Integrated electrical and automation systems

Tom F. Nestli, Peter Tubaas

As process plants get larger and more complex, automation systems must handle an ever-increasing number of signals. At the same time, the number of electrical consumers increases, making an electrical control system essential. The electrical control system is an automation system in itself providing an interface between the process control and the electrical consumers and actuators. ABB takes responsibility for all these systems and their integration. By letting ABB handle the integration and all the interfaces, customers benefit from faster project execution, reduced re-engineering, higher quality, and higher operational efficiency.

Electrical systems are clearly a core part of any process plant, providing electrical energy to drive motors, energize heaters, power lighting and auxiliary equipment. The electrical system is invariably complex, relying on thousands of components and kilometers of cabling. The complexity of the system increases with the size of the process plant. Such large process plants are reliant on automation systems to operate efficiently and safely. These automation systems will typically respond to tens of thousands of signals in a quick, predictable and reliable manner. The seamless integration of the electrical and automation systems are highly desirable in a process plant, a benefit recognized by ABB at the Statoil Snøhvit – or Snow White – liquefied natural gas (LNG) plant. Here, the Electrical Control and Supervision System (ECSS) communicates with a wide range of equipment and ensures a stable power supply to the LNG facility.

Snøhvit

The Snøhvit field – named after the fairytale character snow white – was discovered more than 20 years ago. The road to develop this gas field has been long and winding, but the project is finally close to production start. It is planned to go on-line during the summer of 2007.

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Soon, gas from the Snøhvit field, approximately 140 kilometers offshore in the Barents Sea, will be flowing into the gas processing plant for treatment and shipping to the global LNG market. The core products of the plant will be liquefied natural gas (LNG, 5.67 billion m^3/year), liquefied petroleum gas (LPG, up to 250,000 tonnes/year) and condensate (up to 900,000 m^3/year). All products will be exported by ship.

Snøhvit is the first development in the Barents Sea. The oil and gas fields were discovered in the early 1980ies. Combined with the adjacent Albatross and Askeladd fields, Snøhvit contains more than 300 billion m^3 of natural gas. Gas will be extracted from the seabed using subsea equipment, which are operated remotely from Melkøya. The subsea control system was delivered by ABB in the UK (now Vetco Aibel). The topside of the subsea control system, which is an integrated part of the overall Safety and Automation System (SAS), was delivered by ABB in Norway.

Complete control of the plant

Snøhvit is an extremely complex installation. The process is extensive, encompassing subsea control processing, complex LNG processes, and storage and loading of the final products.

No system is more critical to the processing plant than the combined safety and automation system. The number of signals running through the Snøhvit process is enormous; the Process Control and Data Acquisition (PCDA) system has to handle more than 30,000 signals simultaneously. An unscheduled halt in production is extremely expensive. Therefore, ABB's control systems are constructed and tested to provide the highest level of security and minimal downtime.

The hot exhaust gases from the gas turbines are used to provide heat for the parts of the process that demand high temperatures.

The philosophy of process plant owners in general, and Statoil in particular, is to provide its operators with a "single window" into the plant. ABB's 800xA Extended Automation system provides this facility and was, therefore, chosen for the Snøhvit project.

Plant power demand

Complexes for liquefied natural gas require a reliable and stable energy supply. Most LNG plants are, however, situated in areas in which the pow-

MS Nordlys, one of the ships of Hurtigruten – The Norwegian coastal ship operator – entering the port of Hammerfest.

1 Map of northern Norway.

er supply is either unreliable or non-existent. The Snøhvit plant is no exception and must, therefore, rely on its own power supply.

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To meet the power demand, the Snøhvit plant contains a 1.65 TWh power plant with five gas turbine-driven generators of about 50 MW each. These power the large refrigeration compressors of up to 65 MW, driven by variable-speed electrical motor, that are required to liquefy gases. The hot exhaust gases from the gas turbines are used to provide heat for other parts of the process. This set-up saves energy and provides about ten additional uptime days per year due to the much higher availability of electrical drivers (as compared to gas turbine drivers).

The Snøhvit plant not only includes its own power station and large compressor drivers, but also a large distribution network with several thousand relatively small electrical consumers. A large variety of ABB electrical components are included in ABB's deliveries to the plant. These include high voltage switchgear of the EXK-0 type, rated for 145 kV, and medium voltage switchgear of the UniGear ZS1 type, rated for 6.6 kV and 11 kV. Also included are optical arc detection systems to provide early detection and quick protective action of switchgear to extinguish arcs. Further, MNS type switchgear is used at low voltage levels of 400 V and 690 V. Some 500 cubicles supplying power to about 2,500 consumers are included at these voltage levels; of which some 600 consumers are Insum starters (intelligent motor starters) and 75 consumers are variable speed drives of ACS 800 type. ABB's protection and control unit (REF542) is used throughout the plant to provide the highest level of security and selective protection actions in the event of a fault in the power system.

