

ABB technologies
that changed the
world

Power and productivity
for a better world™





Fully automatic power system for operating sugar centrifuges in 1943

ABB technologies that changed the world

ABB has a long history and a rich heritage of technology innovation. ABB and its forerunners, Asea and BBC, not only invented or pioneered many power and automation technologies, but has retained technology and market leadership in many of these areas, often for decades.

This brochure presents some of the technologies that have shaped the world we live in today.

High-voltage DC transmission	4
Variable speed drives	9
Industrial robots	12
Substations	16
Extended automation	20
Marine propulsion systems	25
Flexible AC transmission systems	29
Network management	33
Crane systems	37
Transformers	42

High-voltage direct current, HVDC

Prior to the 1950s, high-voltage direct current (HVDC) transmission delivering large quantities of electricity over long distances with low losses was impossible. The technology simply did not exist.

The problem lay in switching between alternating current (AC) and direct current (DC). AC electricity is produced by generators and powers most types of electrical devices, but DC electricity is needed for efficient, high-voltage transmission. Mechanical switching apparatus designed to convert AC into DC and vice versa proved unworkable. And the only alternative, mercury-arc valves, could not operate at sufficiently high voltages.

But by the early 1950s, developments in current conversion technology led by Asea, ABB's Swedish forerunner, enabled the company to build the world's first commercial HVDC power link, between the Swedish mainland and the island of Gotland. This gave islanders access to reliable supplies of cheap electricity from the Swedish mainland and the local economy flourished.

Since the installation of this 100-km long, mostly under-sea cable, ABB has continued to develop HVDC technology, replacing the fragile mercury-arc valves in the 1970s with semiconductor devices, and maintains its lead in HVDC technology to the present day. To date, ABB has installed 60,000 megawatts (MW) of HVDC transmission capacity in 70 projects, and is a market leader in the manufacture of high-voltage transmission cable as well.

ABB's HVDC technology has had a truly revolutionary impact on the way that electrical energy is delivered, all over the world.

Some of the world's biggest cities, including Los Angeles, São Paulo, Shanghai, and Delhi, rely on HVDC transmissions to deliver huge amounts of electricity, often from



Pulling the Gotland cable ashore in 1950. The power link connected the island to Sweden's mainland power grid, supporting the development of the island's economy.



Laying cables for the New Zealand interisland link across the Cook Strait, 1985. The link delivers hydropower from the South Island to centers of demand in the north.



The 580 km NorNed power link between Norway and the Netherlands was inaugurated in 2008. By enabling hydropower from Norway to supplement thermal generation in the Netherlands, the link helps to avoid almost 1.7 million tons of carbon dioxide emissions each year.



Uno Lamm, pioneer of HVDC technology, in the Gotland control room, mid-1950s. Lamm's work established a technology lead that has been held by ABB ever since.



A technician in the Gotland valve hall, part of the world's first commercial HVDC transmission system, commissioned in 1954.



An ABB technician tests HVDC Light valves, used to connect the world's most remote wind farm, 125 km off the German coast, in 2009.

thousands of kilometers away, with remarkable efficiency and minimal environmental impact.

Power trading and clean energy: National and regional power providers also interconnect their networks and trade electricity using HVDC, while offshore wind farms can use it to feed renewable power into mainland grids – safely, reliably and without disturbing sensitive marine environments. StatoilHydro's Troll A gas platform in the North Sea uses an HVDC link to receive clean, low-cost hydroelectricity from the Norwegian mainland, instead of generating power (and emissions) on the platform with gas turbines or diesel engines.

Electricity trading between power grids in neighboring countries contributes to the overall reliability of each system, and allows more renewable power to be incorporated into the generation mix. Parts of the grid that rely on wind or solar power can be supported by other parts with more predictable sources, such as hydro or thermal generation.

Using the 580 km NorNed HVDC link, the Netherlands can import clean hydropower from Norway during the day when electricity demand is high, and export excess capacity from its thermal power stations at night when demand is low. This enables thermal power stations to run at an optimal, constant rate, using imported hydropower to meet periods of peak demand. In combination, these measures yield a reduction in CO₂ emissions of almost 1.7 million tons per year.

Record-breakers and groundbreakers: ABB's achievements using this remarkable technology include the world's longest and most powerful HVDC installation (the Xiangjiaba- Shanghai power link currently under construction in China, which will deliver 6,400 MW of electricity over 2,000 km) and the world's longest underground cable transmission system (the 180 km Murray-link HVDC Light project in Australia).

HVDC Classic and Light: Since its inception in the 1950s, ABB has adapted HVDC technology for specialized applications.

HVDC Classic is used primarily for bulk power transmission over long distances, overland or underwater, and for interconnecting grids where conventional AC methods cannot be used.

ABB's most recent development in the Classic technology is ultra-HVDC, with voltage ratings of up to 800 kilovolts (kV). Transmission at this voltage level represents the biggest leap in transmission capacity and efficiency in more than two decades. The technology is being used on the Xiangjiaba-Shanghai link in China, creating a power superhighway capable of delivering enough electricity for up to 31 million people.

HVDC Light, launched in 1997, enables long-distance transmission using low-impact underground and underwater cables, or overhead lines. It is used for grid interconnections, long distance cable-based transmission, and to connect offshore installations, such as wind farms and oil-and-gas installations, to the mainland power grid.

