project time, such as implementing improved distribution network analysis with the goal of execution of a complete load flow within a few seconds. Customization of standard software as well as a voluminous data engineering work. However, a careful project schedule and good communication between project groups on the customer and the supplier side is here the key.

Figure 9  CLP, DMS Control Center and System Architecture

4.4 Gothenburg Energy, Sweden; a case on System Integration

Gothenburg Energy is a community owned distributor for the second largest city in Sweden. The company is responsible for energy supply in the city. The energy service comprises electricity and gas as well as district heating. With a turnover of 200 MUSD in the electricity branch, covering 240 000 customers and 4200 Gwh of delivery it is one of the large actors in the Swedish electricity market (figure 10).

During 1995, it became obvious to the management in Gothenburg Energy to focus the customer even more, due to the deregulation in Sweden. That is to know the customers expectations and needs even better and to improve the performance of the operations from the customers point of view. The integration between systems for maintenance planning, customer information and the systems having documentation of the distribution networks forms a basis to improve customer service. By combining information from these systems one quickly can identify those customers that are affected of an interruption of supply and their importance. This information is used to prioritise repair and supply restoration activities accordingly. Similarly one can produce mailing lists of customers whom to inform, when performing such planned maintenance that will interrupt the supply.

The IT-concept decided upon was grouped into a number of applications areas. A such this became one of the first Panorama installations that ABB has performed:

1. Customer Information - A customer information system (CIS) for large customers and a CIS for ordinary customers. An accounts receivable system and a sales support system. All of these systems are common for electricity, gas and district heating.
2. Bulk Trading - A system for electronic trading on the NordPool market of bulk power and for computerised forecasting of the load has been installed.
3. Energy Metering - At major customer premises, and at customers that have selected to buy electricity from other suppliers, electronic energy meter terminals are installed. A metering administration system has been installed, where metering results are stored and processed according to the legal rules. The ABB AMR system also maintains and creates the relations between delivery points, metering devices, meter values, customers and suppliers.

4. Asset and Maintenance Management - The general purpose Asset and Management System (ABBs AMS) is common for electricity, gas and district heating and comprises the distribution network as well as the production units. The AMS comprises more than 1 million objects (apparatus) when fully implemented. A Geographical Information System (GIS) is common for the distribution networks of electricity, gas and district heating.

5. Energy Management - The distribution systems for electricity and district heating are monitored and controlled by separate S.P.I.D.E.R. SCADA systems. In the future the district heating system is planned to also accommodate the gas distribution network. Both SCADA systems are integrated with the asset management system. Data about assets usage and malfunctions are forwarded from the SCADA to the AMS system as input for the planning of maintenance works. Status about planned and ongoing work orders are forwarded to the SCADA systems to form a basis for coordination between operation and maintenance.

5. Conclusion

An open electricity market introduces intense competition between suppliers. To be successful in this market, information is key. Trading of power becomes a matter of handling both the market process and handling the financial risks, both short and long term. Therefore the need for analysis tools and decision-support systems rapidly evolves.

A similar need for information applies to network operations on all voltage levels. The competitive electricity market with its more dynamic energy contracts, requires more efficient support for scheduling network resources. New advanced decision-support tools are needed here too for the operation of interconnected power networks.

The rapid development of information technology in terms of micro-processor technology and communication speed and web-technology, as well as in software engineering and software standardization, offers a new opportunity for the utility industry to avoid the “island of operation” position that was common only a few years ago.

Today, a corporate IT-strategy integrating the objectives of the entire corporation is a reality, giving the full advantage of information as a strategic resource. As a consequence, the demand on network management
systems will increase as a result of privatization and deregulation. However the new network management will need to restructure its traditional applications, to implement new ones and integrate these with the business support systems. The new network management will continue to be a corner stone in supporting the new power companies to improve their quality of service and to secure that they reach their business goals.
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