



# ABB Review

The corporate technical journal  
of the ABB Group

[www.abb.com/abbrevreview](http://www.abb.com/abbrevreview)

## Special Report: ABB in China

Infrastructure challenge page 6

Productivity challenge page 40

Manufacturing challenge page 62

Research in China page 77



## ABB in China

The phenomenal rise of China onto the stage of the world economy has created a growing middle class in the country – people with the taste and the means to improve their living standards. This desire has spawned a continuously increasing demand for goods and services, which are being supplied through domestic businesses in partnership with foreign companies. To satisfy these needs creates business opportunities and drives the economy forward. Comfortable and modern housing, more convenient transportation and expanding industry are all putting pressure on energy supply, which is now falling behind the demand curve. The result is brown outs and black outs in some of the major cities.

From its huge base of talented and driven people, combined with relatively cheap labor, China has in a record time built a global manufacturing hub producing goods for both domestic consumption and export. This global role has moved 300 million people out of poverty in the last two decades. The fast growth has created pressure on raw materials, industrial safety, the environment, and even on the labor force, which currently is showing a shortage of skilled people in some areas. The Chinese government is aware of the consequences of fast growth and is searching for ways of controlling it without hampering the country's vast potential.

This special issue of ABB Review, called ABB in China, outlines ABB's position in the Chinese economy – our capacity to supply many of the products, technical solutions and services demanded. Our operations are an integral part of the Chinese economic miracle, and we are assisting in overcoming some of the challenges resulting from this rapid change. Our technologies supply the market with electrical equipment for industrial as well as domestic use, in buildings and transportation. Through partner channels we ship 100,000 products per day, which find their way into many applications improving comfort, safety and productivity. We have solutions to safely remedy the energy shortage in the big eastern provinces by building transmission lines with our HVDC technology, distribution networks in the local regions and energy efficient automation to boost industrial productivity and safety.

The Infrastructure challenge section features an overview article describing the plans for expanding energy supply. We talk about our involvement in transmitting green power from Three Gorges to the Eastern provinces to keep the city lights shining. Technologies to boost grid capacity are reviewed and

we discuss ABB's involvement in connecting the different provincial networks into a future Chinese grid. An experiment with energy trading using sophisticated software from ABB is described. A brief review of our transformer and switchgear technologies are also included.

The next section – called Productivity challenge – describes solutions to industrial automation issues. The lead overview story reviews the productivity and energy demand for the different sectors of the economy with emphasis on the industrial sector and its sub sectors. The benchmarking of energy efficiency in the Chinese industry with that of leading international industries reveals great potential for improvement. This sets the stage for the ensuing articles, covering many industry applications from steel and paper to harbors and ships, and robotized welding. CO<sub>2</sub> reduction using modern drives technology is depicted with a smorgasbord of strong examples.

The Manufacturing challenge section presents some of our many factories in China. Our successful decade in low-voltage (LV) motors manufacturing is highlighted, world quality transformer manufacturing is described and we take a look at a calibration lab for flow meters. LV products such as switches and breakers and installation material is briefly presented.

Finally we introduce our latest Corporate Research lab, which was opened in March in Beijing with a focus on China's future electricity supply and network infrastructure.

With almost a century of involvement in this remarkable country, ABB is proud to be part of China's success and to be supporting its ongoing sustainable growth.

Wylie Rogers  
Corporate Communications  
ABB in China



## A century of commitments to China

On a visit to China last year, ABB's chairman, Jürgen Dormann together with the Board of directors, outlined a 5-point strategy for the company's profitable growth in this country. This strategy further underlined our continuous long-term commitment to the Chinese economy, which began almost a century ago with the delivery of a steam boiler. Since then ABB has delivered small and large projects to the power and industrial sectors that have resulted in significant modernization and productivity improvements. ABB's largest endeavor to date is our successful engagement with Chinese partners in the Three Gorges transmission project.

In early 2005 ABB had the privilege of welcoming vice premier Huang Ju and his delegation to our high-tech semiconductors factory in Switzerland. The technology produced at this factory makes possible our high-voltage direct current links that transmit power from the East to the West of China.

In late February, ABB reported \$2.6 billion in orders in China for 2004, a 62% increase compared with 2003, reflecting the strength of our technologies and of the vitality of China's growing economy.

To emphasize our long-term commitment to China, we have, during the past year, strengthened our management team and are in the process of adding several new manufacturing factories. In addition, we opened a global Corporate Research facility in Beijing in March 2005.

A look back in time suggests that what we are now seeing is the reemergence, and not the emergence, of China as a major world economy: in the 1820s China represented 30% of the global economy, while the U.S. provided less than 2%. By the 1950s, however, the U.S. was the dominant economy and China had shrunk to a mere 4%. Today that figure has climbed to 10% with its global share forecast to reach 20% of the world economy by 2030. ABB is committed to supporting these ambitious goals, but we are, at the same time, fully aware of the challenges ahead. China's unparalleled growth is threatened by power shortages, lack of industrial energy efficiency and environmental issues. The Chinese government is, however, properly addressing these challenges: Premier Wen Jiabao's recent remarks at the third session of the 10th National People's Congress underscored the fundamental improvements that are required to tackle these concerns. Premier Wen addressed five major focus areas, rightly attaching great impor-

tance to the enforcement of energy saving measures and the creation of new power capacity, primarily through a large number of new power plants, and through greater reliance on renewable energy.

ABB's products, systems and services minimize losses in the transformation, transmission and the distribution of electrical power. Our HVDC technology, for example, is already achieving the highest power transmission efficiency in China. Energy efficient equipment such as drives and motors help reduce the demand for electricity, and indirectly, CO<sub>2</sub> emissions. Productivity is enhanced with our automation systems, and our electrical breakers and switches provide improved safety in buildings and factories.

This ABB Review special report is dedicated to ABB in China. We review our technologies in the light of the priorities established by the Chinese government. We present projects and solutions to many issues on both the power supply and the power demand – particularly energy efficiency – side of the country's energy balance.

ABB is a strong supporter of the "Go West" initiative and this is illustrated with our single largest investment in Chongqing and new offices in far-flung places such as Hohhot and Urumqi. The manufacturing segment in this special report provides an insight into some of our high quality factories located throughout this vast country.

We are greatly encouraged by China's progress on the implementation of its WTO commitment. ABB looks forward to working alongside China to help this process along. We remain committed to helping China achieve its goal to be a well-off society, in an all-around way by 2020.

Sincerely,  
Peter Leupp  
Chairman and President  
ABB in China

# ABB Special Report ABB in China

## Infrastructure challenge

**6**

### Powering the economy

The thirst for power of China's booming economy must be met by huge generation and transmission investment.

**11**

### Three gorges

The dam that will generate enough power to meet three percent of China's need.

**15**

### HVDC transmits green energy in China

Moving green energy from the dams to the cities.

**19**

### More power to the cities

Thyristor controlled compensation is helping transmit more power.

**22**

### Grids united

A joint venture by Tsinghua University and ABB is interconnecting China's regional grids.

**25**

### Drilling through

ABB switchgear is contributing to the reliability of a major refinery.

**27**

### Advanced diagnostics of turbine vibrations

Optimizing performance and reliability through diagnosis.

**32**

### Power reform

ABB paves the way for regional electricity trading.

**36**

### Propeller power

Harnessing the winds with ABB drives.

**38**

### Piped heat

A district heating project in northern China.

## Productivity challenge

**40**

### The Chinese Century

The infrastructure vision behind China's phenomenal growth.

**46**

### Roll model

Presenting two steel rolling mills that are benefitting from ABB's reliable and highly dynamic drives.

**48**

### Lifted productivity

Cranes with ABB technology are lifting business at Quindao port.

**50**

### In total control

Precise positioning boost the productivity of ships.

**52**

### Ancient traditions, modern tools

Reviving the ancient Chinese art of papermaking.

**54**

### Robots confine hazards

Painting and welding made safe, precise and reliable.



6

57

### Energy efficiency

Innovative technology from ABB is contributing to energy efficiency. Nine hands-on examples are presented.

## Manufacturing challenge

62

### Manufacturing challenge

What it means to be part of China's booming economy.

64

### Transformed

Chongqing's advanced transformer factory.

68

### ABB intelligent power distribution system

70

### Calibrating precision

Delivering accurate calibration to flow measurement.

72

### Motors power efficiency

74

### Low voltage equipment

Distribution-side reliability and efficiency.

## Corporate research

77

### Committed to China

Innovation is the lifeblood of ABB: a new corporate research center opens in China.



40



62



77

China is emerging as one of the largest global energy consumers, second only to the US. Since 1980, rapid economic growth has stimulated an equally remarkable growth in energy production and consumption. According to forecasts by CERA (Cambridge Energy Research Associates), China's demand for primary energy is likely to double between 2004 and 2020.

The power industry has recently had difficulty satisfying demand – growth in energy demand has outpaced supply growth. This represents a shift compared to the late 1990s, when problems were with oversupply. China's rapid development, changing demographics, and economic restructuring have driven a relentless growth in energy consumption and present new challenges for power suppliers.

# Powering the economy

The infrastructure challenge

Alia Malik



China's main source of energy by far is coal. Such heavy reliance on a "dirty" source has been costly; the government is planning to diversify the industry through increased use of cleaner sources such as nuclear, hydroelectric, and natural gas. China is rich in many of the resources needed for energy production, but the regions where these are concentrated are far away from the main centers of consumption. The further growth of industry and commerce thus calls for heavy investment in both generation and transmission infrastructure.

The government is committed to such goals as diversifying energy sources, improving efficiency, expanding coverage, and limiting the human and environmental costs of the rapid growth.

#### Soaring energy demand: trends and forecasts

Since the late 1990s, when oversupply in the energy industry led to a moratorium on the approval of new coal-fired plants, supply and demand have shifted radically **1**.

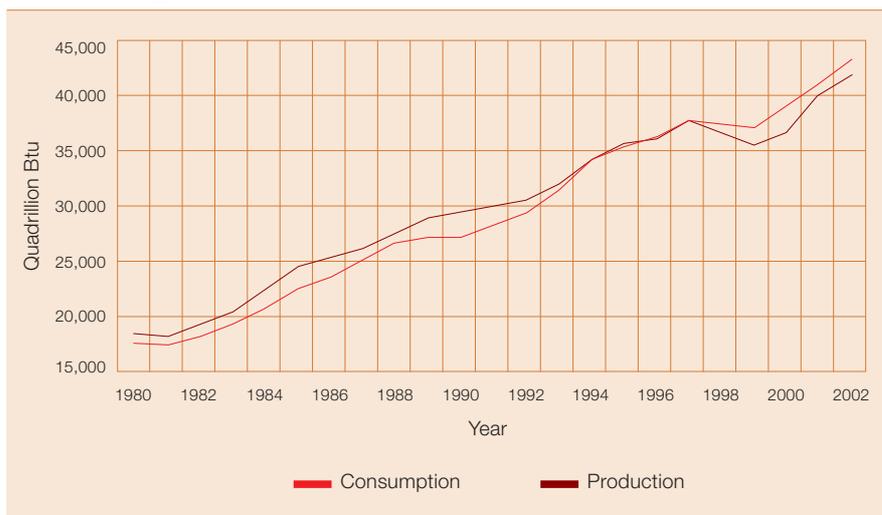
During the summers of 2003 and 2004 supply shortages led to about two thirds of Chinese provinces imposing brownouts and rationing energy. The EIA (Energy Information Administration) predicts that Chinese electricity consumption will grow twice as fast as the world average between 2001 and 2025.

This rapid growth is positioning China among the giants in energy consumption – a trend that will continue for the next five, ten, or even twenty years.

#### What is driving energy demand?

Increasing living standards, especially in Eastern China, have substantially changed consumption patterns to include modern goods and services. This, combined with China's position in global export manufacturing, have in turn created opportunities of which the most important is rapid industrial growth – around 10% a year since 1980. Over the last three years in particular, following heavy focus on areas such as construction and infrastructure, industrial energy demand has been very high. The scale of fixed asset investment in buildings, roads, and factories has been huge in the last few years, and is by nature highly

**1** China's energy production and consumption (source: EIA).



energy-intensive. The construction boom and – by international standards – still poor energy efficiency in China help explain the scale of the energy demand increase.

Though industrial consumption accounts for roughly two thirds of the

growing energy needs in China, domestic consumption is also an important force to consider. This has grown steadily, a trend that is likely to continue through the coming decades. The rise of the middle class in China is only starting to impact energy needs. As China becomes increasingly



wealthy, factors such as demand for cars and more electricity in bigger houses will continue to increase. Likewise oil and electricity demand will rise. Urbanization also has a huge role to play in this equation. Only 37% of the Chinese population currently lives in urban areas, which is well under the global average of about 50% and far below the developed world average of over 70%. As the country liberalizes and develops, this balance is likely to shift towards heavier urbanization.

**Consumption reflects the rural – urban divide**

In China, there are significant differences between urban and rural energy consumption. Presently rural residents use below 40% of that of their city-dwelling counterparts. Due to high costs and poor access to commercial energy, this population currently supplements its commercial consumption with biomass and direct coal burning. If this inefficient and polluting non-commercial energy use is included in the energy balance, rural residents are using one third more energy than their urban peers <sup>2</sup>. In order to cut back on the current waste, pollution, and health hazards of biomass and coal burning, rural provision of commercial energy is a government target. Growing urbanization will also contribute to this shift. The scale of the Chinese population means that changing demographics such as urbanization, rural electrification, and rise of the middle class are likely to have a

huge impact on the Chinese and global energy market.

Demand side changes are being facilitated through fundamental shifts in the energy supply. Rising energy needs are being accommodated through a variety of government efforts and private sector developments. There has been rather slow progress in deregulating and privatizing the energy industry. As part of the transition to a market economy, incentive structures have to be changed, distorting subsidies lessened or removed, price controls lifted and more active competition encouraged. Efficiency improvements will come as a direct result of China's shift towards market-based pricing.

During the 1990s, oil production in China doubled but still failed to keep up with rising demand – currently the fastest in the world.

**From coal to “clean” energy**

The most important source of Chinese energy is coal <sup>3</sup>. China possesses vast coal reserves and is both the largest producer and consumer of coal in the world (China is, in fact a net coal exporter). The government is working to decrease this heavy reliance on coal relative to other fuels, but coal will continue to grow in absolute

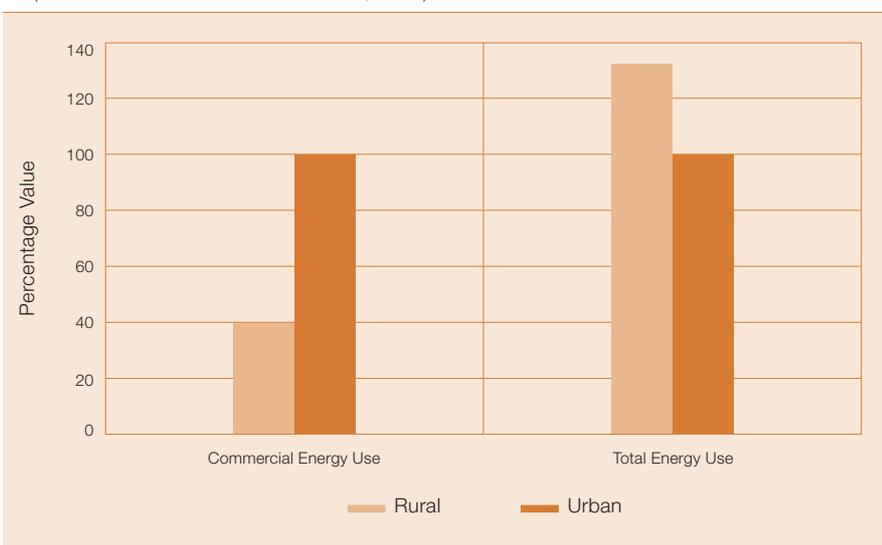
terms and will definitely remain the country's largest energy source through 2025. The 10th five-year plan includes a 17% increase in coal supply between 2000 and 2005 – below the growth targeted for other energy sources, but still quite substantial.

Oil is the next biggest source. During the 1990s, oil production in China doubled but still failed to keep up with rising demand – currently the fastest in the world. China has been a net oil importer for the past decade. It is forecast the country will import 84% of its needs by 2030 (IEA).

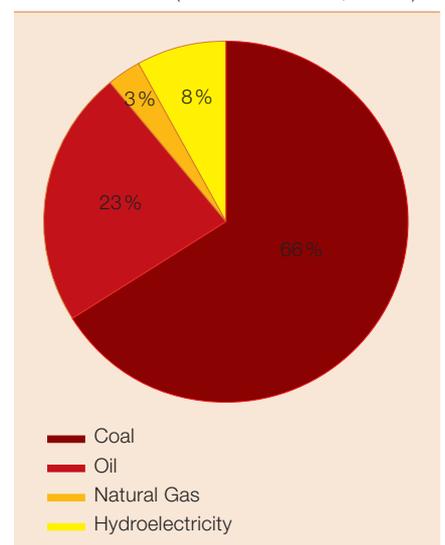
The next most important source of energy for China is hydroelectric generation. China possesses the largest hydroelectric resources in the world. This is a significant source of energy generation and will be increased by nearly 50% during the 10th five-year plan. The Three Gorges project is probably the best known of China's endeavors to develop its hydroelectric resources. This 18,200 MW facility is meant to be completed by 2009 with a capacity to single-handedly supply 3% of current demand. Apart from the Three Gorges, there are 25 smaller projects underway along the Yellow River (15,800 MW) and a 5,400 MW plant on the Hongshui River. Construction has also started on a 14,000 MW development at Xiluodu and 6,000 MW at Xiangjiaba.