Electrical control and supervision system

The complex nature of the electrical system requires an automated ECSS. This system is required to unite the thousands of motors, switches, contactors and circuit breakers, and to minimize the effects should a fault develop. A single unscheduled shutdown for the entire plant is extremely expensive.

The ECSS is at the heart of the electrical system and communicates with the vast range of ABB products using serial links and Ethernet. It is also linked with the automation system and other third-party deliveries. The system consists of 48 AC800M controllers. The ECSS processes some 44,000 signals at any one time – more than the plant's automation system. The ECSS provides a wide range of functions, enabling a stable power supply to the plant, lowering operation costs and reducing emissions, while at the same time increasing safety.

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An important part of the ECSS is the Power Management System (PMS)[1]. Since a relatively small fault may lead to a cascade of equipment shutdowns that could affect a large part or the entire plant, faults must be handled quickly and appropriately to avoid a domino effect. ABB's PMS is also based on the 800xA Extended Automation system and is designed to monitor, control and protect all sections of a process plant. It includes functions such as:

- Supervisory control and data acquisition (SCADA), including generator, circuit breaker, mode and motor control
- Power control, including tie line control, peak shaving and load sharing

An ABB engineer taking an overview of the plant at Melkøya (Photo: Peter Tubaas, ABB)

Two ABB engineers discsussing the plans for the day at the LNG plant in Melkøya (Photo: Peter Tubaas, ABB)

- Load shedding, including fast, slow and frequency based load shedding, as well as manual load shedding

ABB can draw on more than 50 years of experience with automation and electrical systems to optimize their integration.

Probably one of the most important and most frequently relied upon parts of the PMS is the load shedding function, which helps ensure that the consequences of any one fault in the electrical system has the smallest possible impact on the functioning of the plant. ABB has delivered and commissioned more than 30 PMSs worldwide, demonstrating that the PMS substantially improves plant uptime, efficiency and reliability.

The ECSS not only provides an interface between the process plant's automation and electrical systems; it also provides indispensable functionality and reliability in a plant where a system shutdown could cost millions of dollars. Although full communication and data exchange with the process plant's automation system is provided, the ECSS is not depending on it to operate. On the contrary, the ECSS can operate in isolation to ensure safe and reliable operation of the electrical system.

Main electrical vendor approach

In the past, oil companies and engineering, procurement and construction (EPC) contractors have very often purchased different types of equipment (eg, transformers, high voltage switchgear, medium voltage switchgear and low voltage switchgear) under separate contracts. Project risks can be reduced, however, by including most of the electrical equipment and systems – as well as engineering – under one large contract. The result is lower costs and faster project execution with safer systems that are fully integrated and interoperable. Safety is improved during installation and commissioning since project co-ordination is more easily achieved with only one contractor.

Statoil recognized the merit of such an approach and merged all purchases of high voltage, medium voltage and low voltage switchgear, as well as the ECSS, for the Snøhvit project into a single contract. In addition to equipment delivery, ABB has provided a wide range of engineering services, including a long list of electric network studies. These are required to ensure safe operation and maximum efficiency of the plant.

Since the Snøhvit plant is physically connected to the northern Norwegian power grid, it soon became of interest to study the dynamic behavior of the entire plant – including the gas turbine generator sets – and its connection to the grid. ABB has performed a dynamic stability study that was used to set and adjust the parameters of the power management system, as well as the dedicated generator control algorithms. This ensures not only stable operation of the process plant, but also ensures that the process plant contributes to the stability of the northern Norwegian power grid – as required by the grid operator.

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ABB at the cutting edge

ABB can draw on more than 50 years of experience with automation and electrical systems to optimize their integration. Uniting the electrical and automation systems is becoming a necessary feature of large process plants. Operating such plants without an automated system is almost unthinkable, not only for safety reasons, but also for reasons of cost savings and increased efficiency. Customers like Statoil rely on experienced companies like ABB to ensure safe and reliable plant operations.

Tom F. Nestli
ABB AS Process Automation Division
Oslo, Norway
tom.nestli@no.abb.com

Peter Tubaas
ABB Corporate Communications
Billingstad, Norway
peter.tubaas@no.abb.com

Footnote

[1] See article "Not on my watch" on pp 30–34 of this issue of ABB Review Special Report.