Variable speed drives

About 40 percent of electricity is consumed by industry, and two-thirds of that is used in processes driven by electric motors. Variable speed drives, which regulate the speed of a motor by controlling the amount of power it draws, can reduce a motor's energy consumption by 50 percent in many applications. Yet less than 10 percent of motors are equipped with such a device.

The workhorse of modern industry

The vast majority of electric motors are used to power fans, pumps and compressors, and most operate at full speed, all the time, even when the process they are driving does not require it. Process speed is usually adjusted by throttling – which is like slowing a car by applying the brake while keeping the accelerator flat on the floor. This wears out equipment and wastes huge amounts of energy, resulting in large quantities of unnecessary greenhouse gas emissions.

With ABB variable speed drives, motor driven processes become vastly more efficient.

Improvements in efficiency and performance

Launched in 1969, ABB's variable speed drives control the core variables of the motor, and adapt its speed and torque according to the precise needs of the application. This means mechanical controls are no longer necessary. The result is a dramatic reduction in power consumption – around 50 percent in many applications – as well as considerable improvements in process control.

Developments in semiconductor and control technology over the past 40 years have continuously reduced the number of components in drives, leading to enhanced reliability and significant reductions in size. Thanks to ABB's direct-torque control, patented in 1995, drives have achieved new levels of performance in speed and torque control, and the company's development of simple user interfaces and more effective heat dissipation systems have produced some of the smallest, most user-friendly devices on the market.

The contribution of ABB's drives to energy saving are most obvious in those equipped with energy efficiency calculators. These devices, which are built into the drives, continuously measure the motor's performance and calculate the energy saved by use of the drive. The results can be displayed in units of electricity saved, cost reduction (in local currency) or emissions avoided: all-important parameters for plant operators.

ABB is the world's leading supplier of low-voltage drives and high-power medium-voltage drives, with a product portfolio that extends from 100 watts to 100 megawatts.

Widespread applications

ABB drives are used to improve energy efficiency in most industries and applications, from single-phase residential and commercial buildings to all-electric drive systems powering entire gas liquefaction plants and huge gearless mill drives that grind ore and minerals at mines and processing plants.

In fact, drives are an integral part of much larger ABB power and automation offerings that help customers use electrical energy effectively and increase productivity in energy-intensive industries like cement, metals, mining, oil and gas, power generation, and pulp and paper.

Remarkable results

Some of the improvements achieved by ABB drives in energy efficiency, productivity and process control are truly remarkable.

In 2008, ABB's installed base of low-voltage drives saved an estimated 170 terawatt-hours of electric power, enough to meet the annual needs of 42 million European households and reduce global carbon dioxide emissions by some 140 million metric tons a year. That's like taking more than 35 million European cars off the road for a year.

As society faces the challenge of reducing environmental impact while meeting rising demand for electricity, ABB's drives will be making a positive contribution for many years to come.



In the mid-1960s, prior to the introduction of modern variable speed drives, ABB's forerunner delivered drive and control systems for the printing presses at Sweden's largest newspapers, including Svenska Dagbladet, shown here.



A new fan system powered and controlled by ABB motors and drives reduced energy bills at a Swedish hospital by \$400,000 in 2005.



ABB drive systems combine outstanding efficiency with compact design, important qualities in large machinery like this excavator.

The industrial robot

ABB pioneered the world's first industrial paint robot and the world's first commercially available all-electric micro-processor-controlled robot in the late 1960s and early 1970s.

To this day, ABB remains a market and technology leader in robotics with more than 175,000 robots sold to customers all over the world – one of the largest installed base in the industry.

The impact of these robots on manufacturing processes and industrial productivity has been revolutionary. Their ability to achieve huge increases in output and process quality - and similarly huge reductions in downtime, operating costs and manpower - have made them indispensable to industrial production.

ABB robots play a significant role in our daily lives: hardly a moment goes by without our using a product that was manufactured or handled by an ABB robot.

For instance, ABB robots pick, pack and palletize our food and beverages for companies like Nestlé, Unilever and Cadbury. They carve, sand, finish, paint and package the furniture and flooring in our homes for two of the biggest names in the business – Ikea and Tarkett; and they weld, grind, polish and paint our PCs, laptops, iPods, mobile phones, cameras and game consoles for the world's leading brands and manufacturers – Apple, Dell, Foxconn, Hewlett Packard, Motorola, Nokia and many more.

They make the solar panels on our roofs, the glassware on our tables, building materials for our homes, the ceramics in our bathrooms, and the cookers, dishwashers, plastic containers, wood cupboards and metal sinks in our kitchens.

When we are ill, the tablets and other medications we take are picked, packed and palletized by ABB robots



Björn Weichbrodt in 1973, programming an early prototype of ABB's all-electric robot.



In 1974, Magnusson AB became Asea's first external robotics customer. The company used the robot to polish stainless steel pipes for use in the food industry.



ABB's FlexPainter IRB 5500 in 2009, combining fast painting speed with resource efficiency.



The IRB 2600, launched in 2010, has a payload capacity of up to 20 kg and an ultrawide working range. It has the smallest footprint in its class.

for companies like AstraZeneca, GlaxoSmithKline, Johnson & Johnson and Schering-Plough. They are even being used in hospitals to help with physiotherapy sessions.

Above all, ABB robots make the cars, buses and trucks that we drive. Most auto makers and their suppliers use ABB robotics solutions for some or all of their manufacturing processes – in powertrain assembly, press automation, body-in-white and painting the final product.