Natural gas is currently a very small power source. Both western China

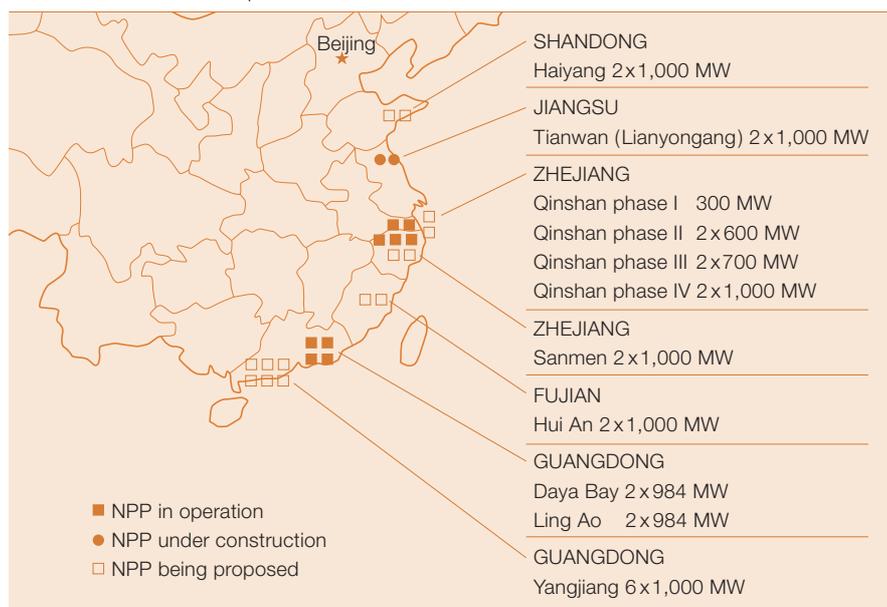
<sup>2</sup> Rural and urban energy consumption (data source: State Statistical Bureau, 1998).



<sup>3</sup> Sources of energy consumption in China 2002 (data source: NBS, 2003a).



4 Chinese nuclear development.



and neighboring countries, such as Russia, possess substantial natural gas reserves. Gas from areas such as Xinjiang as well as imports will see increasing use in power generation. One clear advantage of natural gas is that it burns much more cleanly than coal. As part of Beijing's preparations for a "green" 2008 Olympics, a substantial part of the city's power supply is being switched to natural gas.

Nuclear energy, like natural gas, constitutes only a small fraction of present energy generation **4**, but will expand at a furious pace in the coming years. The 10th five-year plan has targeted a 266% growth in this sector. Forty new nuclear power plants will be built by 2025.

#### Poor efficiency

The Chinese power generation sector is highly inefficient – a situation that will not be sustainable as the economy continues to develop and energy needs continue to grow. A World Bank study (1997) estimated that if efficiency levels were increased to OECD levels, China would save the equivalent of one-sixth of current consumption. From an energy efficiency standpoint, Chinese production is not competitive compared to most developed countries. According to Li et al (2000), energy consumption in China per unit of GDP produced is four times that in the Japan. Efficiency improvements are an area where the Chinese energy sector can boost prof-

itability while ensuring that energy needs are met.

#### Moving the energy: power grids

China's vast energy resources are predominately concentrated in areas far away from the booming coastal and southeastern cities where consumption is greatest. One of the problems with the current system is that it is regionally focused and has insufficient interconnection. The government is planning to establish a unified national power grid by 2020, selling power at market-determined rates. This is a major factor in the efforts to better match energy supply and demand in China. One key part of this plan is the "West to East Plan", with major lines in the north, center and south connecting the production of the resource rich West to the needs of the energy-hungry East. The 2020 strategy also envisages connections to Russia in the North and Thailand in the South.

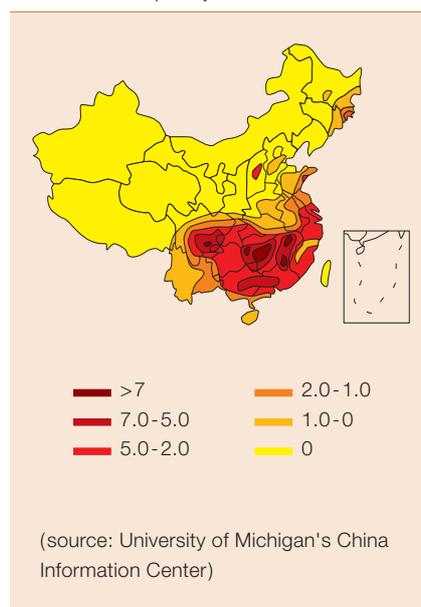
Nuclear energy, like natural gas, constitutes only a small fraction of present energy generation, but will expand at a furious pace in the coming years.

#### Health and the environment:

##### hidden costs of energy production

China's rapidly expanding energy industry has caused some serious side

5 Acid rain frequency in China.



effects. In particular, rapid development of the power sector has taken a substantial toll on public health and the environment. Air quality is highly degraded and there is a serious problem with acid rain **5**. For example, a 1998 WHO (World Health Organization) study found that 7 out of the world's 10 most polluted cities in the world are in China. Acid rain has caused economic damages estimated at \$13 billion and factoring in effects of air pollution reduces GDP figures by 3%<sup>1)</sup>.

The major culprit is coal, which is difficult to burn cleanly and serves as the biggest source of fuel for 1.3 billion people. In rural areas particularly, where burning coal in homes is common, indoor air pollution is severe. Factories subject to lax emissions standards cause bad outdoor air pollution. According to a World Bank report, air pollution costs the Chinese economy \$25 billion each year in health expenditure and lost labor productivity. Respiratory disease accounts for a quarter of all premature deaths in China, a statistic that has jumped by 25% over the past decade. In addition, poor safety standards leading to coal mining accidents have cost around 6,000 lives a year. The 10th 5-year plan aims to increase the use of clean fuels, such as hydro, natural gas, and nuclear from 26% of the total to 31% between 2000 and 2005 and ban the use of some of the worst quality coal.

The human and environmental costs of energy consumption and production in China are very serious, and have contributed to directly calculable economic losses, which the Beijing government is taking more and more seriously.

Economic growth is predicted to remain high for decades to come, which in turn means that the energy sector will continue to expand.

#### Conclusion

In 2003 and 2004, China's electricity consumption increased by an aston-

ishing 15% per year. If added to the 10.4% growth in 2002, this in itself is more than the total power generation installed in Brazil. As Scott Roberts, chief representative in the Beijing office of Cambridge Energy Research Associates, puts it "they are adding a middle-sized country every two years in terms of energy consumption."

Economic growth is predicted to remain high for decades to come, which in turn means that the energy sector will continue to expand. Given the scale of the Chinese energy industry and of its growth, efficiency in power generation and consumption is too low and environmental and health costs too high. The stakes are very large, but efforts by the central government to guide the energy indus-

try's development are in the right direction. Diversifying energy sources, raising production standards, moving towards market-based prices, and improving interregional connectivity will all help facilitate the healthy development of the Chinese energy industry.

**Alia Malik**

external writer

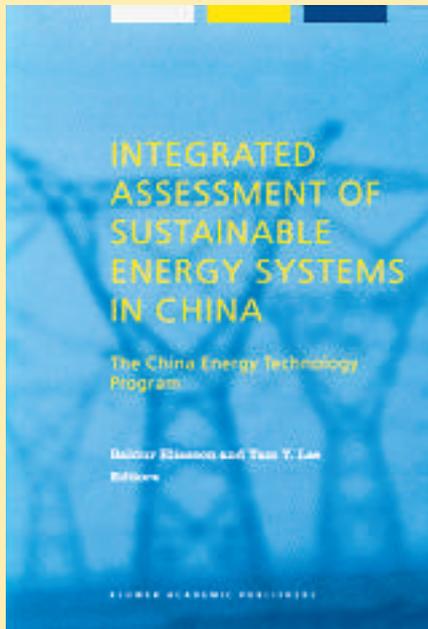
aliamalik1@yahoo.com

---

#### Footnotes:

<sup>1)</sup> **Zhang Jianyu**, program manager, Beijing Office of Environmental Defense.

## The China Energy Technology Program



a study, the China Energy Technology Program or CETP. The work was led by ABB in co-operation with universities of world renown and three Chinese research centers. The aim was to identify and analyze the cradle-to-grave impact of a range of power generation options for sustainable growth, focusing on the needs of Shandong, a rapidly developing coastal province located between Beijing and Shanghai.

Some 70 scientists, engineers and academics of electricity from three continents contributed to this comprehensive three-year study, as did customers and consumers. The results were published in 2003 under the title "Integrated Assessment of Sustainable Energy Systems in China".

In this publication, the CETP project group presents an integrated view considering not only the short-term techno-economic parameters but also the long-term environmental aspects of the available options. The encouraging results for Shandong province can be summarized in a few bullets:

- It is feasible economically and socially justifiable to generate more electricity with less air pollution.

- Cost effective methods and technologies exist which reduce air pollution and stabilize green house gas emission.

The technologies, the tools and the methodology developed within this program are certainly aimed at being universally applicable to situations similar to Shandong. Decision makers in China or elsewhere will be able to make better and more informed decisions related to the selection of appropriate technologies for electricity generation. As the Secretary General from the Ministry of Science and Technology of the People's Republic of China, Mr. Dinghuan Shi, expressed: "The policy makers who read this book will most certainly find it invaluable in developing a sustainable system of energy production that will support China's development goals. I am very glad to have been part of this successful project and look forward to continued international co-operation as the future unfolds."

The increasing global need for electricity – the largest part of which is generated from primary energy sources – is having a significant impact on the environment by the emission of anthropogenic greenhouse gases. Under the auspices of the Alliance for Global Sustainability, alternative strategies giving greater consideration to renewable energy sources have been the focus of

# Three Gorges

18.2 GW of hydro power from the Yangtze river

Patrick Schmid

With a length of 6300km, China's Yangtze is the world's third longest river. It drains a basin of 1,683,500 square km and provides irrigation and transport for tens of millions of people along its banks. But the Yangtze is also a liability: raging flood waters have repeatedly killed thousands and destroyed homes and crops. In 1993, the construction of a

dam began at Yichang. With a length of 2,309m and a crest elevation of 185m, it will be the world's largest dam.

The Three Gorges Project will not only bring greater predictability to the waters of this mighty river, but will generate huge amounts of electricity – equivalent to one ninth of China's

total 1992 requirement. This environmentally clean supply will help satisfy China's growing demand while reducing reliance on polluting coal-fired stations.

ABB is part of this exciting project, supplying gas-insulated switchgear for the generating stations.



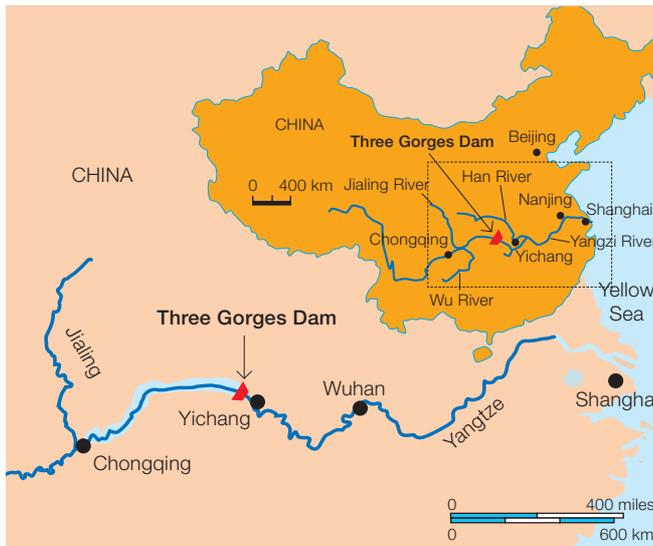
A dam project at Yichang was first considered by engineers and scientists in the early 1900s. They predicted that a regulation of the river could save thousands of lives by preventing floods. In the 1930s news reports described how hundreds of people died in the raging floodwaters. In 1954 33,000 died when the Yangtze burst its banks. The argument for building the dam became even more pressing. Over the past years (the dam has been under construction since 1993) hundreds more have lost their lives.

The Chinese government says the dam will control devastating floods, provide much-needed electrical power to China's growing cities and allow 10,000-ton freighters to enter the nation's interior – which is currently limited to boats under 3,000-tons. The dam's hydro-power generation will replace 40–50 million tons of coal combustion each year and help reduce pollution and save resources.

**Geography of the Three Gorges Project**

The Three Gorges Project (TGP) is vital in the development and harnessing of the Yangtze river. A reservoir is being created by flooding the river valley along 600km of its length <sup>1</sup>, including the majestic Qutang, Wuxia and Xiling gorges, which give the

<sup>1</sup> The location of the Three Gorges dam and reservoir on the mighty Yangtze river.



project its name. The dam itself is situated in Sandouping near Yichang City, Hubei Province, about 40km upstream of the existing Gezhouba Project.

Upon completion, the TGP will be the world's biggest hydroelectric power station in terms of total installed capacity.

The TGP is the largest water conservancy project ever realized in China, or anywhere in the world. With a normal pool level<sup>1)</sup> of 175m, the total storage capacity of the reservoir is

39.3 billion m<sup>3</sup>. The TGP is a multi-purpose development project producing comprehensive benefits, the most important of which are flood control, power generation and navigation improvement.

**China's second Great Wall – the world's largest hydro power station**

In April 1992 the National People's Congress voted in favor of the dam. Construction started in 1993. Upon completion, the TGP will be the world's biggest hydroelectric power station in terms of total installed capacity.

The Three Gorges dam has a length of 2,309m and a crest elevation of 185m <sup>2</sup>. The dam has a two-way five-step ship-lock and a vertical ship-lift for ships up to 11,800 tons <sup>3</sup> – an impressive sight.

The Three Gorges hydroelectric power station consists of two powerhouses <sup>4</sup> at the toe of the dam<sup>2)</sup>, separated by the spillway section.

In total, twenty-six 700 MW Francis-type turbine generator units are installed – 14 units in the left-bank and 12 in the right-bank powerhouse. The overall installed capacity is 18.2 GW producing an annual power of 84.7 billion kWh <sup>5</sup>, equivalent to one-ninth of China's total in 1992 – or more than the total consumption of Belgium or Finland.

In August 2003 the first batch of four generator units went into operation. In November, another two units joined them. Until the completion of the project in 2009, four units will be added every year.

The left bank powerhouse will be completed in 2005 and the right bank powerhouse in 2009.

On the right bank, room is reserved for a future underground powerhouse

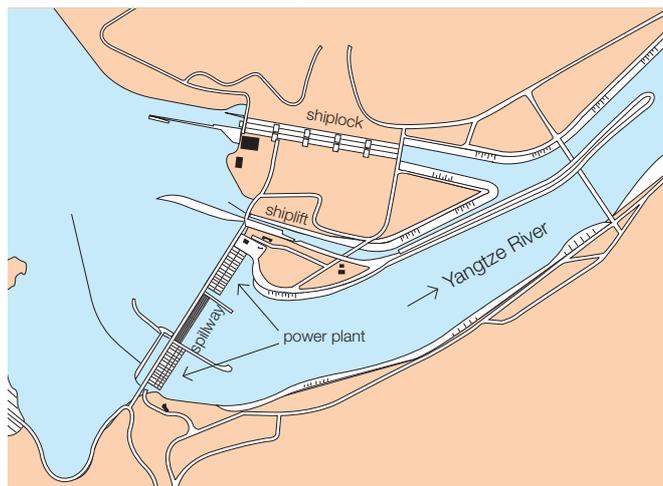
<sup>2</sup> The reservoir has a storage capacity of 39.3 billion m<sup>3</sup>.



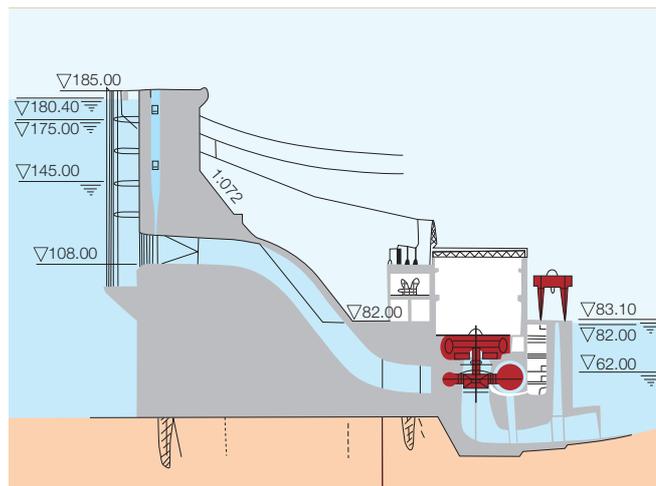
**Footnotes:**

- <sup>1)</sup> The normal pool level of reservoir is the maximum level to which the water surface will rise during normal operations.
- <sup>2)</sup> The toe of a dam is its junction with the ground surface.

3 The dam will be 2,309 m long and 185 m high.



4 Cross section of one of the two powerhouses.



– adding six further 700 MW generators.

The Three Gorges hydropower station will be connected to thermal power and hydroelectric grids in central and eastern China, serving the power-hungry and booming economy and boosting the reliability of electricity supplies.

**Compact switchgear**

The gas-insulated switchgear (GIS) design 6 allows the substation to be significantly smaller than a conventional installation – while its high reliability and efficiency help increase the availability of power from the TGP power station.

Three elevation levels (EL) of the downstream powerhouse are important for the 550 kV GIS:

- EL 82m where the main transformers, the 550kV shunt reactors and other auxiliary equipment are installed.

- EL 93.6m where the 550kV gas-insulated switchgear and its accessory equipment are located, and
- EL 107m, being the roof of the powerhouse, where the 550kV outgoing bushings of the GIS and other 550kV conventional outdoor equipment, such as wave traps, voltage transformers and surge arresters are arranged.

The GIS hall (left bank) is 581.5 m long and 15m wide.

**Technology Transfer**

In line with China’s strategy for increasing self-sufficiency in key areas of power generation, ABB is sharing its 550kV GIS technology with two Chinese partners.

