



Industrial Smart Grid

Smart Grid in Industrial Networks

Abstract

ABB is a frontrunner in Smart Grid technology. It implements already today in industrial networks those solutions and functionalities, which are defined desirable for tomorrow's network operator's transmission and distribution grid, Smart Grid.

Renewable distributed generation with intelligent metering, control and protection systems, which are capable to islanding operation, load shedding and power quality improvement, and energy efficiency and self-healing functionality, as well, makes today's factory power distribution system in pulp & paper industry as a -Smart- Grid.

General Smart Grid

Electricity is the most versatile and widely used form of energy and its global demand is growing continuously. Generation of electrical energy, however, is currently the largest single source of carbon dioxide emissions, making a significant contribution to climate change. To mitigate the consequences of climate change, the current electrical system needs to undergo significant adjustments.

Electrical power systems have been built up for more than 100 years. They are now one of the most effective components of the infrastructure on which modern society is based. They deliver electrical energy to industrial, commercial and residential consumers meeting ever-growing demand.

Most of today's generation capacity relies on fossil fuels and contributes significantly to the increase of carbon dioxide in the world's atmosphere, with negative consequences for the climate and society in general.

In the fight against climate change, clean renewable power generation of pulp & paper industry as well as intelligent transmission and distribution network– Smart Grid – may have an important role to play.

Expression “-Smart Grid-” is not strictly defined. It can be considered as a concept for modernizing power systems by integrating the electrical and information technologies. The integration covers the whole system, from generation, transmission, and distribution to consumption. At the low voltage level the solution is usually called as a Microgrid.

When we speak about -Smart Grid-, we have better to define it by its capabilities and operational characteristics than by specific technologies. As a rule it means increasing of automation and a gradual modernization of multi-vendor electrical energy transmission and distribution networks with conventional distributed and, especially,

renewable generation units and storages connected to the consumer point. The same customer may act both as a power producer and a consumer. This requires bi-directional power flow capability in the supply network connection point and in the other parts of the supply network, too.



Fig.1 Future Grid

With distributed intelligence and sophisticated Information and Communication Technology (ICT) with distributed intelligent devices (IED), more can be done locally at the switchgear or even at the device level, to allow operators and computing resources in the control room to operate more effectively.

The state of the system is known and monitored on-line all the time due to the increasing information from the system. The system is provided with controllable intelligent devices, which can automatically operate to sustain the balance between supply and consumption, to keep power quality on a high level and to improve reliability and availability.

ABB describes -Smart Grid- by broad characteristics rather than specific functions.

So the -Smart Grid- is:

- **Adaptive**, automatically responding rapidly to changing conditions.
- **Predictive**, in terms of applying operational data to equipment maintenance practices and even identifying potential outages before they occur.
- **Integrated**, in terms of real-time communications and control functions.
- **Interactive**, between customers and markets.
- **Optimized**, to maximize reliability, availability, efficiency and economic performance.
- **Secure**, from external attack and naturally occurring disruptions.

Specific examples of how smart technologies can impact the operation and overall health of the grid include the following:

- **Real-time situational awareness** and analysis of the distribution system can change operational practices and improve reliability.
- **Fault location and isolation** can speed recovery after a fault by connecting reserve power or automatic rearrangement of power supply.
- **System automation (SA)** facilitates the safe local and remote control and monitoring, as well as the protection of the electrical system for optimal supply quality and improved system reliability.
- **Smart metering and Energy management** allow optimal balance and cost control between the bought external power and own production.
- **Distributed automation and monitoring systems** provide operators with advanced decision support and control functions.
- **Power quality control** by special functions, such as reactive power compensation and possible load shedding.

This -Smart Grid- differs from the conventional distribution system by two-way real-time communication, intelligent digital metering, remote monitoring and predictive, condition-based maintenance, distributed generation, power flow control, pro-active, real-time protection and islanding, self-healing capability, and network topology complexity.

Industrial -Smart Grid-

Industrial network specialties:

An industrial power distribution network forms a good starting point for the gradual development of -Smart Grid- functionality. Today the industrial power distribution network already has a great deal of intelligence and functionality. In many cases the equipment is provided with local intelligence and processing capacity, and local data and measurement results are obtained from the equipment and the process. Devices in multi-vendor systems communicate and operate mill-wide with each other.