In fact ABB robots not only boost industrial productivity, they can also achieve a massive improvement in energy efficiency and greenhouse gas emission reductions. The FlexPainter IRB 5500 paint robot, for instance, has reduced paint shop energy consumption by 50 percent at automotive factories all over the world.

Paint shops consume vast amounts of electrical energy, typically about half the total power consumption of an entire automotive plant. Not surprisingly, the FlexPainter paint robot has had an immediate impact on the auto industry, taking a 30 percent market share within 18 months of its introduction in 2006.

Revolutionizing the workplace

ABB robots have also benefited health and safety by dramatically elevating the nature of work and improving working conditions for employees. Robots have eliminated monotonous and dangerous tasks like lifting and carrying heavy objects and have reduced labor turnover and raised job satisfaction in many workplaces that are dangerous, dull or dirty.

With robotics manufacturing facilities in Asia, Europe and North America, ABB solutions include robots and controllers, application equipment and software, standardized modular manufacturing cells, and global service and support.

Substations

As the world's leading supplier of electrical substations, ABB has delivered key improvements in the reliability and efficiency of transmission and distribution systems. ABB substations have been installed in all kinds of environments, from deserts and mountains to offshore rigs and crowded city centers.

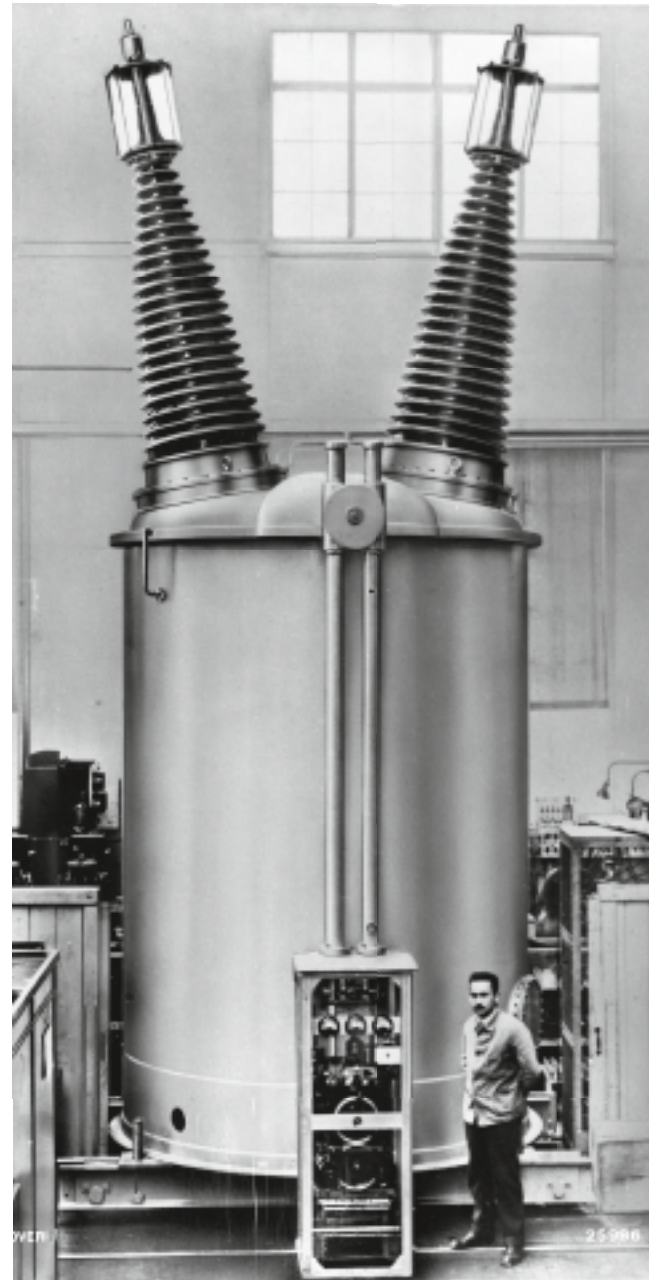
Substations are vital installations in the power grid. They include equipment to monitor, protect and control the transmission and distribution of electricity, providing efficient, reliable power supplies.

They feed power from generating stations into the grid and provide the link between transmission and distribution networks. Transformers and switchgear are some of the fundamental components that enable these functions. Transformers are used to adjust voltage to required levels and switchgear (switches that are used to connect and interrupt power flows) provide a means of isolating sections of the grid for maintenance work, to minimize equipment damage caused by faults and limit the spread of disturbances in the grid.

ABB has been building substations since the 1900s and has an installed base of tens of thousands of substations worldwide, including over 10,000 high-voltage substations, more than any other supplier.

Over the decades, ABB substation innovations have had significant impact in the key areas of size, performance and intelligence. The need to transmit and distribute large amounts of electricity to increasingly crowded cities, using as little space as possible, has been a powerful driver for the development of high-performance substations.

Building on a wealth of experience in air-insulated switchgear (AIS), ABB delivered the world's first substation using gas-insulated switchgear (GIS) in 1965. Compared to traditional substations, compact GIS enables the foot-



Oil-filled circuit breaker from 1927 built by BBC. Once a key component of air-insulated switchgear, these breakers were later phased out in favor of minimum-oil and gas-insulated breakers, which were more compact, more reliable and required less maintenance.

print of a substation to be reduced by up to 70 percent. This makes it possible to install substations not only in space-restricted city centers, but also on offshore oil and gas platforms, in power plants, office buildings, and even underground. ABB serves both the AIS and GIS markets, and provides hybrid systems to suit a range of specific needs.