For the TGP about 25% of the Left Bank GIS has been produced in China by New Northeast Electric (Shenyang) High Voltage Switchgear Co. Ltd. And Xi’an Shiky High Voltage Electric Co. Ltd.

**The Future:**

**The Three Gorges Project will be the world’s largest SF<sub>6</sub> gas-insulated switchgear (GIS)**

The construction of the Right Bank started in 2003 and will take six years.

Presently, the GIS for the Itaipú Project in Brazil/Paraguay, with 54 type ELK-3 circuit-breaker bays (also supplied by ABB Switzerland) – is the biggest ever built. Chosen as the principal supplier of the Right Bank GIS, ABB is proud to be supplying the entire GIS for the Three Gorges Project. After completion in 2009, this will become the largest SF<sub>6</sub> gas-insulated switchgear installation worldwide – featuring 73 type ELK-3 circuit-breaker bays.

5 The dam will supply 84.7 kWh per year – equivalent to 11% of China’s 1992 consumption.



6 Gas Insulated Switchgear (GIS) installed in the powerhouse.





To achieve this goal, a technology transfer arrangement was implemented, comprising submittal of the entire technical documentation, training of personnel at all levels, and support in implementing the new technology at both Chinese factories. The Technology Transfer focused on high quality standards and timely delivery of the products in order to meet the challenging project schedule.

On 15 July 2003, a milestone was achieved when the 550 kV gas-insulated switchgear of Left Bank 1 went into service.

#### GIS on the left bank

The 550kV gas-insulated switchgear consists of two stations: Left Bank 1 with 5 outgoing lines and Left Bank 2 with 3 outgoing lines.

Extensive overvoltage calculations were performed by ABB with the latest software to simulate switching operations in the future network. These calculations showed that it was necessary to equip only the circuit-breaker of the two outgoing lines to Wanxian with closing resistors.

The assembly of the 550kV GIS on site was carried out by Bajun Hydro-power Construction Group as subcontractor under supervision of ABB.

On 15 July 2003, a milestone was achieved when the 550kV gas-insulated switchgear of Left Bank 1 went into service.

#### TGP GIS switchgear

Characteristics of the GIS arrangement are:

- One-and-a-half breaker arrangement (a configuration in which three breakers are used to connect two lines to two busbars).
- One generator is paired to one transformer. Two such transformer units are then combined into a common incoming 550kV branch. A 550kV circuit-breaker bay is installed on the high-voltage side of each transformer.
- Left Bank 1 and 2 can be separated by busbar sectionalizing breaker bays.

Left Bank 1 comprises:

- Four one-and-a-half breaker diameters connected to four combined units.
- One two-breaker string.

Left Bank 2 comprises:

- three one-and-a-half breaker diameters connected to three combined units.

The arrangement as employed in the TGP (Left Bank) results in a total of 39 three-phase circuit-breaker bays.

Another important milestone was reached on 7 February 2004 when the GIS equipment of Left Bank 2 passed the high-voltage on-site tests successfully long before the contractual completion time. Left Bank 2 went into service on 30 April 2004.

The Wuhan High Voltage Test Institute performed the high-voltage on-site tests, consisting of the standard AC-tests plus an additional impulse voltage test.

#### Good performance thanks to GIS

The use of compact-sized gas-insulated switchgear (GIS) made its installation possible directly above the respective transformers, in the space between the generator hall and the dam, at almost no additional cost. Furthermore it results in an optimal arrangement with regard to function and operation of the electromechanical chain, comprising the generators, step-up transformers, switchgear and overhead power lines. As a result, an almost ideal configuration of all control and protection equipment is provided, which in itself makes a valuable contribution to the reliability of the station and reduces costs.

Although the large distances between the generators result in rather long busbar sections, this is inherently a strength as all components are easily accessible.

Installation of all high voltage switchgear in the powerhouse represents a perfect concept for hydroelectric projects.

#### Patrick Schmid

ABB High Voltage Technology  
Zürich, Switzerland  
patrick.schmid@ch.abb.com

# HVDC transmits green energy in China

Gunnar Flisberg, Leif Englund and Abhay Kumar

The continuously growing demand for electricity calls not only for heavy investment in power plants, but also in the transmission grid that brings this power to where it is needed. An important transmission technology is High Voltage DC (HVDC). HVDC is cheaper and more energy efficient over long distances than its AC equivalent.

ABB has recently completed two major 3000 MW  $\pm$ 500 kV links to bring electricity from the new Three Gorges hydro plant to major load centers – a third such project is in progress.



Electrical energy is considered one of the major assets in expanding the GDP of a nation, hence its supply becomes crucial to economic growth. Similarly, the consumption of electrical energy is central in the improvement of quality of life all over the world. The People's Republic of China is no exception. ABB's reliable HVDC transmission systems in China are bringing electrical energy from centers of generation to areas of consumption; efficiently, effectively and economically.

Following commencement of transmission of power in November 2002, a rated power of 3000 MW was transmitted for the first time on 31 October 2003 from Longquan to Zhengeng – when a sufficient number of generators had been synchronized at the Three Gorges power station – one of the largest hydro power projects in the world. Since then, the Three Gorges to Changzhou ±500 kV DC Transmission Project (3GC) [1] has been transmitting close to its rated 3000 MW continuously, bringing green power to the Shanghai area. The 3GC transmission has run at its overload capacity of 3300 MW quite frequently during the summer of 2004.

Following on from this success, another ABB 3000 MW HVDC project went live between Jingzhou and Huizhou on 1st April 2004. Since then, the Three Gorges to Guangdong ±500 kV DC Transmission Project (3GG) [1] has been transmitting additional power from the Three Gorges Hydro Power Station, thereby meeting the increasing power demand of the Guangdong area.

The next major project will be completed in 2007, when ABB's third 3000 MW HVDC link will start transmitting power over 1060km from the sec-

ond phase generators of Three Gorges (Right Bank). ABB was also awarded the Three Gorges to Shanghai ±500 kV DC Transmission Project (3GS) on June 14, 2004 by the State Grid Corporation of China (SGCC) – China's largest power grid operator and supplier of electricity to more than half the economy. This new project will further enhance the power supply situation in the Shanghai area. ABB will execute this project in co-operation with its consortium partners – XB for converter Transformers & Smoothing Reactors, XPR for thyristors valves, PERI for thyristors, NARI-Relays for control and protection system and BDCC/XIHARI for system design/studies.

**Focal points and principal parameters of 3GS**

The normal sending (rectifier) station of the Three Gorges to Shanghai link will be located at Yidu, close to the city of Yichang (Hubei Province) and will be connected to the Three Gorges Power station by three 58 km long 500 kV AC lines.

The normal receiving (inverter) station is located at Huaxin in Qingpu close to Shanghai and will be connected by a pair of five km long 500 kV AC lines to Huangdu station – part of the 500 kV AC ring around Shanghai city.

**What sets the 3GS project apart?**

The basic design parameters of this transmission link are similar to the 3GC and 3GG projects. They are summarized in **table 1**.

The transmission distance of the 3GS HVDC project is almost 200km longer

than that of the 3GC project. The principal features setting 3GS apart include:

- New transformer design.
- Box-in of transformers to limit acoustic emissions.
- 500 kV AC Gas Insulated Switchgear (GIS) in both converter stations.
- New DC filter solution.
- New building-block arrangement of control and protection functions.
- Stand alone AC protections of converter transformers.
- Factory System Test (FST) for control/protection equipment performed in China.
- New design of chemical treatment plant for water cooling system.
- Changed rating of some AC filters.

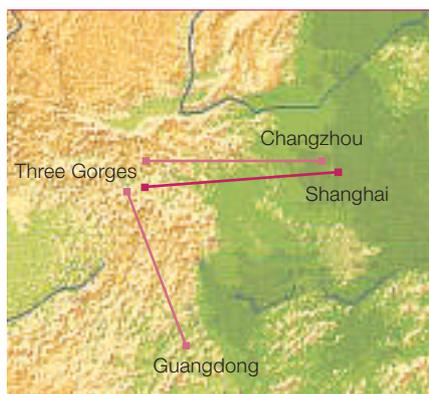
The use of different suppliers for the new project has meant that some interfaces have had to be redesigned. The closer integration with the owner's own products also leads to different interface requirements.

**Audible noise – a critical issue**

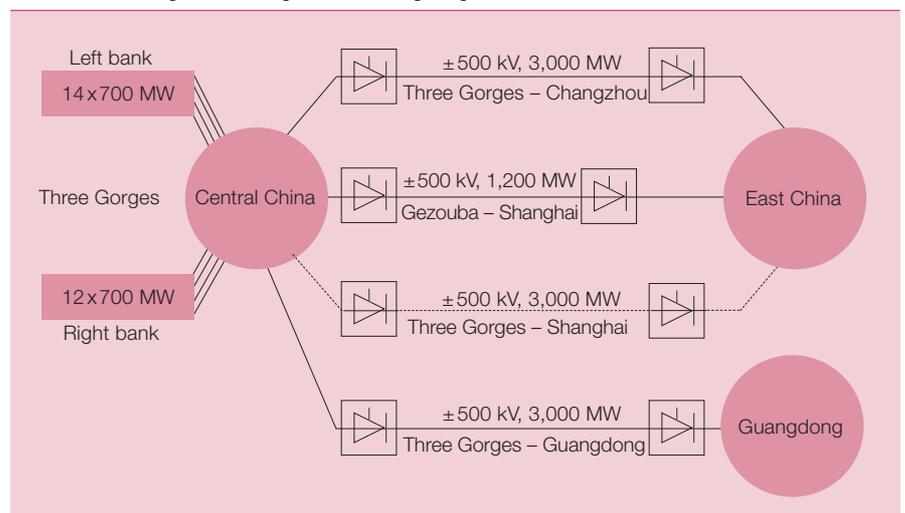
Being located close to built-up areas in Shanghai, audible noise reduction at the inverter facility has been an important design parameter. A target of 45dB(A) was set. Several noise-reducing measures have been combined at Huaxin station, including the following:

- The arrangement of converters and filters at the station was acoustically optimized.
- Similarly, single filter layouts were optimized.
- All filter components were designed to be as silent as possible. Attenuation measures include the dividing of filter capacitor stacks to limit their

**1** 3x3000 MW HVDC Links.



**2** Four HVDC links will carry hydroelectricity from the Three Gorges power plant to industrial region of Shanghai and Guangdong.



height. Some capacitors were fitted with damping elements.

- Transformers have been boxed in.
- Transformer and smoothing reactor tanks have beams to be filled with sand on site.
- All cooling fans are acoustically optimized and noise dampers used where appropriate.
- The station perimeter wall is designed as an acoustical screen.
- Filter reactors have built-in noise screens.
- Space is set aside for future sound screens for filter areas and for free-standing screens.

### Securing Success

In order to secure the success of the new project, a thorough review of operating experience from previous projects was compiled and evaluated. A brief summary of this review is presented below:

#### Thyristor valve operation performance

3GC and 3GG use a combined count of 8352 thyristors. Since being taken into commercial operation, there have been no thyristor failures in any of the four converter stations. No other disturbances have occurred.

#### Converter transformers and smoothing reactor operation performance

36 converter transformers and 6 smoothing reactors of ABB design are in operation at Longquan, Jingzhou and Huizhou converter stations. A small number of false trippings has occurred due to moisture in the gas relays. The relay covers have since been modified to allow better air circulation. Furthermore, rain protection has been provided and the input boards for tripping de-sensitized by adding parallel resistors across channels. Locally manufactured transformers have suffered from some gas generation. A loose contact has been found and corrected.

#### Outdoor insulation performance

There has been one flashover on a DC voltage divider in Jingzhou under extreme fog conditions. The cause of this is now under investigation. At the moment an insulator batch problem is thought to be the cause.

#### Control equipment operation performance

There was, at first, some irregular behavior from control/protection equipment in the 3GC project. The

cause was traced to both hardware and software in the control and protection equipment – resulting in a crash of the active computer system. When this occurred, the system automatically switched to the redundant control and protection system and all functionality of the power transmission was maintained.

Several software changes were successfully implemented. To master the hardware problems, the computer main boards were replaced by a newer and more reliable type. Current operational statistics suggest that these efforts have been fruitful and that the problems are not recurring.

3 Thyristor Valves at Huizhou.



4 Control Room, Longquan.



5 Jingzhou converter station.



Table 1 Three Gorges to Shanghai HVDC link (3GS) project characteristics.

Main parameters	Yidu/Huaxin
Nominal power rating, MW	3000
Nominal dc voltage, kV	±500
Transmission distance, km	1060
<b>Power overloads at max ambient temperatures with redundant cooling in service, MW:</b>	
Continuous	3150
2 hour	3390
10 seconds	4230
5 seconds	4500
<b>Converter transformers:</b>	
Type of thyristor	1-phase, 2-winding
Power rating, MVA	297.5/283.7
<b>Smoothing reactors:</b>	
Type	Oil-insulated
Value, mH	290
<b>Thyristor valves:</b>	
Type	YST-90
Arrangement	Double valve, suspended from ceiling
No of thyristors per valve	90/84
DC filter type	Passive, DT6/12 and DT24/36
<b>AC filter:</b>	
Type	Passive
Yidu, no x type; MVar	3×HP11/13, 3×HP24/36, 2×HP3, 1×SC; 1371
Huaxin, no x type; MVar	5×HP12/24, 4×SC; 1890
AC system voltage, kV	535/500
AC system frequency, Hz	50
<b>Losses:</b>	
Converter station, %	1.3
DC Line, %	5.8

**Table 2** Outages on Three Gorges to Changzhou (3GC) in 2004.

Date	Duration	Outage	Category	Event (Counter-measure)
5th March 2004	0.42	Monopole	DC Control & Protection	Computer in standby mode when restarted / Supervision software bug
15th March 2004	1.82	Monopole	AC and AUX Equipment	Transformer Guard malfunction
26th July 2004	0.53	Monopole	AC and AUX Equipment	Manual fire call point mis-operation (replaced faulty component)
8th Aug 2004	0.29	Monopole	DC Control & Protection	Computer changing to standby mode after replacement / Software bug
23rd Nov 2004	4.81	Monopole	DC Control & Protection	False trip from transformer saturation protection

Figures of equivalent outage hours under column 'Duration' are approximate only and not confirmed.

**Table 3** Outages on Three Gorges to Guangdong (3GG), July to December 2004.

Date	Duration	Outage	Category	Event (Counter-measure)
5th July 2004	1.56	Monopole	Other	Human error (Improved site procedures)
17th July 2004	3	Monopole	AC and AUX Equipment	Mal-operation of OLTC gas relay
7th Nov 2004	9.23	Monopole	Primary DC Equipment	Flashover over DC voltage divider
22th Dec 2004	13.45	One pole followed later by other pole	DC Control & Protection	LAN network disturbance

Figures of equivalent outage hours under column 'Duration' are approximate only and not confirmed.

**Reliability and Availability**

A summary of operating experience from the two projects already in commercial operation is presented below:

**Three Gorges to Changzhou ± 500kV DC Transmission Project**

This link went into commercial operation on 16th June 2003. Operating experience has been excellent with an availability against forced outages of over 99.9%. In 2004, very few outages caused by ABB equipment have occurred. The monopolar outages are listed in **table 2**. No bipolar outage has occurred.

In all there have been 5 monopolar outages against a design target of 12 outages per year. As the equipment burning-in period is still ongoing, this performance is seen as excellent. Similarly, an outage time of less than 8 hours (including administrative time) represents a good record against a design target of 44 hours (excluding administrative time).

**Three Gorges to Guangdong ± 500kV DC Transmission Project**  
Operating experience from 3GG has also been excellent. Since the start of commercial operation on 27th May 2004, the availability against forced outages has been over 99.8%. The

**6** First Converter transformer for Huaxin at ABB's test lab in Ludvika – After successful completion of type tests.



forced outages due to ABB equipment during the second half of 2004 (July to December) are listed in **table 3**.

Four monopolar outages in these six months against a design target of 10 per year is equally a good record for a new system.

**Learning from experience**

In planning the Three Gorges to Shanghai project, this experience was evaluated in detail and measures were taken to further improve on this track record.

**Execution**

The execution of the Three Gorges to Shanghai ± 500kV DC Transmission Project is advancing according to schedule. The first converter transformer was type tested on March 17, 2005, just 9 months after the contract

was signed. Judging by current progress, the project could be completed several months early.

The commissioning of the Three Gorges to Shanghai line in 2007 will enhance the cross-region electricity transmission capacity considerably and go some way towards balancing the power generation disparities in the different regions of China.

The new HVDC link will enhance the capacity of the network over long distances, while at the same time reducing transmission losses. Wang Xiaohui, power industry analyst with CITIC Securities says, "The soaring demands of power consumption and fast-growing power plant construction – a result of the country's robust economic development – has put much pressure on China's overloaded power grid system". The Three Gorges to Shanghai link is a great step towards easing this pressure.

**Gunnar Flisberg**  
**Leif Englund**  
**Abhay Kumar**  
ABB Power Technologies  
Ludvika, Sweden  
gunnar.flisberg@se.abb.com

**References:**

[1] **Leif Englund** et. al., "HVDC Superhighways for China", ABB Review issue 4/2003

# More power to the cities

Improved utilization of transmission systems through thyristor controlled series compensation  
Rolf Grünbaum



Global electricity consumption is continuously rising, increasing pressure on existing infrastructure. To alleviate this, power grids are being interconnected, assuring the stability of supply and facilitating trading. This is leading to a rapidly growing demand for transmission capacity. It is not always practicable to meet this demand by building new lines: Planning and construction takes time and is expensive; environmental concerns and the intensification of land use mean new lines are not always acceptable.

The raising of capacity on existing lines is an alternative. Many technologies exist that can contribute to this enhancement. One approach lies in the compensation of line reactance. The use of Thyristor Controlled Series Compensation (TCSC) provides a variable compensation mechanism permitting a raising of transmission stability – freeing line capacity for active power.