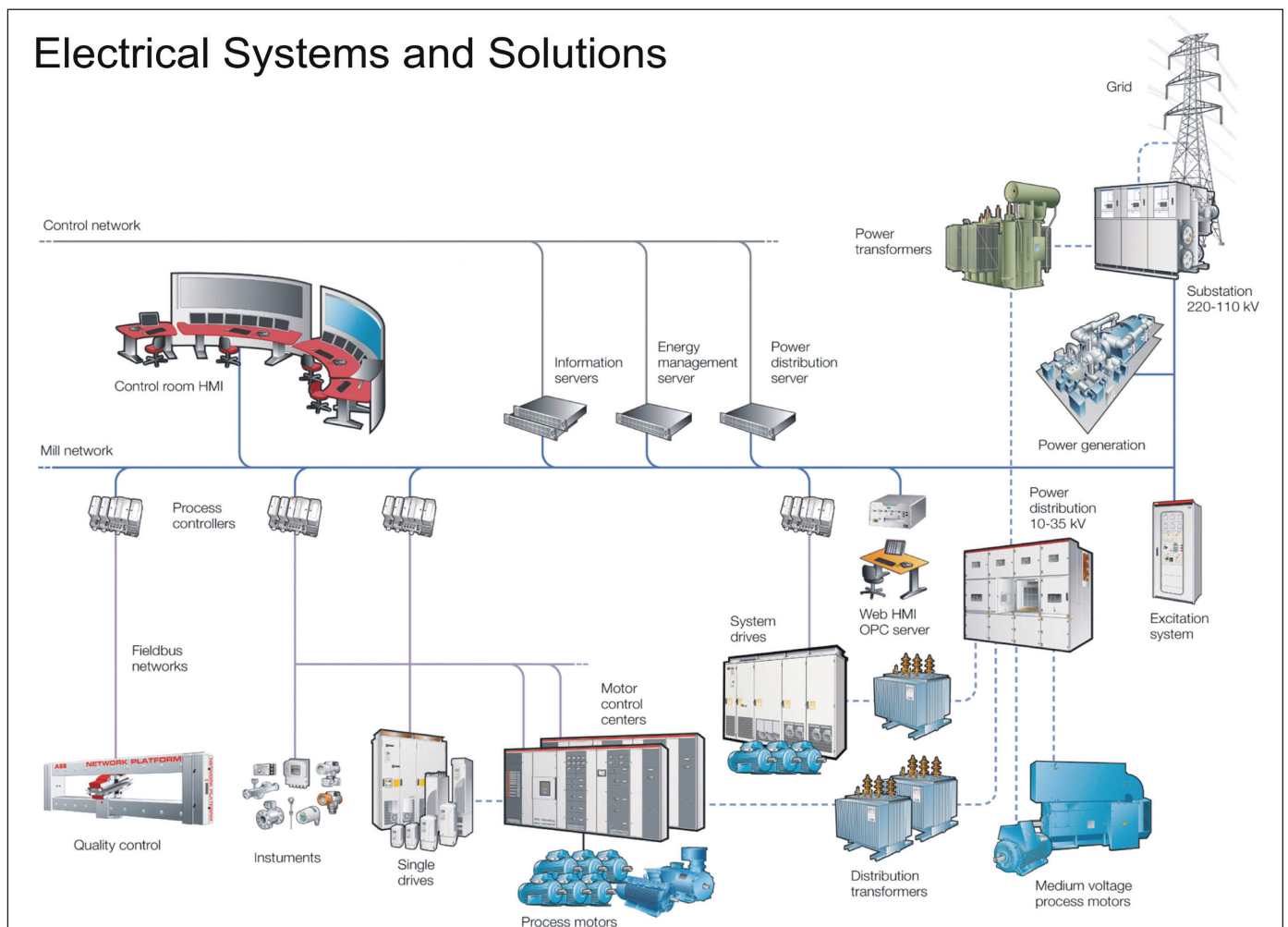


Fig.2. Intelligent industrial communication and power network concept

Most of the features of -Smart Grid- concept are also desirable in an industrial power supply network, which can form part of a wide -Smart Grid-. -Smart Grid- is also easier to configure in an industrial distribution network than in a public utility network. There is only limited number of Common Coupling Points (CCP) to the external public power supply and usually only one consumer customer who also has its own generation capacity (renewable or conventional). Besides, distribution distances are limited. Power density inside the factory site is often very high and the distribution network is heavily loaded. Two parallel network structures, power distribution network and communication and information network, form together the infrastructure for a -Smart Grid-.