Among ABB's landmark installations are the substations that serve the world's largest operating hydropower plants; Itaipu in Brazil and the Three Gorges in China. ABB recently delivered switchgear that can handle more than one million volts (1,100 kV) for the world's most powerful long-distance AC transmission network that is currently under construction in China. The technology offers a single switch, which could turn on and off the entire electrical power of a country the size of Switzerland (population 7.7 million).

ABB has also played a leading role in the development and implementation of the first global standard for the control and protection of substation equipment that enables real-time, open communication between substation devices, regardless of the manufacturer. The new standard has significantly enhanced substation performance and enabled the thousands of copper communications cables that were needed in a single substation to be replaced by just a few fiber optic cables.

ABB's substation technologies will continue to play a central role in the evolution of the world's power networks, supporting the development of more reliable, flexible and smarter grids.



One of the world's first gas-insulated switchgear installations in Sempersteig, Switzerland, delivered in 1966 and commissioned in 1967.



A 440 kV air-insulated switchgear installed by ABB near São Paulo in Brazil, 2007.



ABB commissioned ultrahigh-voltage gas-insulated switchgear at a record-breaking 1,100 kV in 2009, further raising the efficiency of long-distance transmission.

Extended automation

At the heart of the process industries such as chemicals, oil and gas, and power generation are control systems that automate and manage the carefully coordinated series of treatments used to convert raw materials into a continuous flow of product.

These systems are networks of interconnected sensors, actuators, controllers and computers, often distributed across vast processing plants, that help manufacturers to run their operations as safely and cost-effectively as possible, minimizing waste and ensuring consistent product quality.

ABB pioneered one of the world's first distributed control systems in the early 1980s, and to this day remains the global market leader and the company with the largest installed base of process automation systems.

In the past three decades, ABB innovation has dramatically improved industrial productivity by expanding traditional automated control to include all plant automation functions, easily accessible in a single operations and engineering platform.

When ABB launched its Extended Automation System 800xA in 2004, it quickly gained widespread acceptance and won numerous awards for its ability to extend the reach of distributed control systems into a completely new dimension.

No longer was data tied up in separate, incompatible systems; with System 800xA it could be accessed, managed and redeployed throughout the system with a single click of the mouse. It provided – for the first time – a single environment and a common platform for a plant's entire operations, from engineering to process optimization and asset management.

System 800xA can not only integrate the automation and information management systems in a single plant, but



A typical control room from the late 1960s. This control system was produced by Taylor Automation, which became part of the ABB Group in 1990.



The Tesselator color display system, launched in 1983, gave operators a clear view of automated processes.



Since 2005, ABB has revolutionized operator effectiveness and control room design with System 800xA and the Extended Operator Workplace, as used at the Tjeldbergodden gas terminal in Norway.

link plants at different sites, and in different countries, into a single, integrated entity.

Over the past five years, ABB has developed System 800xA into an automation platform with a uniquely broad and integrative capability that addresses the specialist needs of industry.

In oil and gas, for example, where safety is a primary concern, ABB has developed System 800xA HI (High Integrity), which integrates two previously independent automation platforms – safety and process control - into a single (yet functionally separate) system.

In pharmaceuticals, ABB has developed a comprehensive and scalable process analytical technology solution, which ensures that pharma products are manufactured to consistent levels of quality and safety.

And for energy-intensive industries like pulp and paper, cement, mining and power generation, ABB has used the new international standard for substation automation and plant electrification to integrate process control, plant electrification and information management systems on a single platform.

More than 5,000 System 800xA installations are now in operation worldwide. They include some of the largest and most complex production facilities in the world:

The world's largest alumina refinery

System 800xA controls the seven production lines and the material handling systems at Vale's Alunorte alumina refinery in Brazil, the world's largest with a production capacity of 6.3 million tons of alumina a year.

The refinery is linked to the Paragominas bauxite mine by a 244-kilometer pipeline – the first of its kind in the world - through which up to 14.4 million tons of bauxite a year is delivered for processing into alumina.



The giant Ormen Lange gas processing plant in Norway is equipped with ABB's System 800xA. The plant supplies 20 percent of the UK's gas supplies via the world's longest underwater pipeline.



System 800xA is used to control parabolic mirrors in Europe's largest thermal solar power plant, Andasol, in southern Spain. Tracking the sun's movement across the sky ensures maximum productivity.



The Collahuasi copper mine in northern Chile uses a range of ABB power and automation products, including the world's largest gearless mill drive (shown here) and System 800xA to optimize operations.

System 800xA controls both the mine and the pipeline, making the entire Alunorte-pipeline-Parogominas chain one of the largest upstream automation projects ever undertaken.

Chinese wonder of the pulp and paper world

The Hunan Juntai pulp mill is one of China's most advanced, most automated mills and is one of the biggest single investments in the Chinese pulp and paper industry.

System 800xA controls the manufacturing process of the entire mill and includes quality control systems, advanced process control, instrumentation and intelligent motor control. The plant produces up to 400,000 metric tons of high-quality pulp a year.