From a technical point of view, limitations of the power transmission capacity of a grid can be eased by adding new transmission lines. In reality, however, this may not be practicable or desirable for a variety of reasons: Adding new lines and/or extending existing substations is often too costly and time-consuming. Concessions for new rights-of-way may be difficult or impossible to obtain. Aspects of environmental impact are today much more important than they were in the past and need to be properly considered when dealing with transmission development procedures. Techniques to improve the steady-state and dynamic stability of the line, permitting more power to be transmitted, provide an attractive alternative to the construction of new lines. Thyristor-Controlled Series Compensation (TCSC) is one such option that offers technical, economic and environmental advantages.

In long distance AC power transmission, care is taken to maintain synchronization as well as voltage stability, particularly in conjunction with system faults. Series compensation makes safe bulk AC power transmission a reality over distances of more than 1,000 km. The advent of thyristor-controlled series compensation has added further capability as well as flexibility to AC power transmission. Consequently, this technology is applied across the globe to strengthen long transmission corridors, where capacity limitations due to dynamic stability issues were previously faced. The impact of TCSC on power transmission systems can be summarized as follows:

- Balancing of load flows.
- Increasing first swing stability, power oscillation damping, and voltage stability.
- Mitigation of subsynchronous resonance risks.

**Controllable series compensation**

A series capacitor in a grid introduces reactance of opposite sign to that of the inductive line reactance. Through this mechanism, the effective transmission reactance of the grid is decreased, and the power transmission capability increased under stable conditions.

With the reactance of the series capacitor equal to  $X_C$  and the inductive reactance of the line equal to  $X_L$ , we

can introduce a measure of the degree of series compensation introduced into the grid,  $k$ :

$$k = X_C / X_L$$

Using TCSC, the degree of compensation  $k$  can be varied at mains frequency (50 Hz) at a speed limited only by the speed of response of the electronic scheme. This makes TCSC suitable for applications where series compensation was not previously used, for examples, post-contingency power flow control and damping of active power oscillations.

Active power oscillations are frequently a limiting factor on the power transmission capacity of radial interconnecting ties. The TCSC concept is very useful for extending the possibilities for AC power interconnection between regions, both for increasing geographical distance and transmitted power.

TCSC configurations comprise controlled reactors in parallel with sections of a capacitor bank **1**. This combination allows smooth control of the fundamental frequency capacitive reactance over a wide range. The capacitor bank of each phase is mounted on a platform to ensure full insulation to ground. The thyristor valve contains a string of high power thyristors connected in series. The inductor is of air-core design. A metal-oxide varistor (MOV) is connected across the capacitor to prevent overvoltages.

If the thyristor valve is triggered just before the zero crossing of the capacitor voltage, a capacitor discharge current pulse will flow in the parallel inductive branch **2**. The discharge current pulse ( $i_v$ ) is added to the line current ( $i_l$ ). The capacitor voltage is thus increased in proportion to the charge passing through the thyristor branch. This is interpreted by the power system as an increased or boosted reactance of the series capacitor.

By varying the conduction angle of the thyristor valve, the boost level of the series capacitor can be controlled continuously. The boost factor of the TCSC,  $k_B$ , is defined as equal to the ratio between the apparent reactance ( $X_{app}$ ) and the physical reactance ( $X_C$ ) of the series capacitor.

**2** shows TCSC waveforms for the steady-state condition.

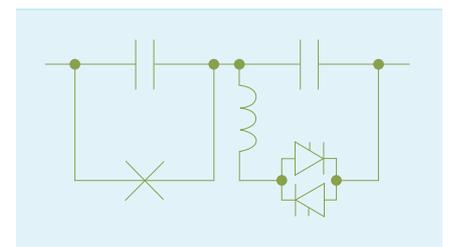
A patented control strategy called Phasor Estimation Technique is applied to enhance TCSC damping performance compared to conventional power oscillation damping control algorithms.

**Power oscillation damping in India**

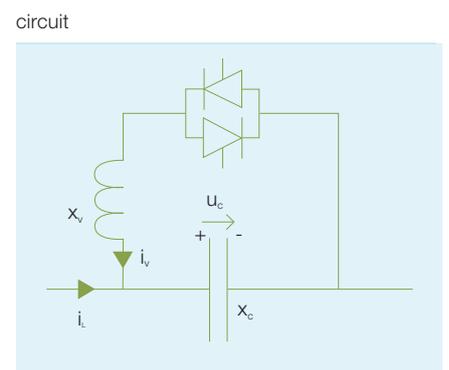
In India, two TCSC have recently been installed on the Rourkela-Raipur double circuit 400kV power transmission interconnector – between the eastern and western regions of the grid **3**. The main purpose of this major 412km long AC interconnector is the transfer of surplus energy from the eastern to the western regions of India under normal operating conditions, and also during contingencies. The TCSC are located at the Raipur end of the lines.

The TCSC enables damping of inter-area power oscillations between the regions, which would otherwise limit power transfer over the interconnec-

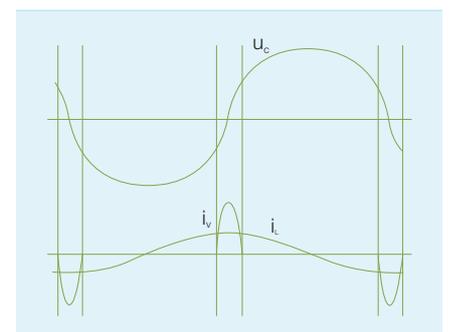
**1** Thyristor-Controlled series capacitor.



**2** TCSC in steady-state.



waveforms



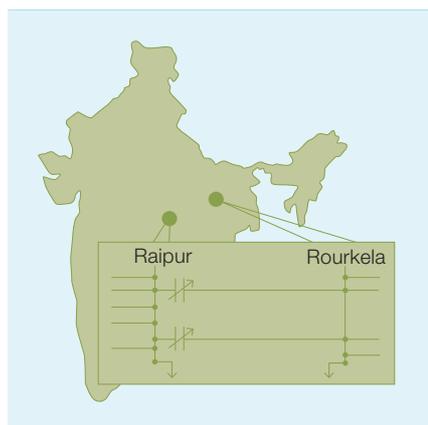
tor. Dynamic simulations performed during the design stage, and subsequently confirmed at the commissioning and testing stage, have proved the effectiveness of the Raipur TCSC as power oscillation dampers.

### Main circuit design

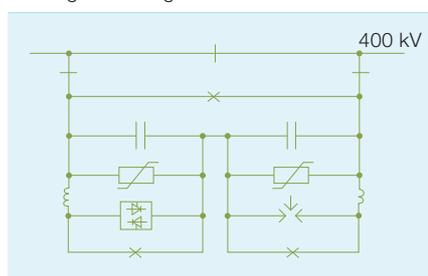
Studies performed on the power system have traced the poorly damped dynamics of the grid to low frequency inter-area oscillations between the eastern and western regions. As a countermeasure the studies recommended the installation of two fixed series capacitors, each rated at a compensation degree of 40%, and two thyristor-controlled series capacitors, each rated at 5% degree of compensation. This measure has been implemented <sup>4</sup>.

For power oscillation damping (POD), by means of the boost factor, the TCSCs introduce a modulation of the effective reactance of the power lines. During power swings the inserted TCSC reactance can be varied between 20.5  $\Omega$  capacitive (corresponding to a boost factor of 3.0), and 1.3  $\Omega$  inductive (corresponding to TCSC bypass). With suitable system control, this reactance modulation counteracts the active power oscillation, thereby damping it quickly.

<sup>3</sup> The Raipur-Rourkela series compensated 400 kV power transmission corridor.



<sup>4</sup> Single-line diagram of one of the TCSCs.



### Control and protection

The control system is based on the ABB MACH 2 concept, which is a hardware and software system specifically developed for power applications. The MACH 2 system is built around an industrial PC with add-in boards and I/O racks connected through standard type field buses such as CAN and TDM. This has facilitated very high performance and small hardware dimensions.

The TCSC can be controlled from two different locations. The local control room is equipped with an Operator Work Station (OWS), based on a personal computer. The TCSC can also be remotely controlled via a Remote Work Station (RWS) from the substation control room.

Current measurements for the control and protection functions are attained by use of Optical Current Transformers (OCT). An OCT consists of a current transducer in the high voltage busbar and an optical interface module in the control room. Signal transmission between transducer and interface is carried out by means of an optical fiber system including platform links, high voltage signal columns and fiber optic cables.

The purpose of the TCSC at Raipur is to actively damp power oscillations on the interconnection between Raipur and Rourkela. The TCSC control functions can be divided into four tasks:

- Firing control, to calculate the valve firing instants.
- Monitoring functions.
- Superior controls such as reactance limiting and sequence control.
- Power oscillation damper (POD).

When power oscillations are detected, the POD control function changes the reactance reference in such a way that the power oscillations are damped out.

### Thyristor valve

For controlled series capacitors, a thyristor valve is used to vary the apparent reactance of the capacitor. This is done by adding charge to the capacitor through the thyristor valve (ie, boosting the capacitor voltage).

The valve, located on platform level, is water-cooled and equipped with two vertically mounted, antiparallel stacks of thyristors. Each valve string consists of 14 thyristors in series, each with a wafer diameter of four inches. All communication between valve and the ground mounted control system is via fiber optics.

The thyristor valve is rated for a continuous current of 1850 A. It is furthermore rated to withstand short-circuit currents up to 55 kApeak, safely above any plausible fault situation that the valve may have to endure in operation. A site view of the Raipur TCSC is shown on page 19.

### Conclusion

With its rapidly growing power use, China will be facing heavy investment in its transmission infrastructure for years to come. Variable series compensation, as provided by TCSC, could play an increasing role in stabilizing grids and enhancing the capacity of existing lines.

### Rolf Grünbaum

Regional Marketing Responsible, FACTS  
Västerås, Sweden  
rolf.grunbaum@se.abb.com

# Grids united

ABB and Tsinghua University are helping interconnect China's grids  
Qianjin Liu, Qiang Lu, Christian Rehtanz

Rapidly growing industries in China rely heavily on a stable and continuous power supply. This means China's power grids are coming under increasing pressure. Because the centers of power consumption are often far from the principal generating areas, the interconnection of regional grids and the development of long-

distance transmission infrastructure are now priorities for China's utility sector.

There is much more to interconnection than just joining wires. Numerous planning, implementation, monitoring and protection measures must accompany the interconnection if insta-

bility and unpredictability are to be avoided.

In coordination with Tsinghua University, ABB is addressing these issues and is helping China's electricity grids interconnect. Thanks to this program, the nationwide exchange of power is fast becoming a reality.



As part of ABB's new corporate research center in Beijing, China, a group has been formed to conduct research and development in the area of power systems engineering. This group has, as its mission, to "contribute to the development of the power technology market through solutions to power systems issues and research on future systems requirements." Initial discussions with ABB customers in China indicated that various system performance shortfalls had been faced regarding the interconnection of the regional power grids. To better understand and alleviate the issues involved, ABB Corporate Research in China has initiated a project with Tsinghua University under the title "Interconnection of China's regional Grids".

As the leading technical university in China, Tsinghua is deeply involved in technical issues connected with the operation and planning of the national power system grid. Tsinghua University is also the site of China's State Key Lab of Power Systems led by Professor Qiang Lu **1**, a member of China's National Academy of Sciences. Professor Lu has worked extensively with China's power system and it was he who orchestrated the co-operation with ABB.

The Tsinghua project will identify the key technical issues and then develop the required systems solutions. The initial phase of the project has already been completed and it provides a summary of the historical development of China's transmission grid, and a summary of the problems that have accrued as well as a database of the transmission system configuration.

#### China's power grid<sup>1)</sup>

At present, China has seven inter-provincial networks **2**, namely: the North China Grid (NCG); Northeast China Grid (NECG); Central China Grid (CCG); East China Grid (ECG); Northwest China Grid (NWCG); South China Grid (SCG) and Sichuan and Chongqing power networks (CYG) as well as four independent provincial grids in Shandong, Xinjiang, Hainan and Tibet. 500kV has become the backbone structure in most regions except in the northwest, which relies on 330kV networks.

In China, the major energy sources are located in the west (hydro) and

the north (coal). The major load centers are in the east and south. Interconnecting the regional grids is therefore a natural step in the development of China's power systems. Grid planners intend to realize "west to east power transmission, north and south power exchange and nationwide interconnection".

#### The interconnection of China's regional grids

Interconnecting the regional grids began in 1989 when a 500kV 1,200 MW HVDC tie line, connecting the Central China Grid with the East China Grid, went live. In 2003 a second 500kV HVDC transmission line went into operation, increasing the transmission capacity between East and Central China to 4,200 MW. In May 2001, the NECG and NCG achieved synchronous interconnection through a 500kV AC line, as did Fujian Province and East China in December 2001. The Sichuan and Chongqing power networks and Central China were similarly interconnected in April 2002, and Central and North China in September 2003. In 2004, a 3,000 MW HVDC transmission link was completed between the Three Gorges power plant in Central China and Guangdong in the South China Grid. Numerous other interconnections, both AC and DC, are currently being studied and planned.

#### Issues encountered

In the area of system security, if the amount of power exchange between regional grids is large, any disturbances on the interconnecting lines significantly affect the frequency and voltage stability of the connected power systems. For example, once the Sichuan and Chongqing Grid (named ChuanYu Grid, CYG), the CCG and the ECG are interconnected, large amounts of power will be transmitted from the CYG to the ECG through the CCG **3**. The intertie line between the CCG and the ECG, the Genan DC line, will carry up to 1,200 MW of power. If the Genan DC link is interrupted while the CYG is sending power to the CCG through the Wanlong line intertie **4**, the CCG will have surplus power and the frequency will rise. In 2001, the Genan DC link experienced this problem four times when sending large quantities of power to the ECG. Each interruption caused the frequency of the CCG to exceed the upper limit of 50.2 Hz. The most serious incident occurred on June 4, 2001:

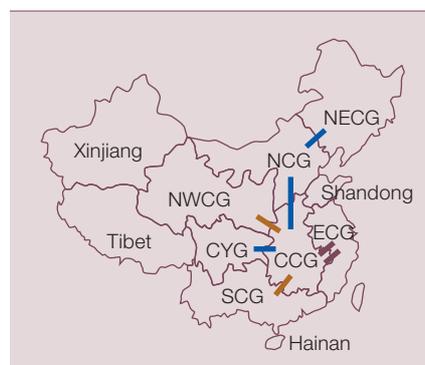
**1** Professor Qiang Lu of Tsinghua University.



**2** Interconnection of China's regional grids.

NCG=The North China Grid  
NECG=Northeast China Grid  
CCG=Central China Grid  
ECG=East China Grid  
NWCG=Northwest China Grid  
SCG=South China Grid  
CYG=Sichuan and Chongqing power networks

■ AC link in operation  
■ DC link in operation  
■ DC link under construction



while the Wanlong line was transmitting 550 MW to the CCG and the Genan DC link was sending 1,040 MW to the ECG, a DC interruption drove the frequency of the CCG to 50.31 Hz. To limit such rises, generator tripping equipment was installed in the Gezhouba hydro plant in 2004 – the main source and starting point of the Genan DC link.

As for voltage stability, the CCG has been encountering low voltage problems in the rainy season when the hydro units are running at full capacity.

#### Footnote:

<sup>1)</sup> The following paragraphs are summarized from a Tsinghua University report from April 2005.

2 Tsinghua University



ity. After interconnection with the CYG, the problem worsened due to the large power being “wheeled – through” the system. The voltages of many critical 500kV buses need reactive power support from generators located in load centers.

The weak interconnection of regional grids also causes low frequency oscillations between areas. For example, following the interconnection of the NCG and the NECG, a low frequency oscillation was observed on occasions. This was triggered under special conditions when certain important elements in the NCG were out of operation. Similar problems happened to the CYG and the CCG after they were interconnected: the Wanlong line connecting the two regional grids is most vulnerable and sometimes experiences a low frequency oscillation. The most critical situation occurred after the NECG, NCG and CCG were interconnected. According to a report by the state power company, a low frequency oscillation was measured by primary metering units (PMUs) installed at a substation in the CCG. Although many generators are equipped with power system stabilizers – following the interconnection of the NECG and the NCG, more than 60 large capacity generators were fitted – this low

frequency oscillation can still be observed.

The transient stability of China’s regional grids is also affected by the interconnections. These modify the transient stability limits of many transmission lines. For example, the limit of the Dafang double-circuit line in NCG decreased from 1,580 MW to 1,450 MW. If this line fails, power systems covering Beijing, Tianjin and Tangshan will have to handle up to 1,500 MW of excess power. This unbalanced power will cause a loss of synchronization between the NECG and the NCG. Some studies show that the transient stability of the NECG deteriorated after it was interconnected with the NCG. Temporary remedies are now in place to limit power transmission on the tie lines, and to trip tie lines in emergencies, in order to maintain the transient stability of these two regional grids. In the long term, however, the interconnection backbone will have to be strengthened.

**Potential system solutions**

HVDC is playing an important role in the interconnection of China’s regional grids because of its ability to asynchronously link systems with different nominal frequencies, and its ability to

**FACTS**

FACTS covers a number of technologies that enhance the security, capacity and flexibility of power transmission systems. FACTS solutions enable power grid owners to increase existing transmission network capacity while maintaining or improving the operating margin necessary for grid stability.

See also: ABB Review 4/2003 pp 21–26 and ABB Review 1/2005 pp 22–25.

transmit large amounts of power over long distances more economically. As more and more DC transmission projects are installed, the coordination of controls between DC and AC systems grows in importance. In fact because of their ability to rapidly control the transmitted power, HVDC systems can be used to enhance the stability of the AC system, and provide damping for power system oscillations.

FACTS (Flexible AC Transmission Systems) play the principal role in enhancing the controllability and power transfer capability in AC systems. Since the interconnections of China’s power networks are relatively weak, this situation is likely to last for some time. It is foreseeable that FACTS controls will play a more important role in China’s power networks, increasing the transfer capability and enhancing system security.