In this environment it could be easier to understand and implement the -Smart Grid- concept, because some of the regulations for public power transmission and distribution, such as islanding, open market place, power quality requirement and so forth, are not valid here. Also there is no fluctuating power generation to worsening the power quality in the system. Actually many of -Smart Grid- features and operations are already implemented inside the industrial network. Even the bi-directional power flow capability in CCP is already realised in many cases.

Because electricity is kind of raw material for the production, it must be available in a reliably manner, whenever required by the process. Thus availability and reliability are the most important features of an industrial power distribution network.

Power generation units in the industrial distribution network may be considerable large (in a range of hundreds of MW). During disturbances in the external supplying grid the transmission operator wants to keep these generator units connected to the network to support stable frequency and voltage levels in the transmission grid. During hazardous faults, short-circuit or earth faults, and during longer lasting interferences industrial plants want to keep their processes alive as far as possible. For this reason, during hazardous grid interferences, an industrial plant is operated in most cases in the islanding mode separated from the external power supply.

Power quality and energy efficiency are also important factors for keeping production costs at their minimum. Consumers are penalized by the grid operators for too high reactive power and harmonics levels, which also reduce the active power distribution capacity of the network. It is profitable to provide industrial distribution networks with proper reactive power control and correct harmonic filtering.

Features of industrial -Smart Grid-

The structure of the network must be carefully designed so that only the controlled short time overloading of the system may occur in some parts. Moreover, alternative supply paths and isolation of a possible faulty part of the network can be implemented if required. In many cases parallel CCP and main transformers are better than only one large unit. If the sum of the fault currents exceeds permissible limits, current limiters may be used between parallel systems or sufficient operational values may be selected. Own power generation does not always cover 100% of the power needed in the process, so lacking power must be bought from the open markets and supplied from the external network. Amount is highly dependent on the market price. If the price is high enough the existing extra power may be sold to the markets and be fed into the external network. This needs two-directional capability (protection, power measurement and so forth) in the CCP.

Communication and control

IEC61850 is nowadays the leading communication standard. Different protocols and signals, such as simple binary I/O contacts, time-critical protection signals, voice communication, low speed SCADA, video surveillance, high-speed data transfer, internet access, and LAN connections, are connected by multiplex technology for high capacity communications systems so that multi-vendor environment forms an unity with common information sharing. Both hard-wire and optical fibers as well as wireless solutions are applied. DCS/Scada connection may be implemented via older priority solutions and leading standards like IEC61850. At the limited department level controllers alone may have sufficient functionality for control and monitoring purposes.

Nowadays the multi-parameter protection and control functions are more and more common. In the hazardous protection functions however the maximum operational speed of the protection is needed. In these cases the GOOSE solution is used for interlocking and fast operation of protection.

Intelligence

The “backbone” of the -Smart Grid- is ICT. Coordinated control and distributed automation and monitoring systems, distributed intelligence of devices, interaction of control system and operational devices, and communication of the measured data for control and decision purposes make the grid smart. The operator may have different type of Artificial Intelligence supporting tools, which may automatically operate, or may give operational instruction in different cases. There are tools for power quality control, like load shedding, transformer on-load tap changer control, control of filtering banks, generator excitation control, reactive power control and so forth.