Marine propulsion systems

ABB's Azipod® propulsion systems have had a huge impact on the operating efficiency of ships and other floating vessels – reducing their energy consumption and greenhouse gas emissions by as much as 25 percent.

When launched in 1990, Azipod opened up a new dimension in marine technology as the world's first rotating propulsion device to be fitted to the outside of a ship's hull.

Replacing conventional propulsion-shaft systems, which can be difficult to accommodate on board, an "external" propulsion device offers a number of advantages, most obviously space saving and noise reduction on board.

The Azipod system's other benefits are low fuel consumption, greater speed using less power, and better maneuverability. The system typically reduces energy consumption of open-water vessels by 5 to 15 percent, but savings as high as 25 percent have been recorded.

The system's high-efficiency electric motor is located in a rotating pod fixed to the hull of the ship and controlled by powerful variable-speed drives on board the ship. ABB generators can produce electricity for both the propulsion system and the power requirements of the entire vessel.

To date, more than 80 vessels are equipped with Azipod units, which have accumulated more than five million operating hours in some of the most demanding marine applications – icebreakers, luxury cruise ships, research vessels and offshore supply vessels, as well as drilling rigs, ferries and megayachts.

Compared to the conventional propulsion-shaft and rudder alternative, the Azipod system, in addition to using less fuel, delivers substantial improvements in hydrodynamic efficiency. Their improved maneuverability allows



Waterway service vessel Seili was fitted with the first Azipod prototype in 1990. Azipod propulsion has now been installed in 81 vessels and has accumulated more than 5 million hours of operation.



Icebreaking support vessel Fesco Sakhalin uses two 6.5 MW Azipod units, delivered 2006. ABB is the world's leading supplier of power and propulsion systems for the marine industry.

ships to operate in more confined spaces and in more challenging sea conditions, and the near elimination of noise and vibrations is a comfort to passengers, especially on luxury cruise liners.

Notable Azipod achievements include the following:

The world's largest cruise liners

Royal Caribbean's Oasis of the Seas, currently the largest cruise liner in the world, can carry more than 7,500 passengers and crew, and is the first ship of its kind to be equipped with three fully steerable Azipod units. The third unit delivers the additional control, flexibility and power demanded by such a large vessel.

25-percent fuel saving for Chinese train ferry

The Bohai Train Ferry links the Chinese cities of Dalian and Yantai across the Gulf of Bohai, a distance of 185 kilometers. The ferry began operations in 2007. ABB provided Azipod power and propulsion solutions for three new ferries, each of which can accommodate 50 railway freight cars, 50 20-ton trucks, 25 passenger cars and 400 passengers. According to Bohai Train Ferry, the vessels consume 25 percent less energy than conventional roll on-roll off vessels.

Huge savings for high-speed Japanese ferries

The two largest and fastest RoPax (roll on-roll off passenger) ferries in Japan were the first vessels in the world to be equipped with ABB's contra-rotating Azipod propulsion system. Launched in 2004, the ferries have brought huge benefits to their owners, Shin Nihonkai Ferry, including a 20 percent reduction in fuel consumption compared to the previous vessels. The ferries are faster than their predecessors and can carry 15 percent more cargo by volume.



An Azipod unit in dry dock, 2009. The pod contains the high-efficiency electric motor that drives the propeller, saving space on board for additional cargo and greater design flexibility.



Oasis of the Seas, launched in 2009, is currently the largest cruise ship ever built and the first to be equipped with three fully steerable Azipod units. The Azipod system's low noise advantages are particularly important on luxury cruise liners.

Flexible AC transmission systems (FACTS)

FACTS is a generic term for a group of technologies that dramatically increase the capacity of electrical transmission lines – by as much as 50 percent – while maintaining or improving the system's stability and reliability.

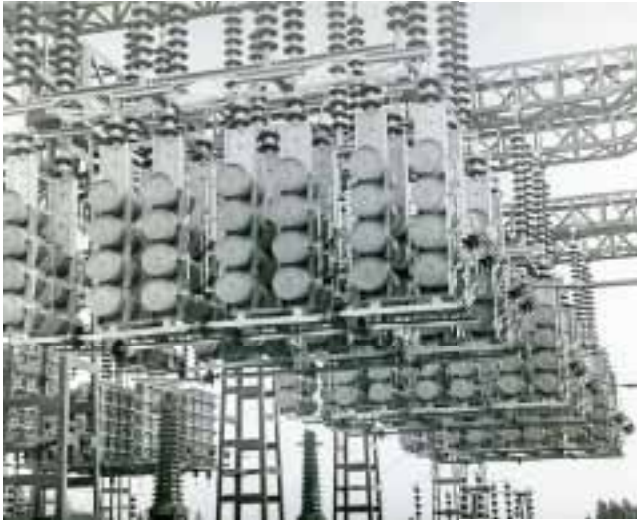
ABB pioneered FACTS technology in the 1950s and has led its technological development ever since. As the world's leading supplier of FACTS projects, ABB has delivered around 750 installations worldwide.

FACTS installations have a small footprint and therefore minimal impact on the environment. They can provide additional network capacity considerably faster and more economically than the alternative of building more transmission lines. It can take 15 years or more to negotiate the rights of way and complete a new power transmission line project; a FACTS solution that would increase transmission network capacity over existing power lines can take as little as 15 months.

In addition to their primary role of increasing transmission capacity and improving control in existing transmission networks, FACTS technologies are also used to improve the efficiency of long-distance power transfer, relieve transmission bottlenecks, and to safely integrate intermittent energy sources like wind power into the grid.