**Qianjin Liu**

Power Systems  
ABB China, Corporate Research Center  
qianjin.liu@cn.abb.com

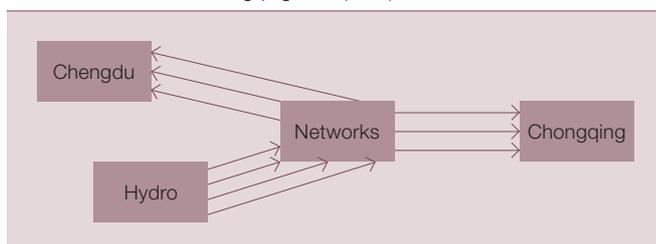
**Prof. Qiang Lu**

Tsinghua University

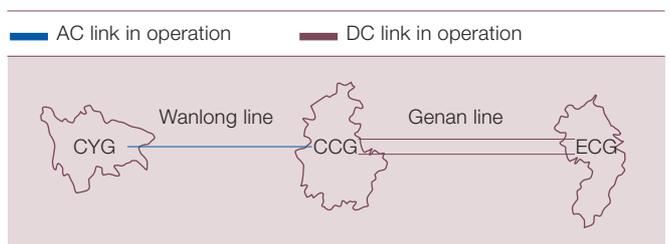
**Christian Rehtanz**

ABB China, Corporate Research Center  
christian.rehtanz@cn.abb.com

3 The Sichuan and Chongqing Grid (CYG).



4 Power transfer in the CYG, CCG and ECG.



# Drilling through

The petrochemical market in China

Jessica Wu

When ABB Xiamen Switchgear Co. Ltd. was awarded its first order for 16 UniGear type ZS1 medium voltage switchgear panels by Zhenhai Refining & Chemical Co., Ltd. (ZRCC) in 1999, no one ever thought that the ABB joint venture with 350-staff could expand its share of ZRCC's wallet to 95% in three years.

During 2002, ABB received seven orders amounting to US\$ 3.4 million to supply 227 panels of UniGear type ZS1 and 12 panels of UniGear type ZS3.2 for expansion and renovation at ZRCC.



ZRCC is one of the most profitable companies in the SINOPEC (China Petroleum and Chemical Corporation) family. The corporation has an annual refining capacity of 20 million tons. ZRCC had previously purchased medium voltage switchgear from local state-owned manufacturers or other joint venture companies. ABB worked hard to get into this market. These efforts bore first fruit in 1999, when a very small piece of the cake could be clinched: A contract was awarded for 16 UniGear type ZS1 panels for the smallest substation among six renovation projects. ZRCC was identified as a key customer due to its strong market position and advanced management. Resources were allocated quickly to take advantage of this opportunity. A sales strategy was developed based on establishing a good relationship to the customer.

A customer as big as ZRCC must be approached on many levels, each re-

quiring different sets of information from overviews of ABB in China to detailed product information. ABB Xiamen Switchgear Co. formed a sales team including the company president and technical expertise. All with the task of winning the customer to ABB's product portfolio by building trust thru having constant contact with ZRCC and their design institutes. In addition, numerous technical training sessions were held both at ZRCC and at ABB Xiamen Switchgear: ABB's first joint venture in China and one of the largest manufacturers of medium voltage primary switchgear and circuit breakers both within the ABB Group and in China.

In May 2001, an incident occurred in a fertilizer project involving a REF542plus – the new switchgear control and protection unit supplied to ZRCC. It was the first application of this new product in China, and ABB

was facing some quality issues. Customer dissatisfaction was obvious. With fast response and constructive ideas the situation was solved to the satisfaction of the customer.

Using ZRCC as pilot, ABB's commitment to the petrochemical industry was fully demonstrated and rewarded. It resulted in rapid development in orders received from both the local industry and new "mega projects" developed with international partners. In a US\$ 4 billion petrochemical plant built and operated by the joint venture CSPC (see inset article), ABB has supplied all power distribution products for the project under a Multi Facility Purchase Agreement concluded with a value of US\$ 12 to 16 million.

In 2005, CSPC will market its products in Guangdong and the other high consumption areas along China's coastal economic zones. Some products will



ABB Xiamen Switchgear receives award from Shell

In the fall of 2004, ABB Xiamen Switchgear Co., Limited was awarded a "Project Appreciation Certificate" by the petrochemicals company CSPC and its engineering subcontractor JGC in recognition of ABB's excellent performance in the realization of CSPC's Lower Olefins Plant (LOP).

CSPC (CNOOC and Shell Petrochemicals Company Limited) is a joint venture of CNOOC (China National Offshore Oil Corporation) and Shell Nanhai BV.

The US\$ 4.3 billion petrochemical plant is being built and operated by CSPC in Daya Bay, Huizhou Municipality, Guangdong province. It represents the largest capital investment in a petrochemical industry by a Sino-foreign joint venture to date. In July 2003, ABB signed a frame agreement to supply all 6kV switchgears – a contract valued at around US\$ 8.5 million.

JGC (Japan Gasoline Co.) was the largest EPC (engineering, procurement and construction) contractor in CSPC's project. JGC is also Japan's largest engineering company – its main business areas are petrochemicals and medicine. The part of LOP contracted to JGC required more than 80 units of 6kV switchgear, amounting to one fifth of ABB's frame agreement.



be exported. In total, this world scale petrochemicals complex will produce about 2.3 million tons of products, aiming to generate USD 1.7 billion in products sales each year. It is being designed to the latest technological standards and will be the most advanced petrochemicals complex in which Shell and CNOOC has participated, with commitment to international best practices for environmental and social standards (see inset article ).

Agreements such as this are not easy to conclude. A small but very committed team worked on this frame agreement for two years before success came its way. To ensure intense competition CSPC invited six local suppliers and joint venture companies to bid each of three packages. ABB was assessed as number one based on technology, quality, service and price.

The adoption of frame agreement is increasing in China especially in procurement for integrated production facilities. The trend is also gaining popularity among power distribution companies as the benefits of common technology and common communication systems are recognized. The experience gained allows ABB in China to provide real support to customers, who are interested in developing long-term relations. This support includes assistance in the concept development, common terms and conditions, as well as training and standardized documentation.

**Jessica Wu**  
 ABB Xiamen Switchgear Co., Ltd.  
 jessica-jie.wu@cn.abb.com

# Advanced diagnostics of turbine vibrations

William H Fornuff, Steven J Johnson, Gang Fu

Rotating masses – such as turbines – are often subject to vibrations. Correct diagnosis of these vibrations leads to the early recognition of tendencies and trends. Such information is used to optimize performance and availability.

Maximum availability is an important characteristic in the world power market. This is especially critical in demand driven markets such as China. Turbine Supervisory Instrumentation (TSI) is an important element of enhanced recognition and diagnosis.



Traditionally, turbine manufacturers have provided the TSI system to match their turbines. Most manufacturers purchased this from suppliers such as Bently Nevada or Philips. Such a diagnostic system is essentially standalone but permits vibration signals and other outputs to be fed to the Distributed Control System (DCS) for indication and trending. In a modern plant-wide DCS, a critical system such as TSI should not be standalone, but be fully integrated with the DCS, which should access the process signals directly.

This article presents an integrated TSI in China, and discusses additional software for turbine vibration analysis and condition based maintenance – providing a total condition assessment solution for the user.

**Total condition assessment**

Li Gang Power Plant Units 1 and 2 have two coal-fired boilers with early 1990s Ansaldo steam turbines rated at 350 MW each. The original TSI for the steam turbines and boiler feed water pump turbines were supplied with the main equipment.

In 2004, Li Gang decided to retrofit the main steam turbine control and boiler feed water pump turbine control systems, and integrate them into the plant DCS. Li Gang chose ABB to provide new Symphony control systems for the main steam turbine and boiler feed pump turbine of both power units. ABB recommended an integrated turbine control and TSI solution based on the advantages of the condition monitoring module (CMM). This approach has successful references abroad, but has not previously been applied in China. The customer accepted this solution.

At the same time, the power plant chose to purchase all new TSI probes from Bently Nevada separately.

ABB provided the following solutions for Li Gang’s main steam turbine and boiler feed water pump turbine TSI system:

- Main steam turbine TSI system hardware mounted in the turbine control system cabinet: One pair of BRC100 controllers and nine CMM modules provided to measure six bearing (X and Y) and case vibration signals, two high pressure chamber differential expansion and

two low pressure chamber differential expansion signals, a shaft position signal, an eccentricity signal, a case expansion LVDT signal and an event marker input.

- Boiler feed water pump turbine TSI system hardware mounted in the boiler feed water pump turbine control system cabinet: Two pairs of BRC100 controllers and three CMM modules separately measuring front and rear bearing (X and Y) vibration signals, two shaft position signals, eccentricity signal and an event marker input on each turbine.
- Four measurement channel CMM’s. Each channel can be configured for any type of measurement. Since the CMM accepts any combination of industry standard transducers including proximity probes, accelerometers, velocity probes and DC LVDT inputs, integration of the Bently Nevada probes posed no problem. For vibration measurements, the CMM calculates overall vibration for machinery protection and operator information. Each channel can be configured to measure relative, seismic or absolute vibration. A once per revolution event marker provides a speed output and phase information for vibration and eccentricity measurements. The CMM can also provide Gap, Not1x, 1x, 2x, and 3x orders

for the machinery diagnostic information system.

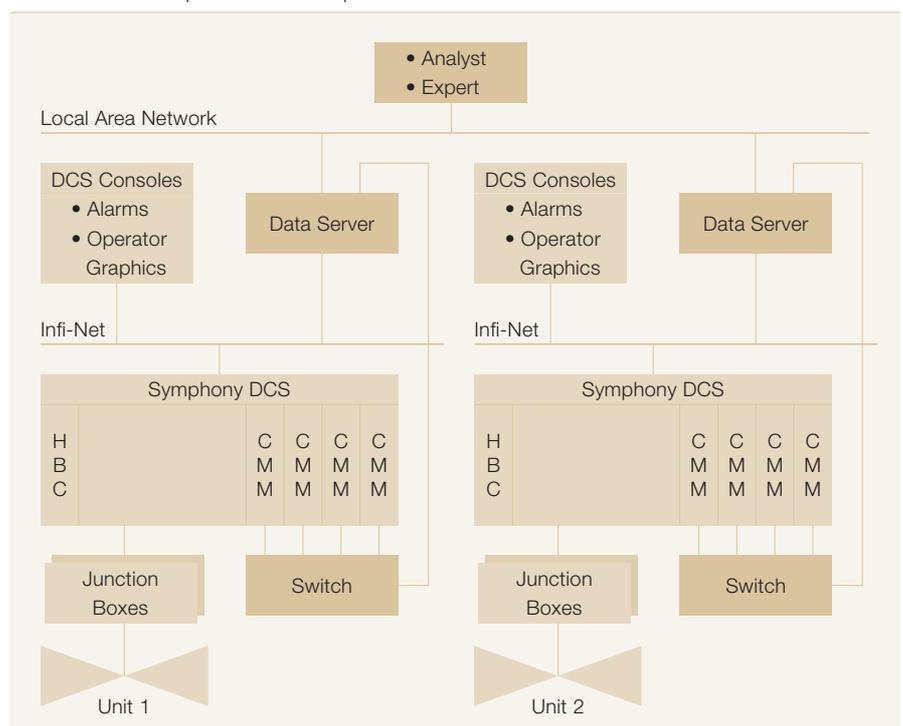
- DCS integrated machinery protection function and all information for the operator. The CMM and logic in the DCS provide flexible, sophisticated alarming for improved turbine protection. Turbine vibration information is implemented as additional graphics on the DCS operator consoles. All alarms and alarm lists are generated by the DCS and include a time tag synchronized to the DCS system clock. There is seamless communication between the DCS and the TSI system. All plant process variables are available for correlation with vibration data.

Li Gang Unit 2 was shut down in late 2004. Li Gang engineers and ABB engineers from China and the USA were on site to support the unit outage and modification work. Close cooperation and planning of the configuration, installation, commissioning and final start-up between Li Gang and ABB led to the first integrated TSI in China. Unit 1 will receive similar modifications in 2005.

**Machinery diagnostic information system: Analyst**

Analyst compiles historical data and provides graphical presentations for the vibration expert. The visual nature of the Analyst program helps the user

1 Li Gang Units 1 and 2 TSI overview. The boxes with darker color depict additional software and hardware not implemented at the plant but discussed in this article.



to quickly recognize patterns and trends in the data. Extensive plant process and condition monitoring data are collected for the rotating machinery. The correlation of vibration and process data leads to quicker and better conclusions.

The Analyst monitors the relevant machinery points and process variables. Typically, 300 to 500 machine and process variables are monitored on a large steam turbine. When an alarm, a run-up, a run-down or a plant trip occurs, the CMM sends time waveforms to the data server via an Ethernet connection. Time waveforms are saved for each vibration measurement.

The Analyst program connects to an unlimited number of machine train systems over a local area network. One or more Analyst programs connect to a data server in the plant and retrieve their data through Ethernet. The local

area network, a wide area network or a modem provides remote access to Analyst and to the server data.

**The Analyst monitors the relevant machinery points and process variables. Typically, 300 to 500 machine and process variables are monitored on a large steam turbine.**

Analyst is Windows 95 / 98 / WinNT / Win2000 / XP compliant. For added flexibility, Analyst data can be transferred to other Windows applications using copy and paste commands. To promote ease of use and to minimize learning time, the user interface has the look and feel of current Microsoft applications. Analyst uses a Microsoft Excel™ style workbook view. The vi-

bration analyst constructs a workbook containing several sheets, where each sheet holds combinations of any of the available types of plots.

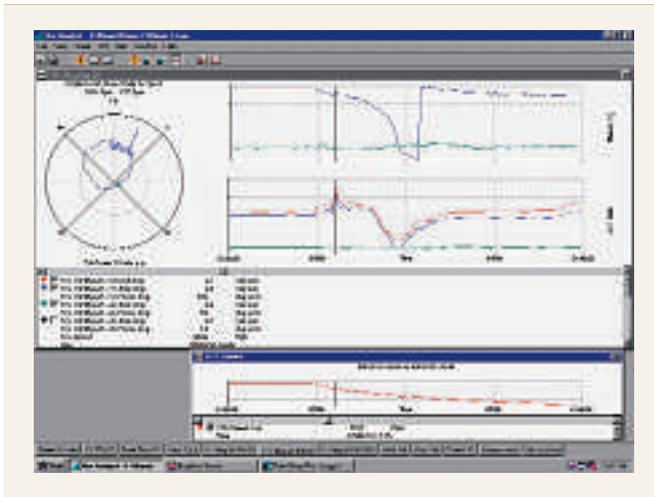
The Analyst program supports ten plot types. Each plot can compare data from the same or from different time intervals; plots can be freely arranged on the sheet. Each sheet has a tab with a user-defined name. Individual plots can also be named. Navigating from sheet to sheet is Excel-style (by clicking on the sheet's tab). Analyst creates new sheets and plots quickly by copying existing ones and making adjustments. The user can also customize plots, add comments, and print them for reports.

**Plot Types Supported by Analyst**

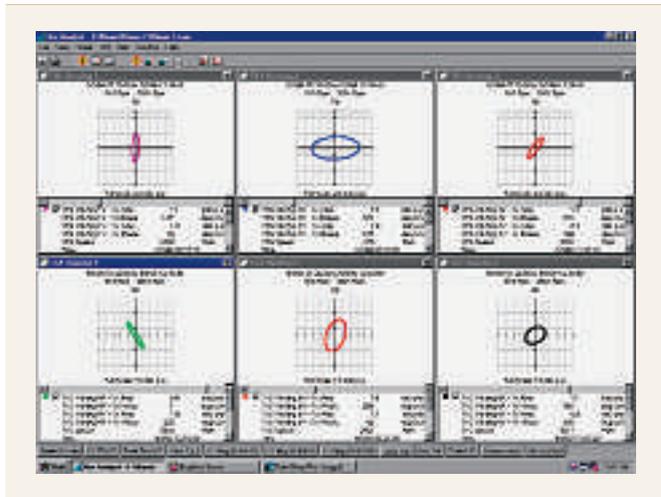
- X vs. Y – The X variable can be time or any other variable.
- Bode – a plot of amplitude and phase vs. speed.

**2 Sample Analyst plots.**

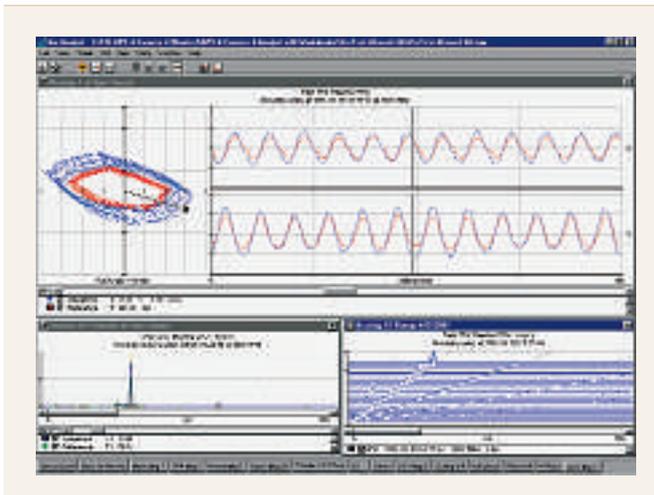
**a** Polar + Trend.



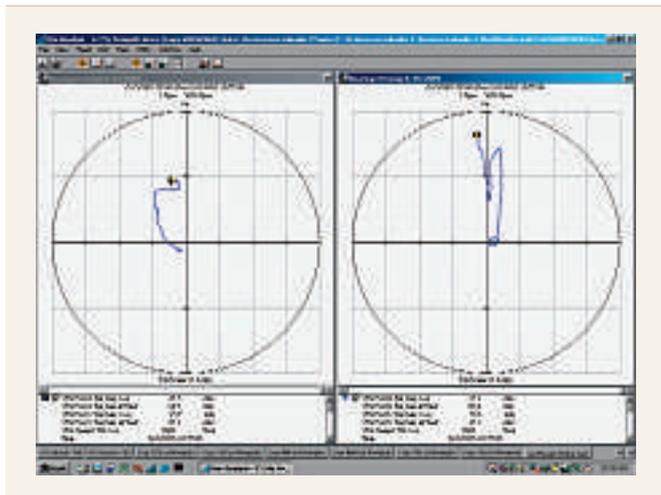
**b** Filtered Orbits.