ABB's Unified Integration Approach

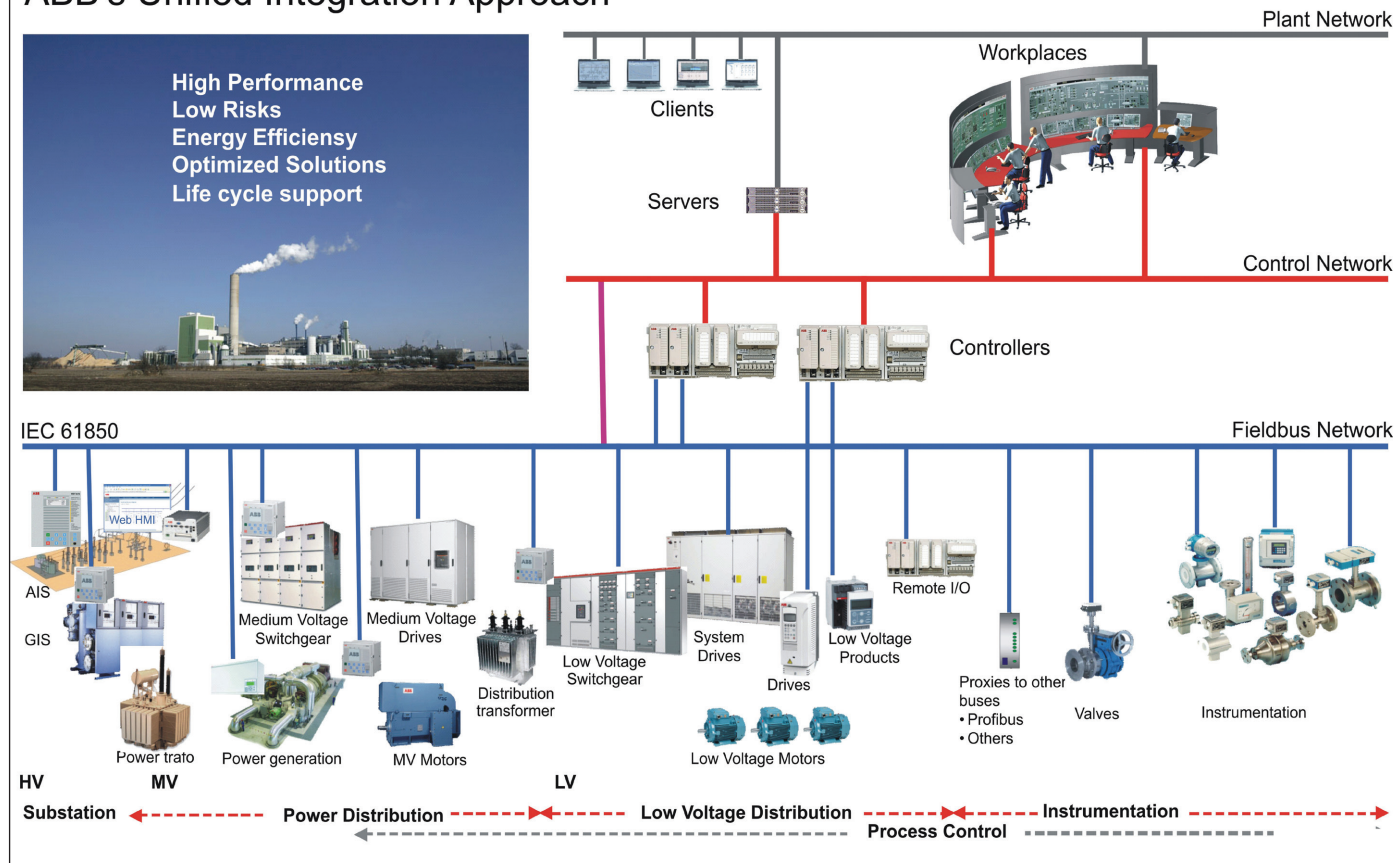


Fig.3. Communications and intelligent control solution

The state of the system and the operational condition of equipments must be known all the time. Information from different part of the network and equipment must be delivered for estimation and decision-making. Prediction of slowly growing fault may also be possible in the specific cases, for example, decreasing operational capability of a motor may be predicted by a slowly increasing trend of the operational temperature.

The loading status of the network and individual equipment is required for optimal power flow control. Also the operational condition monitoring such as circuit breaker operation calculator with the information of the value of breaking currents give extremely valuable information for further service planning. Because the individual equipment may have an individual address of its own, the information of the unit may follow its master, even if the equipment moved into another position in the network. This is part of the Assets Management process.

Data for maintenance and service as well as for system monitoring is produced either by an additional measuring devices and sensors, or by using the existing intelligent devices in the system, such as protective relays, process controllers, intelligent motor controllers and so forth, which use the measured local information and are connected to the information fieldbus.