ABB FACTS innovations are widely used in energy-intensive industrial processes, such as steelmaking and heavy mining and can raise productivity by several percentage points. FACTS technologies can improve power quality, counteracting the potentially disruptive effects that large electric arc furnaces can have on the local power network and surrounding grid.

Dynamic energy storage is the most recent FACTS family member, marrying power stabilizing technology with the latest battery storage technology. This combination pro-



The world's first series capacitor installation (a FACTS technology) in a large power network was delivered to the Swedish State Power Board by ABB's forerunner in 1950.



A FACTS installation at a steel mill in Italy, 2002. By improving the power quality in such plants, FACTS technology can raise productivity by several percentage points.

vides grid stability and a means of storing energy while prices are low, for use during periods of higher demand.

The world's largest FACTS installation for increased reliability and grid capacity

An ABB FACTS solution increased the reliability of a critical transmission line in the mid-Atlantic region of the United States and expanded the line's transmission capacity. ABB completed the world's largest capacity FACTS installation in 2007 to increase reliability and capacity at Allegheny Power's Black Oak substation in Maryland in only 14 months, a world record given the size, complexity and scope of the project.

Increasing transmission capacity by 30 percent

An ABB FACTS solution for the Saudi Electricity Company (SEC) boosted the transmission capacity of a vital power transmission interconnector by some 30 percent. The increased capacity is preventing power shortages in the Saudi capital, Riyadh, and has saved SEC a huge investment outlay in a new transmission corridor.

Exporting surplus energy across India

ABB FACTS technologies are used to stabilize one of India's most important interconnections between Raipur and Rourkela, and enable power to be reliably transferred from India's eastern power grid (where there is a surplus) to the west and south (where there is a shortage). The solution has also provided a substantial increase in transmission capacity and is the largest installation of its kind in the country.

Boosting steel mill productivity

ABB has supplied more than 260 FACTS solutions to steel mills all over the world. One of the most well known is Outokumpu's Tornio Works steel mill in Finland, where ABB solutions create a smooth and stable voltage for the huge melt shop, which has a capacity of around one million tons a year. The solutions also reduce harmonics and flicker to prescribed levels, thereby enabling the plant owner to meet the required grid codes.



A FACTS installation in Finland, 2005, stabilizing voltage and current fluctuations in Finland, 2006. The technology helps to counteract interference with local power networks that cause problems such as lighting flicker.



FACTS installation to support increasing electricity demand in Norway, 2009. FACTS technologies can enhance the security, capacity and flexibility of transmission systems.



FACTS installations at Raipur in India, enabling power to be transferred from India's eastern power grid to the west and south of the country.

Network management and utility communications

ABB network management and utility communications solutions monitor, control, operate and protect the world's power systems. They ensure the reliability of the electricity supplies on which society depends.

Network management and communications systems enable electric utilities and independent system operators to manage in real time their transmission grids, distribution networks, power plants and energy trading markets.

They can collect, transmit, store and analyze data from hundreds of thousands of data points across power networks and over large geographic areas.

They enable data, voice, video and protection signaling and other types of critical information to be communicated quickly, reliably and securely. And they are crucial to any smart grid solution of the future.

ABB played a pioneering role in the development of remote control systems for power networks, which began in the 1920s, and led the development of the first computerized network management systems (SCADA) in the 1970s.

Since then, ABB has continued to push beyond the established frontiers of power system management by developing platforms for generation, transmission and distribution applications in the 1980s, energy trading systems (which allow electricity to be bought and sold as a commodity) in the 1990s, and new smart grid solutions in the 2000s.

Today ABB has delivered more than 400 network management and energy trading solutions, and has by far the largest installed base of any supplier worldwide. On the communications side, around one in four of the world's high-voltage substations are protected by ABB installations, and more than 1.5 billion kilometers of high-



One of ABB's first utility communications installations, circa 1944. The equipment enabled grid operators to transmit signals along their own power lines.



voltage power lines transmit data at ultrahigh speed via ABB power line carriers.

Among ABB's groundbreaking solutions are the following:

Integrating transmission and distribution networks into a single system

Karnataka is India's fastest growing state and its capital, Bangalore, is an international hub for the global IT and biotechnology industries. In 2009 ABB delivered a solution that integrates the state's power transmission and distribution systems, energy audit and customer billing systems into a single state-of-the-art platform. The solution monitors the power network of the entire state, provides accurate and real-time information on power supply and revenues, and enables operators to identify and correct faults quickly.



Engineers integrate fiber-optic cables into existing transmission lines for Swiss utility EKZ in 2006. ABB's communication equipment is used world wide to transmit voice, data, and protection signals on high-voltage lines.

Managing one of the world's largest energy markets

ABB has supplied many of the world's energy trading systems – in California, China, Singapore, Australia, the Philippines, to name a few. The systems provide traders with information on pricing and demand, and automated buying and selling facilities. The New York system is one of the world's largest, enabling its operator to manage a highly complex and congested power network. Electricity worth about \$12 billion is traded annually using ABB's system, which is recognized as the international benchmark for the industry.



A close-up of the first computerized network management system used to monitor and control operations, delivered to Stora Kopparberg Bergslag AB, Sweden, in 1969. The system was replaced by a newer version of the same technology in 1989.