**c** Direct Orbit, Spectrum & Cascade.



**d** Shaft Centerline.





- Polar – a plot of amplitude and phase in a polar coordinate form.
- Polar + Trend – a polar plot plus two trend plots, one for amplitude and one for phase 2a.
- Filtered Orbit – a plot of the dynamic motion of the shaft centerline at an instant in time 2b.
- Average Shaft Centerline – a plot of the average shaft centerline over a time period 2d.
- Time Waveform – a plot of the sampled time waveform vs. time.
- Direct Orbit – a plot of the dynamic motion of the shaft centerline over a short period of time.
- Spectrum – a time waveform from one probe.
- Full Spectrum – time waveforms from X and Y probes are plotted as a spectrum 2c.
- Cascade and Full Cascade – a series of spectra or full spectra at several speeds.
- Waterfall and Full Waterfall – a series of spectra or full spectra at several different times are plotted.

Based on an expert system, the software can process hundreds of measurements and provide diagnosis and repair recommendations in a matter of minutes.

**Diagnostic and predictive maintenance program – Expert Advisor**

Expert Advisor is an automated diagnostic system that assesses the condition of rotating machinery. Expert Advisor accepts data from the CMM's in the DCS. Based on an expert system, the software can process hundreds of measurements and provide diagnosis and repair recommendations in a matter of minutes. The diagnostic engine is well proven (the first version was introduced

in 1988); it uses an empirical rule based logic system to produce accurate machine condition assessments. The diagnostic tool uses over 4,500 rules and more than 650 machine fault messages. Expert Advisor accurately predicts machine faults along with the severity and prioritized repair recommendations.

Expert Advisor resides on a stand-alone computer or a full client / serv-

er environment. On a large system the Expert Advisor is installed on a data server with the capacity to handle two to four main steam turbines, depending on the number of installed sensors, and the large number of balance of plant machines such as large fans and pumps. Expert Advisor results are viewed from the client located anywhere on the network which is able to retrieve data from the Expert Advi-

3 Automated diagnostic report.

**TG Unit #2**  
 Report generated on: 2/17/05 05:46 AM  
 Acquired: 2/17/05 05:45 AM 1xT=3.600 RPM Averages: 0

Amplitudes in mils pk-pk. (Value)=% amplitude to threshold.  
 Maximum level: 2.7 (55%) mils at 1x on 2 Forward Spectrum in low range

**Possible Causes** → POSSIBLE CAUSES:  
 IMPROPER BEARING CLEARANCES  
 WORN OR WIPED BEARING

**Diagnoses** → DIAGNOSES:  
 • Danger  
 • Alert  
 • Early Warning  
 • Initial Recognition

**Data Supporting the Diagnosis**

DANGER: IRREGULAR SHAFT MOTION (HARMONIC) AT BEARING 8	0.5 (93%) mils at 3xT Brg# 8 Reverse Spectrum 0.4 (75%) mils at 4xT Brg# 8 Reverse Spectrum 0.2 (45%) mils at 3xT Brg# 8 Reverse Spectrum 0.1 (27%) mils at 7xT Brg# 8 Reverse Spectrum 0.1 (22%) mils at 6xT Brg# 8 Reverse Spectrum 0.1 (21%) mils at 8xT Brg# 8 Reverse Spectrum 0.1 (21%) mils at 7xT Brg# 8 Reverse Spectrum 0.07 (15%) mils at 5xT Brg# 8 Reverse Spectrum 0.07 (14%) mils at 9xT Brg# 8 Reverse Spectrum 0.07 (14%) mils at 5xT Brg# 8 Reverse Spectrum 0.05 (11%) mils at 4xT Brg# 8 Reverse Spectrum 0.03 (6.3%) mils at 8xT Brg# 8 Reverse Spectrum 0.02 (3.6%) mils at 6xT Brg# 8 Reverse Spectrum
--	---

DANGER: RADIAL BEARING WEAR AT BEARING 8  
 Bearing #8, Eccentricity Ratio=0.9 Shaft CL, travel/clearance (0.9 different from normal value).

EARLY WARNING: ABNORMAL SHAFT CL POSITION AT BEARING 8  
 Bearing #8, Shaft CL, vector angle=58 deg cw from vert (45% rotation from expected angle).

server. The software is Windows 95 / 98 / WinNT / Win2000 / XP compliant. A variety of Setup Wizards allow for fast and easy database and system set up.

On a large system the Expert Advisor is installed on a data server with the capacity to handle two to four main steam turbines.

The CMM provides waveforms for the full spectrum calculation, the angle of maximum axis and aspect ratio of the orbit's ellipse, shaft centerline, eccentricity ratio and other data. The amplitude ratio between the new data and the threshold value at various frequencies is compared to each rule template. If a rule template matches, Expert Advisor gathers the fault and supporting evidence and calculates the severity. The diagnostic tool provides an automated condition assessment of the machine that uses X-Y configured displacement and/or seismic data. This provides a powerful screening and decision advisory function – reducing the data that must be reviewed for an accurate indication of the current condition of the machine. This functionality greatly improves the effectiveness of specialists who are able to focus on overlying issues: Faults such as shaft rub, unbalance, fluid induced instability, mechanical looseness, radial bearing wear, coupling misalignment and rotor crack are automatically detected.

3 shows an example of the automated diagnostic report. This includes a diagnosis of the fault, the severity level (initial recognition, early warning, alert and danger), supporting evidence and a data review. The reporting function of Expert Advisor also produces a trend of the machinery condition. This allows the user to view trends of all previous faults. The severity of the fault is plotted versus date and time. This is useful for long-term analysis and projection 4.

#### End user benefits

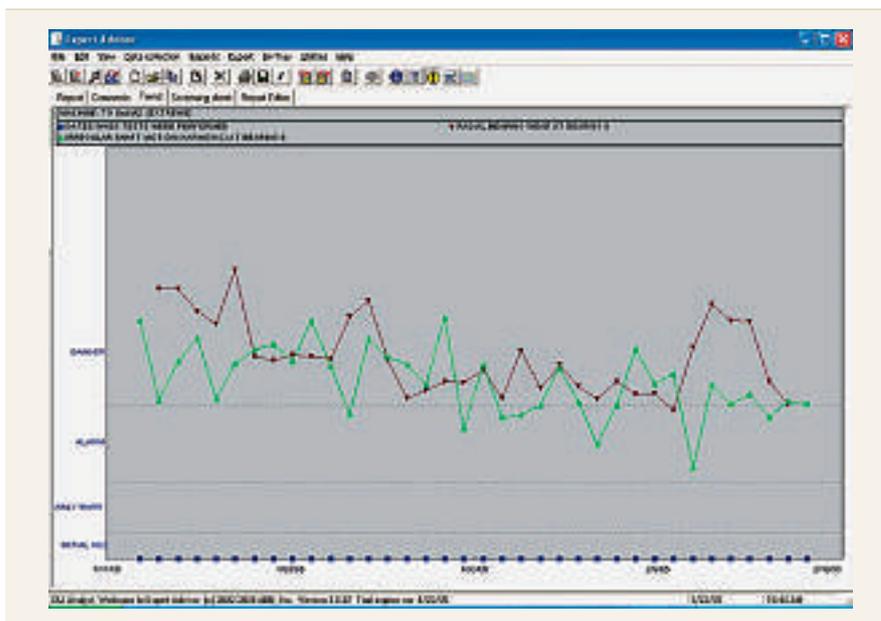
At the Li Gang unit 2 project completion meeting, the power plant engineers underlined the following strengths of the integrated TSI:

- Simple system structure.
- Stable and reliable TSI performance.

#### 4 Machinery condition trend.

Trend of all diagnoses:

- Danger
- Alert
- Early Warning
- Initial Recognition



- Familiar configuration (same as DCS).
- Distinctly higher measurement accuracy than previous system.
- Easily obtained assessment of turbine condition through operator station graphic displays and sophisticated alarming.

Li Gang Chief Engineer Wang Dongping stated "This is the first time an integrated TSI system is used in China. Although ABB provided specialists to support the system, I had some concerns before the system was put into operation. Those concerns were unfounded. I am grateful for ABB's support and hope to continue to work with ABB to further enhance the TSI system functionality and achieve the full potential of this unit".

The Analyst diagnostic software and Expert Advisor machine condition assessment software provides additional benefits to an end user:

- Maximum run time and generation.
- Condition based maintenance to reduce maintenance costs.
- Investment protection for valuable assets.
- Insight into equipment's condition through diagnostic capabilities.
- Warning of impending problems.
- Improvement of overall operation of the machine.
- Shorten planned outages.
- Increased safety of plant personnel.

With the growing pressure on power plants for reliable generation and improved financial performance, an operator must choose the right partner and the right tools. The operator should not have to endlessly manipulate software, wrestle with data and study graphs. Instead, the priority should be to keep the plant running at maximum generation. ABB, as a single source for DCS and TSI, provides that solution.

#### William H. Fornuff

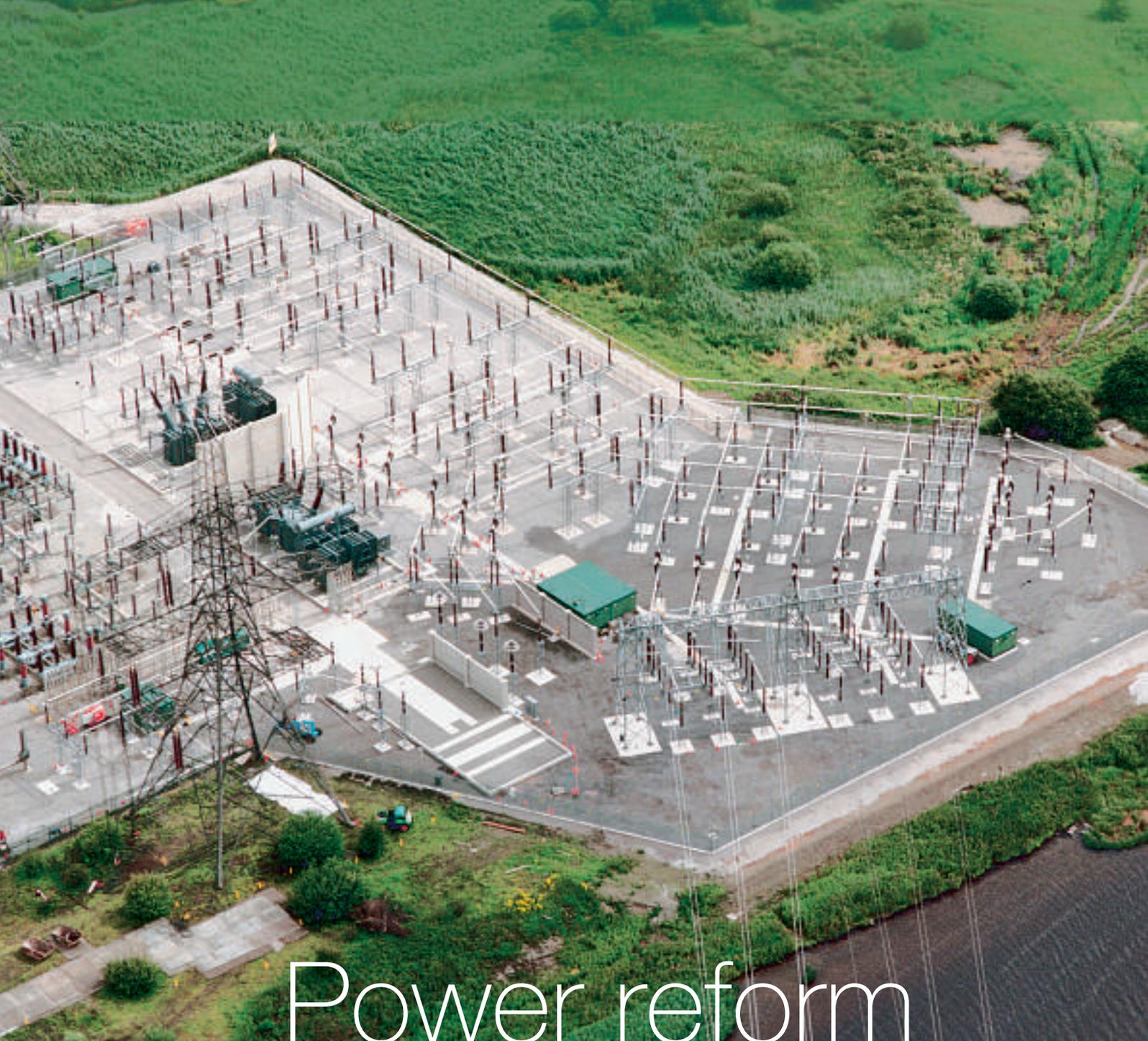
ABB Inc. Utilities  
Wickliffe OH, USA  
william.fornuff@us.abb.com

#### Steven J. Johnson

ABB Inc. Utilities  
Natrona Heights PA, USA  
steve.johnsson@us.abb.com

#### Gang Fu

ABB China  
Beijing, China  
gang.fu@cn.abb.com



# Power reform

ABB technology is helping to liberalize China's power market.

Marina Öhrn, Peter Maltbaek

China has gone through a remarkable transformation in the last decade or so and the stress that this has created on the power sector is considerable. Power consumption in China is increasing at rates completely unheard of at any other time in any other part of the world.

In recognition of this, as well as for economic necessity, the Chinese cabinet officially approved the "Power Industry Reform Program" in March 2002 with the aim of fundamentally restructuring China's power sector and dismantling the vertically integrated monopolistic structure of the industry. The principle measures of the reform promote the separation of administration from operations, the separation of power generation from power transmission and fair and healthy competition among power producers.

As a consequence, the former State Power Corporation of China was split up in December 2002 to form two grid companies (China Southern Power Grid Company and the State Grid Corporation of China), five power generation groups and four other affiliated companies. The State Grid Corporation of China is itself made up of five super-regional sub-grids and three provincial grids. One of the primary objectives of this break-up is the creation of an industry that is more responsive to the booming demand for power.

De-aggregation of the power industry is not an entirely new or unproven concept. It has been adopted extensively in the west and is commencing in other Asian countries. The objectives are to introduce competition into wholesale power generation and retail supply, and to increase the efficiency of production and optimize resource allocation to reduce the overall cost of power to the consumer. These benefits have already been realized, to various degrees, in parts of Europe and the US as well as Australia and Singapore.

China is also rationalizing a power tariff system to stimulate the independent development of the power industry and to promote nationwide grid interconnection. Initially, the aim is to open part of the generation market and implement a transparent cost structure in transmission and distribution businesses. As the reform process continues, a consolidated power market will be created in which transmission and distribution access will become available to independent pro-



ducers. The creation of entities to control the dispatching of power and operate a trading floor type of power exchange is visualized for a second phase. The new tariff will also allow for the direct sale of electricity to large end-users, something which was not previously possible.

A clear legal structure is being established which will define the relationship between parent and subsidiary companies and between regional network and provincial operators. The ultimate goal is the realization of full competition among all market participants, and the establishment of power related financial markets such as power futures and power options.

Each of the eight regions of China currently within the State Grid Corporation has a closely meshed internal high-voltage transmission grid, but the electrical interconnection capacity between these regions is, in many cases, quite limited.

#### Regional power trading in China

Before the benefits of effective power deregulation can be seen, however, the necessary physical infrastructure has to be in place. Obviously power cannot be traded between places that have no physical interconnection. Each of the eight regions of China currently within the State Grid Corporation has a closely meshed internal high-voltage transmission grid, but the electrical interconnection capacity between these regions is, in many cases, quite limited. Boosting the power transfer capability between these regions is now a priority and several major projects are already under construction or in the final stages of planning.

Even though the eight regions within the State Grid are not necessarily aligned directly with the political boundaries of China's Provinces, they are candidates for "regional power markets" in much the same way as Regional Transmission Organizations may cover several states within the US. One such region is in East China.

The East China Grid Company Limited (ECGC) is one of five state-owned groups that oversee provincial power companies. The utilities under the jurisdiction of ECGC serve nearly 200 million people in the city of Shanghai and the provinces of Anhui, Jiangsu, Fujian and Zhejiang – the eastern region of the country that has enjoyed steady economic growth over the past decade. That growth, however, has brought with it severe electricity shortages as the region's generation and transmission capacity struggles to keep pace with the booming economic development.

To meet the increasing demand, ECGC has invested in new generating assets, such as nuclear projects and coal-fired plants, to take advantage of China's extensive reserves. In addition, East China has recently started receiving power from a 500kV DC transmission line that connects the region to hydro-power facilities 800km to the west, including the Three Gorges project. This has provided some temporary relief from the generation shortage, but the challenge of keeping up with demand remains.

Since East China is one of the country's most economically dynamic areas and one of the areas most in need of a major shift in policy, the region was chosen to introduce the restructuring process under a pilot program. This program is intended to ensure that information systems, market mechanisms and regulatory policies are tested and proven before the "experiment" is extended to the rest of the country.

It is expected that the pilot program will do much more than simply boost generation and transmission capacity to support future growth. The program is intended to create and test the future of China's electric power industry.

Early in 2003, ECGC signed a contract with ABB to provide the critical IT systems that will control the physical grid and the electricity markets it will support. ABB will provide a two tiered solution: its Network Manager SCADA/EMS will deliver the SCADA and EMS capabilities and Network Manager BMS – SABLE will provide the framework for the region's wholesale power market. The Network Manager SCADA/EMS system provides a complete set of

advanced power system application functions. Network Manager BMS comprises ABB software solutions for independent system operators, regional transmission organizations, power exchanges and other entities charged with managing competitive wholesale markets for electricity [1]. The integrated IT systems are scheduled for operation in mid-2005.