Protection

As to the protection solution the existing ICT in relays and control systems enables many of the functions described as typical to -Smart Grid-.

- If the operational structure of the network is changed, operational parameters of the intelligent protection may be reset by the control system so that the sufficient protection level remains. Moreover, in hazardous cases, some overloading is permitted for avoiding larger damages, or for example, transformers may be overloaded temporarily in a controlled way.
- If a fault (short-circuit fault for example) occurs, the protection operates immediately. Then the control unit may define the location of the fault, make automatically isolation of the minimal part of the faulty network, and rearrange the new power feeding routs minimizing the consequences.
- If the external power supply collapses, the mill-wide network is operated into the islanding mode. Depending on the share of the own power generation capacity less important loads will be isolated by the emergency load shedding functionality. By this way the most important parts of the process can be kept alive and thus minimize consequences.

What is possible today

ABB has a wide variety of intelligent communicating products and equipment, which match well with the present gradual development of the -Smart Grid-.

- Instrumentation solutions and sensors give direct measurement data about the process.
- Information about the status of the system is gained from intelligent devices like protective relays, or direct measurements by installed sensors.
- Intelligent motor control center with motor starters gives valuable information from the process interface.
- Distribution transformers with their protection give information about loading state and maintenance needs as well as temperatures and power flow distribution of the network.
- IEC 61850 is a dominating concept for industrial communication today. Thus ABB products support this common solution either directly or by communication converters. This also guarantees the flexible use of multi-vendor equipment or earlier product versions of ABB products.
- Power Distribution Control (PDC) concepts and solutions with distributed automation and monitoring systems consist of several solutions such as Emergency Load Shedding (ELSS), Reactive power control (RPCS), On-load tap-changer control, Generator excitation, etc.
- Protection is part of assets management. By a sophisticated protection the fault duration and consequences remain as minimal as possible and elimination of the faulty part and quick recovery of the production process are possible. The sequence of the incident may also be recorded for later analysis purposes.

ABB is a leading electrical system and solution provider for the pulp and paper industry in the world. We have implemented several intelligent complete solutions for industrial power distribution around the world. Level of intelligence of the system has increased and nowadays it is one of the key factors for success in competition, especially in large pulp and paper plants. Many of the above mentioned features, including load shedding, islanding operation and reactive power control, have been asked for existing environment and green field complete projects, so called Composite Plants, during last 15 years, and ABB has implemented them by either adopting existing structure and technology or by using the state-of-the-art solutions all around the world, in Finland and Europe, in Asian and Australia and in South America as well.

References of ABB latest deliveries in pulp and paper mills, with -Smart Grid- capabilities in the electrical power distribution system.

Visy Paper, Australia
APRIL, Kerinci, Indonesia and Ritzhao, China
Stora Enso, Kvarnsveden, Sweden
UPM, Pietarsaari, Finland
APP; Gold East Paper, Dagang, China
SCA, Ciudad Sahagun, Mexico
Sappi Saiccor, South-Africa



UPM Pietarsaari, Finland



APP, Gold East Paper, Dagang, China

What have we implemented

Conclusions

Electricity energy demand keeps increasing in the future. Climate change and Energy efficiency requirements will be dominating drivers when selecting electrical distribution solutions and devices. Only equipments based on low carbon impact and energy efficient technologies are recommended for the future markets.

For improving usability, reliability and availability of the future distribution network, new initiatives are needed, such as high efficient motors, low loss transformers and a -Smart Grid- concept, which represents many of the desirable features of the ideal future grid.

At the Utility level the standardization is seen necessary [2] at the early stage for getting equal procedures and products for -Smart Grid- realisation as a whole. It is the first step for open multi-vendor concept and common understanding of necessary measures, which must be taken for ensuring the functionality, usability, reliability and safety of the system in commissioning and use. This has happened already in some other energy technology fields like utilization of Wind-power and Hydropower.

First versions of -Smart Grid- are a reality today in power distribution networks in pulp and paper industry. In the customer's site, the intelligence level of the present technology in old sites and interest for new investments into the functionality and energy efficiency of the distribution network define the schedule for -Smart Grid- expansion inside the pulp and paper industry. Cost of energy as a raw material is getting higher and thus -Smart Grid- will be profitable solution in the future.

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