Enabling the smart grids of the future

Network management is a prerequisite for any smart grid of the future. These grids will have to incorporate and manage centralized and distributed power generation, intermittent sources of renewable energy like wind and solar power, allow consumers to become producers and export their excess power, enable multi-directional power flow from many different sources, and integrate real-time pricing and load management data. ABB has long been in the vanguard of smart grid development, and is currently involved in numerous projects all over the world to evolve existing power networks into smarter networks.



In 1933, the electricity supply for the Swedish capital, Stockholm, was overseen from this room, equipped with Asea monitoring and control systems. The network served about half a million people.



The City of Malmö Gas and Electricity control room (now part of E.ON), around 1950. The design of control rooms changed little between the 1920s and early 1970s, when computers were introduced and large wall panels were replaced by computer screens.



KPTCL's control room in Bangalore, delivered by ABB between 2007 and 2009. The system enables the monitoring and control of the entire power distribution network for the state of Karnataka, serving some 16 million people.

Crane systems

Several hundred million containers and billions of tons of bulk cargo pass through the world's ports each year. Much of it is loaded, unloaded and stacked by highly automated cranes equipped with ABB automation and electrical systems.

ABB has been in the crane business since 1897 and is now the world's leading supplier of automation and electrical systems for container- and bulk-handling cranes.

Over the past few decades ABB has transformed the way that containers and cargo are handled – by automating crane and terminal operations and enabling goods to be moved quickly, safely and energy efficiently to keep ships' berth times short and handling costs low.

In a typical modern terminal the containers are unloaded by a ship-to-shore crane onto the dock, where vehicles transport them to a huge stacking yard. There, automatic rail-mounted gantry cranes stack them in the required order and position, ready to load onto a truck or rail wagon.

Thousands of containers are moved in this way every day in such a terminal. Each move has to be performed quickly and to the right destination with great precision and without interfering with other containers, cranes or vehicles.

ABB crane systems perform these moves using a combination of patented ABB technologies – load positioning, target positioning and load control systems – that enable the crane to take the shortest and safest path to the target container, approach it at speed, and load it into position with millimeter accuracy.

Ship-to-shore cranes are semi-automatic. For safety reasons each crane is manned by an operator. But the automatic rail-mounted gantry (ARMG) cranes are fully automated, enabling a single supervisor to monitor six to

eight ARMGs from a central control room – a considerable reduction in manpower and a massive boost in productivity per operator.

ABB continues to evolve the concept of fully automated crane systems and terminals. In 2008 ABB completed the world's first automated bulk cargo terminal at Luojing (Shanghai) in China. And in 2009 ABB launched the world's first fully automated dual-hoist system that enables ship-to-shore cranes to almost double productivity by loading or unloading two trucks simultaneously.

Among the many benchmark installations that ABB has provided in the past decade are the following:

The most advanced terminals in the world:

Germany

Hamburg CTA, an integrated crane control system comprising 52 fully automated ARMGs for the stacking yard, which has a capacity of 30,000 containers in stacks of up to five high (2000).

The Netherlands

Euromax, Rotterdam, an integrated crane control system consisting of 16 double trolley ship-to-shore cranes, 58 ARMGs and two rail-mounted railway cranes for phase 1 of the Euromax terminal (2005).

Spain

Total Terminal International, Algeciras, for Hanjin Shipping: 32 ARMGs and 8 STSs (2008)

Japan

Wan Hai Lines Ohi terminal in Tokyo: 8 ARMGs (2001, 2006)

Taiwan

Evergreen Marine terminal, Kaohsiung: 6 ARMGs (2005); Taipei Port Container Terminal, Taipei, 40 ARMGs (2006 and 2008); Yang Ming Lines, Kaoming, 22 ARMGs (2009).



An electric crane (non-production model) built by BBC in the early 1900s.



An Asea magnetic gantry crane at Fagersta Bruks AB, Sweden. The crane has a 30m span and lifting capacity of up to 12 tons (1950s).



The "Viking Norse" was equipped with six 8-ton, electro-hydraulic, programmable deck cranes (late 1970s).



Automated cranes were installed by ABB in 2009, modernizing Shanghai's Luojing port, China's largest bulk-cargo terminal. ABB's electric crane systems are three to four times more energy efficient than diesel cranes and produce no local greenhouse gas emissions.



Dual-hoist, ship-to-shore cranes and automated rail-mounted gantry cranes at Busan Newport in South Korea, installed by ABB in 2009.



A remote crane operator in the central control room at Busan Newport, South Korea, in 2009. 42 cranes are controlled from this room.

South Korea

Busan New Port, 73 ARMGs and 19 ship-to-shore cranes including dual-hoist cranes that handle two containers and two trucks at the same time, thereby doubling productivity compared to conventional crane systems (2007).

China

The world's first automated bulk cargo terminal at Luojing, Shanghai, comprising a fully automated grab ship unloader (a large clamshell bucket, which unloads up to 50 tons of material at a time), a fully automated stacker/reclaimer, and a fully automated ship loader, all operated remotely from a central control room (2009).

Transformers

ABB delivered one of the world's first transformers in 1893. Today, it is the global leader in this vital power technology, with a leading share of the market and an innovation track record that is second to none.

A transformer is a key element in the grid, used to adjust electrical voltage to required levels. A step-up transformer increases voltage, and a step-down transformer reduces voltage, as necessary in different parts of the grid. For example, electricity generated in a power station must be stepped up to the appropriate voltage for transmission (between 100 and 800 kilovolts [kV]) and then stepped down again to the distribution voltage (110-230 volts [V]), which is delivered to homes.