Market participants can enter bids/schedules for the real-time and forward markets via a portal that offers both Web-based and programmatic interfaces.

**Network Manager SCADA/EMS system**

ABB will install Network Manager at ECGC's power network dispatch center. This system will supervise and control the power transmission network and optimize its operations. When complete, the East China Electric Power Group Corporation (ECEPGC) facility will act as a nerve center for 64 Remote Terminal Unit (RTU) links, hundreds of substations and Inter-Control Center Communications Protocol (ICCP) connections to the EMS systems of four adjacent regions [3]. The system will be accessed via fifteen operator consoles (the information will be displayed in Chinese) and will be run on redundant servers to ensure reliability. The

applications can be tuned for real-time control and analysis as well as for optimization and planning purposes.

The Network Manager platform uses a web-based full-graphics interface, a real-time relational database and a modern process communication system to provide uninterrupted real-time communications with field equipment and neighboring control centers. Although it is an open and versatile platform, it allows for easy integration of utility information systems while maintaining IT security levels.

The Network Manager SCADA/EMS is equipped with a full complement of planning, scheduling, and predictive and control software applications required to ensure system reliability while minimizing long-term capital expenditure (see text box).

**Network Manager BMS: wholesale electricity market administration**

ABB's Network Manager BMS is an open, multi-tiered, web-enabled system that includes a range of applications to manage electricity market operations and related communications. Market participants can enter bids/schedules for the real-time and forward markets via a portal that offers both Web-based and programmatic interfaces. They in turn they will receive awards, market data and other communications from the market operator. The software includes:

- Bid validation and verification applications.

- Security-constrained economic dispatch application to perform congestion analysis and compute market clearing prices.
- Components to provide interfaces for settlement and accounting applications.

The system also includes market participant registration, authentication and related transaction security features.

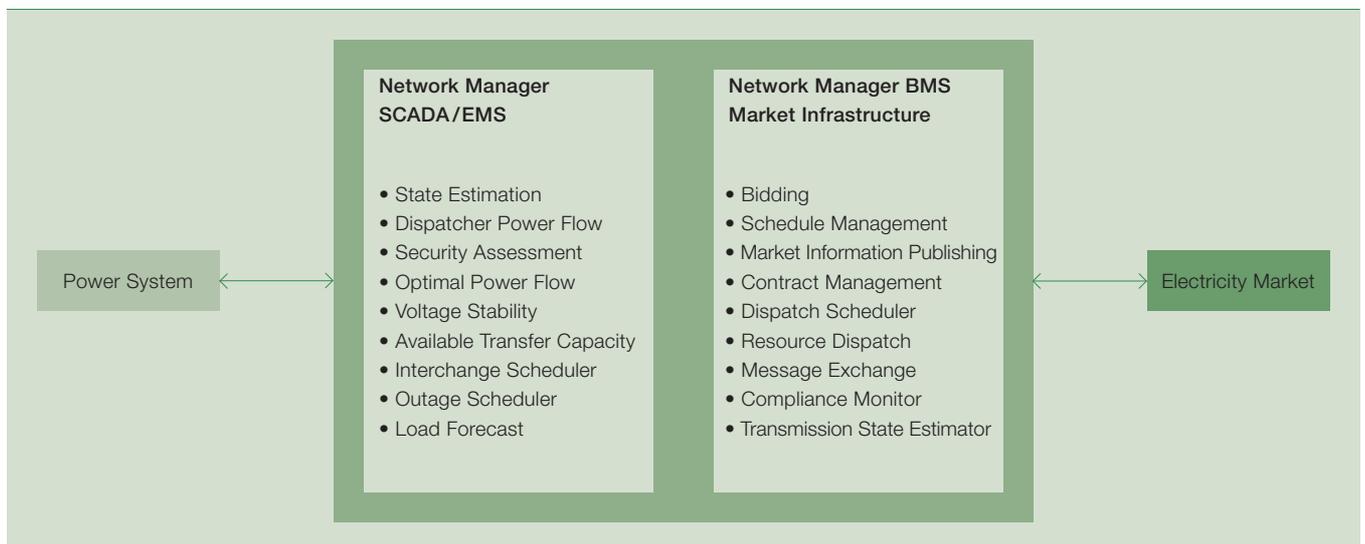
The system is configured to flexibly accommodate changes in market rules as they evolve.

**Systems implementation**

The Network Manager BMS supports energy, ancillary services and congestion management markets in both real-time and forward modes. As an "early delivery" system, ABB provided a day-ahead market system in January 2004 giving ECGC the necessary components to run the day-ahead market. This enabled the organization to begin preliminary market tests, evaluate proposed market rules, and train its staff and market participants in the process and methods of managing the electricity market.

The system is configured to flexibly accommodate changes in market rules as they evolve with the policies instituted by the Chinese government in accordance with its industry restructuring plan. ECGC's goal is to achieve

2 Solution components.



a fully operational market within 12 to 18 months.

Integration testing between the new EMS systems and the day-ahead market systems is currently being conducted in Santa Clara, together with on-going market testing of the market systems. The complete market-ready system is slated to go live in mid-2005. The purpose of getting this system ready for market trials goes well beyond working out processes and identifying potential bugs. Indeed, the extent to which both the market operators and market participants are comfortable using these new tools will have a tremendous impact on how smooth a transition the East China market will make when it eventually opens its doors for business.

#### Ensuring the user's confidence with the new system

Another user of ABB's market operation systems, the Ontario IMO, undertook comprehensive market trials, even extending them beyond the originally scheduled period. Because the IMO had not operated a deregulated power market before, one of the highest priorities in the project was to ensure that the people running the market and those participating in it had as much confidence as possible in the system before using it as a real application.

By design, ECEPGC has separated the implementation of the commercial systems – billing, metering and settlements – necessary to support the wholesale market from the SCADA/EMS and market management systems now being developed.

The result was a decidedly uneventful – and therefore highly successful – market opening. The lesson here appears to be that complex market systems must work as well with their human counterparts as they do with

3 Typical control room.



their electronic ones if the market is to function properly.

#### Flexibility is key

Another benefit of a substantial market trial is the opportunity it affords policymakers to evaluate various market rule adjustments. By design, ECEPGC has separated the implementation of the commercial systems – billing, metering and settlements – necessary to support the wholesale market from the SCADA/EMS and market management systems now

### Network Manager EMS

In addition to the standard SCADA functions (eg, data acquisition, data historian, fault localization, etc.), these applications include:

- Outage scheduling
- Interchange scheduling
- Load forecasting
- Unit commitment
- Automatic generation control
- Economic dispatch
- Reserve monitoring
- Production costing
- Network analysis
- State estimation
- Security analysis
- Dispatcher and optimal power flows
- Operator training simulator

being developed. The early delivery of Network Manager BMS will provide the organization with a sort of economic laboratory in which to try out various market rules and evaluate their impact in a controlled environment, before the other software required for the auxiliary functions of “live” operation (real money changing hands) is configured to the final market rules and subsequently purchased and installed.

Obviously, it is necessary for the market administration software to be able to accommodate a steady flow of changes in order to support this process. However, this level of flexibility is also important after the market opens. Unforeseen events

and changes in policy direction are inevitable, and the systems that enable wholesale energy markets must be able to respond to the vagaries inherent to them.

This means changes must be implemented quickly and without significant reworking. To make this possible, market systems in turn must be flexible and able to accommodate market rule changes through reconfiguration rather than redefinition.

Industry pundits may be willing to commit themselves to a particular tack when it comes to the path restructuring will take. However, when it comes to the IT systems that enable this restructuring, pragmatism is the order of the day. By bringing a flexible, integrated solution to bear, ECGC is well positioned as China journeys towards a competitive wholesale energy market.

#### Marina Öhrn

ABB Utilities GmbH  
Mannheim, Germany  
marina.ohrn@de.abb.com

#### Peter Maltbaek

ABB Inc.  
USA  
peter.maltbaek@us.abb.com

# Propeller power

ABB Drives supporting wind power  
BingWen Ma



Wind power, once a futuristic dream, is fast becoming an important part of the electricity generation spectrum. In the coming years, installation of new generating facilities will increase dramatically. ABB is part of this, development supplying the frequency converters that feed this clean energy into China's grid.

China's power crisis, which started in the summer of 2002, is set to last for some time yet. This summer, restrictions of varying degrees were applied in 20 provinces, autonomous regions and municipalities. Facing the economy's insatiable thirst for energy, authorities are seeking to reduce their reliance on coal burning – the traditional mainstay of China's energy supply. Alternative sources are being promoted and great importance is attached to wind power. China is implementing a new energy policy focusing on renewable energy; as a result of this, the wind power sector is developing rapidly. Energy experts think that wind power is the most practical and strategic choice in meeting China's energy demands. According to government blueprints, wind turbine capacity will develop from the current 567,000 kW to 20,000,000 kW in the coming 15 years. The proportion of wind power in the energy structure will increase rapidly.

Fossil fuels are facing two crises: serious environmental pollution caused by the use of coal and oil as fuel, and the depletion of limited fossil fuel reserves. In the face of these challenges, the development and utilization of new energies has become an important aspect of the sustainable development strategy for world energy. Among these new energies, wind power has the greatest electricity generating potential. The main first-class pollution source in the world is coal, oil and natural gas guzzling power generation. The resulting emission of carbon dioxide accounts for 40% of total emissions – contributing significantly to the greenhouse effect and global warming. Sulfur dioxide and NO<sub>x</sub> from oil burning combine with the water vapor in the atmosphere to form acid rain. This pollutes the environment and harms people's health. A wind turbine with a capacity of 1000 kW can save 2000 tons of CO<sub>2</sub>, 10 tons of SO<sub>2</sub> and 6 tons of NO<sub>2</sub> emissions annually compared to a thermal power generator with the same capacity. Environmental protection is increasingly gaining attention and priority from China's

1 The ACS867 frequency converter.



national government. Environmental protection is now a basic national policy.

The European Wind Energy Association and Greenpeace jointly produced a report called Wind Force 12 – a blueprint for achieving 12% of the world's electricity from wind power by 2020. This foresees global wind turbine capacity reaching 1.231 billion kW in 2020 (38.4 times the world wind turbine capacity of 2002). Annual installation capacity can reach 150 million kW. Wind power has become an important and indispensable force in approaching the global energy issue. It has developed from an inessential supplementary source to a sophisticated technology and industry with a promising commercial future. It is likely to be an important replacement energy as the world's economy shifts away from its intimate dependence on fossil fuels.

ABB is devoted to the research and development of various energy-saving and environmental industrial products. The company's transformers, generators, low-voltage components and high-voltage switchgear are widely used in the wind power industry. With the continuous development of wind power technology, ABB Drives in Finland has developed the ACS867 frequency converter **1** for the new generation of giant and highly effective doubly-fed wind power generators. In cooperation with GE, ABB has become the first company to provide such a product to China. It is used for 1.5 MW generators. ABB is also working with Chinese research institutes, and is providing the ACS867 and technical support for the megawatt-class wind power generators being developed by Shenyang Industrial University.

In combination with the growth of wind generation, ABB frequency converters are feeding more and more clean energy into China's grid.

**BingWen Ma**  
Beijing Drive Systems Co., Ltd  
Beijing, China  
bingwen.ma@cn.abb.com



# Piped heat

ABB supplies district heating in Harbin  
Martin Broberg

The principle of district heating is old. A central plant heats water, which is then piped into houses for heating. By applying new technologies, energy losses can be cut considerably, thereby reducing primary consumption while protecting the environment. ABB has won a district heating project in Harbin, bringing warmth to the households of one of China's coldest provinces.

In close cooperation between its Denmark and China branches, ABB has succeeded in winning a large District Heating contract in the city of Harbin, in one of China's coldest provinces. The total investment volume is 130 MUS\$, of which the ABB part is 40 MUS\$.

The contract was signed on the 18th of October 2004, and became effective at the end of December the same year. Design work, engineering and purchase preparations began immediately. The final handover of the project is planned for the end of the 2006.

Harbin is situated about 1000km north-east of Beijing and has about 9.5 million inhabitants. Sub-zero temperatures typically reign for more than six months every year. No wonder Harbin is home to a famous Ice-Festival: The sculptures cut out of the ice last for nearly six months. Harbin's Daoli district, which the district heating project serves, is one of seven city districts.

With a production capacity of up to 1000 MW, this system represents the largest single district heating network in the entire region. The purpose of the contract is to improve and optimize the heat supply to 900,000 citizens. At the same time, reduction of pollution is a goal. With this in mind, the investment has been nominated as a Clean Development Mechanism (CDM) project. This means, that the reduction in greenhouse gases (GHG's) realized through improvements in the combustion and operational efficiency of the system, can be counted towards the Danish commitments to the Kyoto Protocol. The Danish government will pay compensation to China for these savings.

The purchase of Emission Reduction Credits by the Danish Government is kept outside the ABB contract, but is an additional benefit for the local Government of Harbin as well as for the District Heating Company.



The project scope comprises the following:

- 90km of pre-insulated pipes to be installed underground. The pipe dimensions range from 100cm (inner diameter) for main branches down to 20cm for the small side branches.
- 156 turnkey substations. Here water from the power plant (primary distribution) exchanges heat with water from the secondary network. The hot water in the secondary distribution is then fed directly to the consumers' radiator installations. Water is not exchanged between the primary and secondary systems.
- 468 ABB frequency converters (ACS550), ranging from 75 kW downwards. The frequency converters supply power to the pressure holding pumps and the secondary network circulation pumps. Use of the frequency converters reduces motor electricity consumption by up to 50%. In the long run this translates into significant economic and ecological benefits.
- 1872 ABB instruments that supervise and control the network and substations. This includes pressure and temperature control and supervision and pH monitors.
- 160 ABB KT97 type PLCs (programmable logic controllers), each with about 25 I/Os, plus MODBUS communications to the frequency converters (about 12 signals). The PLC's main purpose is load control of substations, but they also handle communications between the main control center and the individual substations.
- 110 butterfly valves to control and section network branches. The valves are remotely controlled.
- 1 Saturn SCADA system to control and supervise the whole installation, including the 156 substations and four production units, as well as an additional 70 older substations. The SCADA control center consists of four operator stations and two engineering stations, one of which has an output for a wall projector in the control room. An internet connection permits staff and/or customers to access the online data, that the heating company chooses to make available to them. All communication between the control center and the 230 or so sites is via a TCP/IP network, permitting fast response and the possibility to download PLC code from the control center.

- Project Management, supervision and commission. This is done in a close cooperation between ABB China and ABB Denmark. A Chinese project manager deals with all local and daily issues. Additionally, the Chinese staff handles supervision and commissioning. Experience from several similar projects has shown that this work sharing model functions well.
- A complete training package for the customer with focus on daily use and maintenance. It is very important to ABB that the customers' personnel have the best tools at their disposal when the plant is handed over. Awareness of life cycle costs and investment protection are of the utmost importance: The choice of equipment imported reflects this philosophy, as does the meticulous preventive maintenance discipline in which staff is being instructed.

The installation work is supervised by ABB, but carried out by the customer.

ABB has been working on the project for more than three years. Throughout this period, intensive contacts have been maintained with the city, its local government, the district heating utility, design offices and other involved parties. Through the Danish District Heating Export Organization, two symposiums have been held in Harbin: New design principles and ideas were presented showing the end-user how to save energy and how to evaluate life cycle costs of such a plant.

The bidding procedure was a qualification round, where three companies pre-qualified. This process was an open procedure, followed by a detailed evaluation phase. ABB won the contract both in terms of price and on technical criteria.

ABB has realized several district heating projects in China, but the Harbin project is by far the biggest installation realized so far. Harbin's tough climate makes a high availability of the system a must. ABB wishes to make the Daoli system a model for China, to be used as a reference for future installations.

**Martin Broberg**

ABB Denmark

[martin.broberg@dk.abb.com](mailto:martin.broberg@dk.abb.com)

# The Chinese Century

The productivity challenge  
Peter Lennhag

The Chinese economy is being driven forward by growth in exports, investment and private consumption. The resulting affluence is manifested in the fast growth of such sectors as transportation and residential development. Products and services are being consumed at an increasing rate, putting pressure on productivity and energy efficiency.

China's re-emergence as a significant participant in the world economy will define the global energy balance for decades to come. Primary energy consumption in China is projected to double in the next 20 years from today's level. This considerable thirst for energy must carefully be matched with supply and transmission capabilities in a sustainable and balanced manner to avoid blackouts and instabilities. Downside to this economic expansion is the environmental aspects associated with global warming and CO<sub>2</sub> emissions.



At the beginning of 2004, economic observers foresaw a slowdown of China's economic growth due to the Government's economic tightening measures. However, at the beginning of 2005, they were surprised at the 9.5 percent the GDP had grown in 2004: an eight-year high. China had maintained its position as the world's fastest growing economy despite the economic brakes the government implemented.

The three major engines propelling growth are private consumption, exports and investments, especially foreign direct investment (FDI). The latter enters the country at a current rate of 1 billion per week. Foreign investments are a major contributor to Chinese exports, which reached US\$ 593 billion in 2004. Annual FDI may increase from US\$ 60 billion to US\$ 100 billion in the period 2006 to 2010 (assuming no severe political or economic setback occurs).

We are now witnessing a re-emerging China, open to the world since the

introduction of the Open-Door-Policy in 1978, re-allowing foreign investments into the country. With its large population, China's economy is potentially ten times Japan's. China's impact on the world is likely to be enormous.

With respect to consumption, China has surpassed the United States in the consumption of grain, meat, coal, iron, and steel according to a recent report by Washington's Earth Policy Institute. According to the International Energy Agency, its GDP **1** will account for 20% of the World's GDP in 25 years time.

However, the rapid pace of growth has led to a short supply of energy and raw materials.