ABB transformers are found wherever electricity is generated, transported and consumed – in power plants and substations, skyscrapers and shopping malls, ships and oil platforms, locomotives and railway lines, wind parks and solar power fields, water and wastewater treatment plants.

ABB was one of the first companies to develop a commercial transformer, integrating it with the world's first commercial three-phase AC power transmission link, also an ABB innovation, in 1893 to connect a hydropower plant with a large iron-ore mine in Sweden.

Since then, for almost 120 years, ABB has continued to enhance transformer performance by developing new technologies and materials that raise efficiency, reliability and sustainability to new levels.

Besides setting new records in transformer power ratings for both AC and DC transmission, ABB has developed several innovations, including the world's first 800 kV DC bushings (for a high-voltage DC transmission system in China); the world's most efficient subsea transformer, one that can serve offshore oil and gas fields from the sea bed at depths of up to 3,000 meters;



Asea's transformer factory in Ludvika, Sweden, 1923. Operations began in Ludvika in 1900 under the name Elektriska AB Magnet, which became Asea in 1916.



In 1942, Asea delivered what was then the world's largest transformer (120 MVA, 220 kV) to the Värtan substation in Stockholm.



The world's first 800 kV UHVDC power transformer, delivered by ABB for the Xiangjiaba-Shanghai transmission link in China, 2008.

and ultralow-sound transformers for noise-sensitive environments.

By developing new high-performance materials and using fire-resistant insulating liquids, ABB has improved the efficiency, safety and environmental friendliness of transformers.

ABB's new eco-friendly transformer product line can achieve energy savings of 40–50 percent thanks to its amorphous core and bio-degradable oil, which can be reused at the end of the transformer's life, reducing costs and environmental impact.

ABB is the world's largest transformer manufacturer and service provider, capable of delivering high-quality, durable products and services all over the world. Even for aging transformers that have been in service for decades, ABB can improve their performance and energy efficiency significantly while extending their service life by several more decades.

Notable installations include the following:

The world's most powerful transformers

ABB has broken the world record for the most powerful transformers many times – from the world's first transformers for 400 kV and 800 kV AC transmission in the 1950s and 1960s respectively, to the most powerful UHVDC (ultrahigh-voltage direct current) transformers for the 800 kV, 2,000 km Xiangjiaba-Shanghai transmission link in China.

Power reliability for the world's tallest building

When completed in January 2010, Burj Khalifa in Dubai became the world's tallest building, with 164 floors and a total height of 828 meters. To ensure power reliability throughout the building, it is equipped with 78 ABB dry-type transformers, which are renowned for their mechanical strength and reliability. The nearby Dubai Fountain, which is illuminated by 6,600 lights and shoots water



The Burj Khalifa in Dubai, the world's tallest building, is equipped with ABB transformers.

150 meters into the air, is also equipped with ABB transformers. It is the largest fountain in the world.

Environmentally friendly traction transformers

ABB is supplying environmentally friendly traction transformers for commuter trains on the Glasgow urban transport network. The transformers will reduce the trains' environmental impact by using a biodegradable coolant and minimizing energy consumption during operation.

ABB technology: selected highlights since 1883



1889
Jonas Wenström invents the three-phase system for generators, motors and transformers.



1891
Charles Brown (l) and Walter Boveri (r) form BBC, which later becomes the first company to transmit high-voltage AC power.



1893
Asea builds Sweden's first three-phase transmission system, helping to develop what is now the world's predominant transmission technology.



1897
The first high-voltage oil circuit-breaker. This was the foundation of ABB's expertise in switchgear and substations.



1899
The first electric standard-gauge locomotive in Europe was powered by two BBC motors, beginning a new era in railway electrification.



1971
BBC builds the most powerful transformer in the world at 1300MVA.



1969
BBC develops the first gearless cement drive in the world, improving safety, reliability and efficiency.



1963
BBC performs first data transmission at carrier frequency, opening up a new channel for utility communication.



1954
Asea supplies the first HVDC transmission system in the world, delivering reliable power via a 100 km underwater cable.



1944
BBC develops the first high-speed locomotive with a direct-drive system, improving efficiency and reliability, and saving space onboard.*



1974
Asea launches the world's first commercially available, all-electric, microprocessor-controlled industrial robot.



1984
Asea and BBC deliver generators, substation and transmission systems for the world's largest hydroelectric power plant at Itaipu in Brazil.



1990
Azipod is conceived, improving maneuverability and efficiency in vessels from cruisers to ferries and ice breakers.



1991
ABB develops the world's first full-scale thyristor switch for a controllable series capacitor, and maintains technology lead today.



2004
ABB launches the world's first fully integrated industrial automation system, 800xA.



2009
ABB delivers the first fully automatic grab ship unloader to the world's first unmanned bulk-cargo terminal.



2009
ABB commissions UHV gas-insulated switchgear rated at 1,100 kV, enabling new efficiency records for long-distance transmission.



2008
ABB commissions the world's longest, most powerful submarine HVDC link.



2005
ABB introduces HVDC Light to offshore oil and gas production, becoming the first to deliver mainland power to offshore rigs.**



2004
ABB delivers the first multi-vendor substation automation system using the new global standard for the control and protection of substation equipment.

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