### Energy demand outlook

As the second largest energy consumer (behind the United States), China accounts for almost 12% of the world's total annual energy consumption. In 2004, total energy consumption in China reached 1.97 billions of Standard Coal Equivalent (SCE), an

increase of 16% from 2003 [1]. The ongoing fast pace of industrialization, urbanization, and improving living standards will push China's energy demand to a much higher level in the coming years. The Chinese participation in the global economy and share of energy demand is depicted in **1**. By 2020, for example, its electricity consumption is forecast to be 15% of world generation; up a staggering 50% from today's level. It is estimated that the population of China will increase from 1.3 to 1.5 billion people by 2020, and the urbanization rate will reach 58–60% in 2020, with an urban population of 800 to 900 million [2].

Economic growth is expected to average 8% from 2006 to 2010, and 7% from 2010 to 2020 [3]. By 2030, China's GDP is forecast to account for 20% of the global economy.

China is heavily reliant on coal for energy and is both the largest consumer and producer of coal in the world. Coal represents more than 70% of China's energy mix: This is much higher than the global average of 25%. However, the geographic distribution of coal reserves and mining is unfavorable for the country's energy thirsty eastern coastal areas: 80% of reserves are in the northern provinces. As coal shipments saturate north-to-south rail traffic, new railway development is vital. The Ministry of Railways has announced plans to invest more than US\$ 12 billion in 58 new lines and 48 extension projects in 2005 [4].

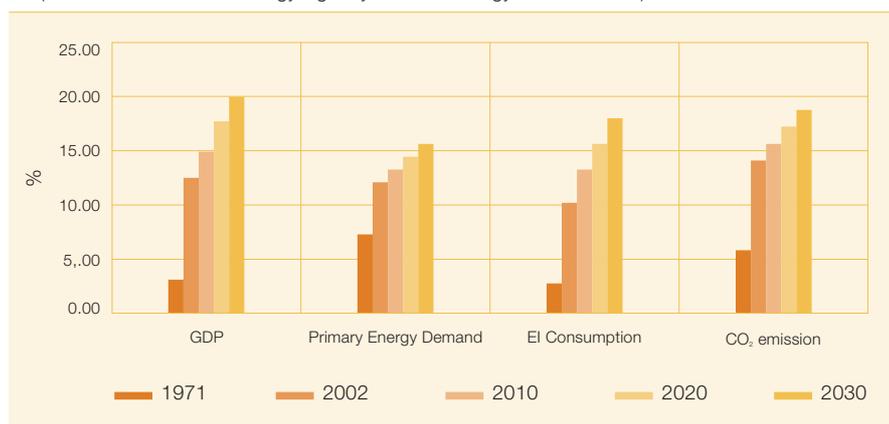
The coal industry is also suffering from serious worker safety problems. With at least 6,000 people killed every year according to official statistics, the government and owners are now working on improving technology and investing in more reliable equipment and machines. China has become more open to FDI in the coal and mining sector and has expressed strong interest in technology with environmental benefits, coal liquefaction, and coal bed methane production.

### Productivity challenge by sector

Rapidly increasing consumption opens opportunities in the process and manufacturing industry to supply required products and services. Improving living standards demand better housing



**1** China's share in the Global Economy and Energy Markets (Source: International Energy Agency – World Energy Outlook 2004).



and transportation, better working conditions and a safer environment. Modern production technologies in combination with energy efficient equipment will enhance productivity, improve product quality and reduce energy demand per ton produced. These measures are all necessary in China's attempt to balance its growing demand with its capability to supply energy in the form of heat and electricity.

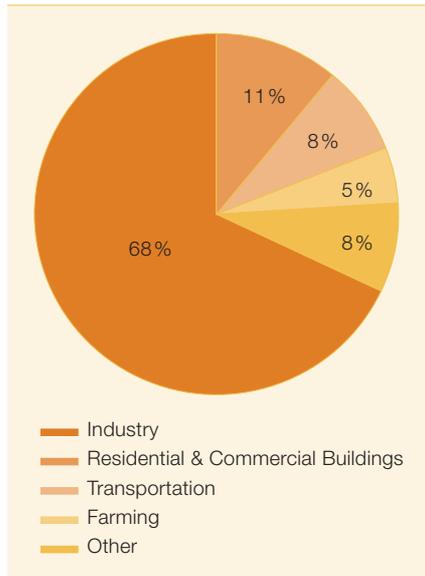
The leading sector in energy consumption is industry, representing 68% of total energy consumption. It is followed by the residential and commercial sector with a share of 11%, and transportation at 8% [2]. It is expected that the industrial sector will continue to dominate energy consumption, though there will be a trend of rising transportation and residential sector share by 2020.

The major energy consumption sub-sectors in the industrial sector are chemicals (including petrochemicals) at 24%, metals including smelting and pressing at 20%, and non-metals including cement, paper and pulp, food, and textile at 20%. The fertilizer, iron & steel, and cement industries are the major users in each of the three largest industrial sub-sectors.

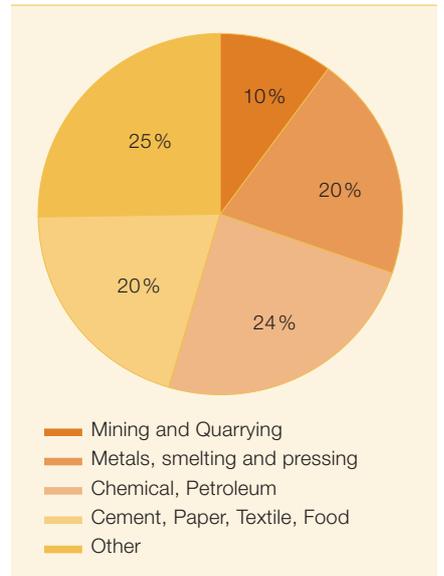
**China's fertilizer industry.**

China's largest industrial sub-sector from the energy consumption point of view is the chemicals industry. Fertilizer production is the largest energy user (38%) within this sub-sector.

**2** Energy demand per sector 2001  
(Source: Statistical Year Book by National Bureau of Statistics of China).



**3** Energy demand per industrial sub-sectors 2002  
(Source: China Statistical Yearbook, 2003).



China's low production efficiency for fertilizers is due to almost 1,000 small plants and the use of coal as feedstock for its ammonia synthesis. Whereas the feedstock used in the United States is almost exclusively natural gas, coal is still used as the main feedstock in China. The energy intensity for ammonium production is 970 kgoe (kg oil equivalent) per tonnage in China, while the international level in advanced countries is

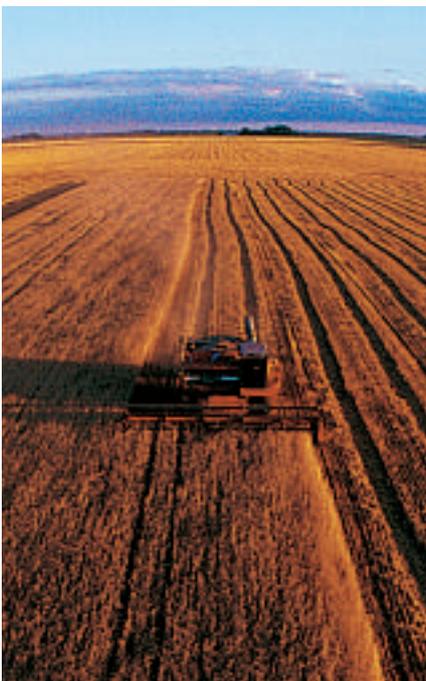
664 kgoe – there is an improvement potential of 24% [5]. Today, China's transportation infrastructure is not sufficiently developed to provide effective transport of fertilizer from the larger plants to rural China.

China has unveiled a 15-year blueprint for the country's chemical industry calling for the expansion of chemical plants and increased foreign investment in the sector.

**China's iron and steel industry.**  
The iron steel industry accounts for

The iron steel industry accounts for

The iron steel industry accounts for



20% of and total industrial fuel use. 92% of energy consumption is used for crude steel production in the iron and steel sector. The energy intensity of crude steel production is 781 kgce (kg coal equivalent) per tonnage in China, while the international benchmark is 658 kgce in Japan. This indicates room for a 16% improvement [5].

Some of the reasons why the energy intensity of crude steel production in China is high are that the production capacity per blast furnace is small, the continuous casting rate is low, and that the iron-to-steel ratio is high.

China used 36% of the world's steel in 2004 and consumption may climb by 13% in 2005. The country is still a large net importer of steel, but imports are declining as domestic capacity is increasing.

There are 66 key steel companies in China with Shanghai Baosteel leading the industry in both capacity and technology. However, Baosteel still accounts for less than 10% of total capacity. In 2004, China produced 297 million tons of steel products and 273 million tons of crude steel, increasing by 23% from 2003. The industry has maintained an annual average growth rate of 20% from 2000 to 2004 [6]. It is expected that the current buoyant market in steel will continue throughout 2005 and into 2006. However, the rapid expansion in steel capacity, (expected to reach 330 million

tons by end of 2005), is likely to result in overcapacity within the industry [7]. China may still become a net exporter of steel, which will impact global markets.

#### China's cement industry.

As the world's largest cement producer, with a share of around 40%, China has ranked first in terms of cement production for many years. From 2000 to 2004, the cement industry showed an average annual growth of 9% [8]. In 2004, the total output of cement in China was 934 million tons, an increase of 12.5% from 2003. The industry has benefited from the growth in real estate and the rapid growth of the national economy.

However, the majority of China's cement producers are small plants using an inefficient process of vertical kilns – despite the Chinese government dramatically halving the number of cement producers from 9,000 in 1993 to 4,700 in 2003. In 2002, cement produced through the newer dry process only accounted for 16% of the total, while the remaining 84% was produced by traditional vertical kilns or small hollow kilns [9]. Only in 2020 are dry kilns expected to reach a share of 40%. No wonder the cement industry consumes around 77% of the energy in the non-metals sector. Energy still accounts for about 40% of the total production costs in this industry. – a dramatic indicator of the industry's inefficiency.

Industry-wide fuel intensity for cement production in China is 171 kgce per ton of cement, while it is 121 kgce per ton in Japan [10]. There appears to be a 29% room for improvement in China. The energy consumption efficiency in the year 2000 in China was the same as it was in 1974 in Japan. Modern process technology is key in achieving these improvements.

The demand for cement is expected to continue to grow as China implements its strategies of developing the western regions, reinvigorating the traditional industrial bases in northeast China, its urbanization drive, its projects for transporting natural gas from the western regions to the eastern ones, and projects related to the 2008 Beijing Olympics and the 2010 Shanghai World Expo.

#### China's pulp & paper industry.

China's paper industry has experienced dramatic growth with consumption increasing by 40 million tons in 20 years to around 50 million tons in 2004.

Paper consumption may reach 65 million tons by 2010. China has become the second largest paper consumer in the world, only behind the United States, and is the world's largest paper importer with annual imports exceeding USD 7 billion.

There are about 4,000 paper and board companies in China, but only



25 of them have a capacity exceeding 200,000 tons per year, and another 31 have a capacity exceeding 100,000 tons per year. Some of the most modern mills in the world are today operating in China. There are currently 29 new projects that will increase annual production capacity by 11 million tons [11].

China will continue to expand its domestic paper production capacity and try to reduce its imports of paper. However, the country suffers from a shortage of pulp and pulp imports are expected to increase from 7 million tons to 10 million tons by 2010.

#### China's automotive industry

China's automotive industry has experienced a high growth period with Shanghai Volkswagen and Shanghai General Motors leading the market. Production and sales of motor vehicles have increased by more than one million each year since 2001. Total production reached 5.07 million in 2004 [12].

From 2000 to 2004, the industry achieved an average growth rate of 23%. Since May 2004, demand has started to stabilize and growth has dropped markedly. The automotive industry is now entering a more challenging phase with fiercer competition as multinational car companies have accelerated their march into China after the country's WTO entry. Car-makers are putting US\$ 13 billion of

new investment into China in the next four years, just as the government is trying to slow down demand for new cars. It is now forecast that industry profits will decline and overcapacity will emerge in the near future. However, China is likely to become an exporter of cars in line with developments the world has witnessed in South Korea and Japan in the past.

#### Transportation sector

The total energy consumption for China's transportation sector amounted to 103 million tons of Standard Coal Equivalents (SCE) in 2001, about 8% of the country's total [13]. It is estimated that the transportation sector will take a larger share of final energy consumption in the future due to the high growth of transportation services.

In 2004, China's total freight handling capacity increased to 6,670 billion tons km, an increase by 24%, and passenger handling capacity increased to 1,630 billion person km, an increase by 18% [14]. Total energy demand for the transportation sector is estimated to reach 190 million SCE's in 2010 and 265 million SCE's in 2020 and by then reach a 14% share of total energy consumption [15].

#### China's harbors.

The harbor industry has achieved fast growth with annual growth rates of 16% from 1999 to 2003. China's total trade exceeded US\$ 1 trillion in 2004 and heavy investments are required to

handle cargo flows. Wal-Mart alone purchases goods for about US\$ 15 billion per year from China. Total sea-board port handling capacity has reached 2.4 billion tons. According to the Ministry of Transportation, the total handling capacity is being expanded to 3 billion tons and the total container capacity will reach 100 million TEUs. A new US\$ 10 billion container facility in Shanghai will become one of the largest in the world. China is becoming the biggest shipping center in the world.

There are about 4,000 paper and board companies in China, but only 25 of them have a capacity exceeding 200,000 tons per year.

#### China's rail network

The rail network forms the backbone of the Chinese transport system and serves most cities. There are now a total of 72,000 km of railway track in China. The China State Council has approved a plan to invest more than 2 trillion yuan to expand this to 100,000 km by 2020.

The annual growth rate for passenger traffic is estimated to remain at 7% until 2020 [16].

To realize this goal, foreign advanced technology will be introduced for the manufacture of locomotives and rail-cars.

#### Construction and building sector

The construction sector accounts for 1% of the total energy consumption in China in 2001. In 2004, the newly started floor space for commercial buildings was 604 million square meters, an increase of 10.4%. Out of this total, the newly started residential buildings represented 479 million square meters.

Total vacant floor space of commercial buildings decreased by 8.3% from 2003, to 123 million square meters in 2004 [17].

The Chinese government has launched a series of measures to cool down the soaring prices of housing and prevent a bubble in the industry. As per capita floor space in urban



areas have just reached 22.8 square meters in 2002, and 25.5 square meters in rural areas, the demand for housing will continue to increase with improving living standards.

### Conclusion

The energy-related industries in China have shown high growth and will continue to do so in the future – driven by an insatiable desire to improve living conditions for the Chinese people. Also in the foreseeable future the industrial sector will remain the largest energy consumer with residential and transportation rapidly increasing. There will be high demand to develop the energy supply infrastructure in the coming ten years. Coal will remain the dominant energy source followed by oil and natural gas.

The energy industry is faced by many challenges, some of these include:

- Energy supply resources are located far from the major demand centers. The largest and fastest growing industrial centers are in the most developed eastern and southeastern areas. The transportation and trans-

mission of energy will present a major bottleneck

- Industries must improve their energy consumption efficiency and move towards best-in-class productivity performance. This requires introduction and wide use of state-of-art technology in production and management.
- All industries must make major efforts to reduce environmental pollution and focus on environmental protection.

Some 300 million residents of rural China are expected to move to towns and cities by 2020.

China is characterized by many positive trends but investors should avoid blind optimism and irrational exuberance towards the growth of China. There will certainly be many challenges in the next 20 years. Overall prospects look good with ongoing industrialization and urbanization. Some 300 million residents of rural China

### Profile: Peter Lennhag

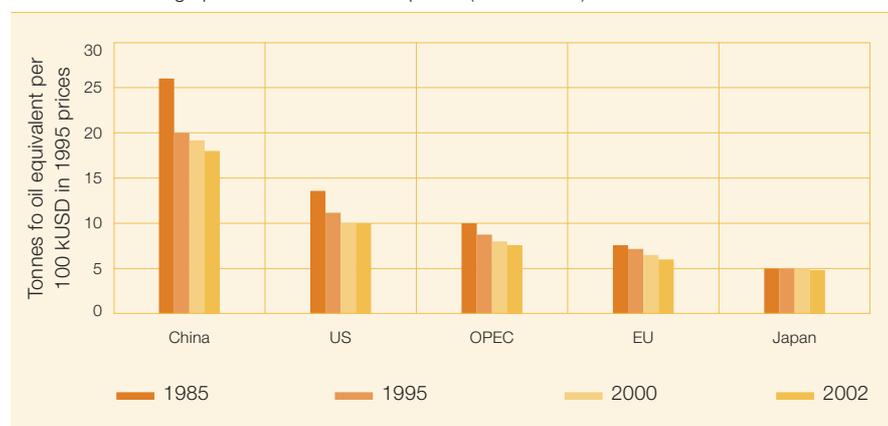
Peter Lennhag is President of Asia Pacific Executive Advisors. He has worked and lived in Asia since 1982 and has more than 20 years experience assisting major Asian companies and leading Western multinationals with strategy and organizational development. His focus today is to help multi national companies to build and grow their businesses in China.

are expected to move to towns and cities by 2020. However, the risks of massive oversupply and eroding profit margins are real in many sectors of the economy.

Hyper-competition and price wars will likely lead to consolidation and clear winners and losers will emerge in all industries. There will be opportunities to strike for savvy investors and buy weaker competitors. Developing creative strategies, building competitive advantages and ensuring flawless execution will become critical to success. Although China has considerably improved its energy efficiency over the last two decades it still has a long way to go to match best in class levels.

<sup>4</sup> indicates that it consumes three times more energy per dollar of gross domestic product (GDP) than the EU average and four times more than Japan. Chinese senior officials have repeatedly expressed their concern over the problem and urged a change in the growth pattern and energy efficiency of the manufacturing and process industries.

<sup>4</sup> Ratio of oil usage per 100 kUSD in 1995 prices (Source: IEA).

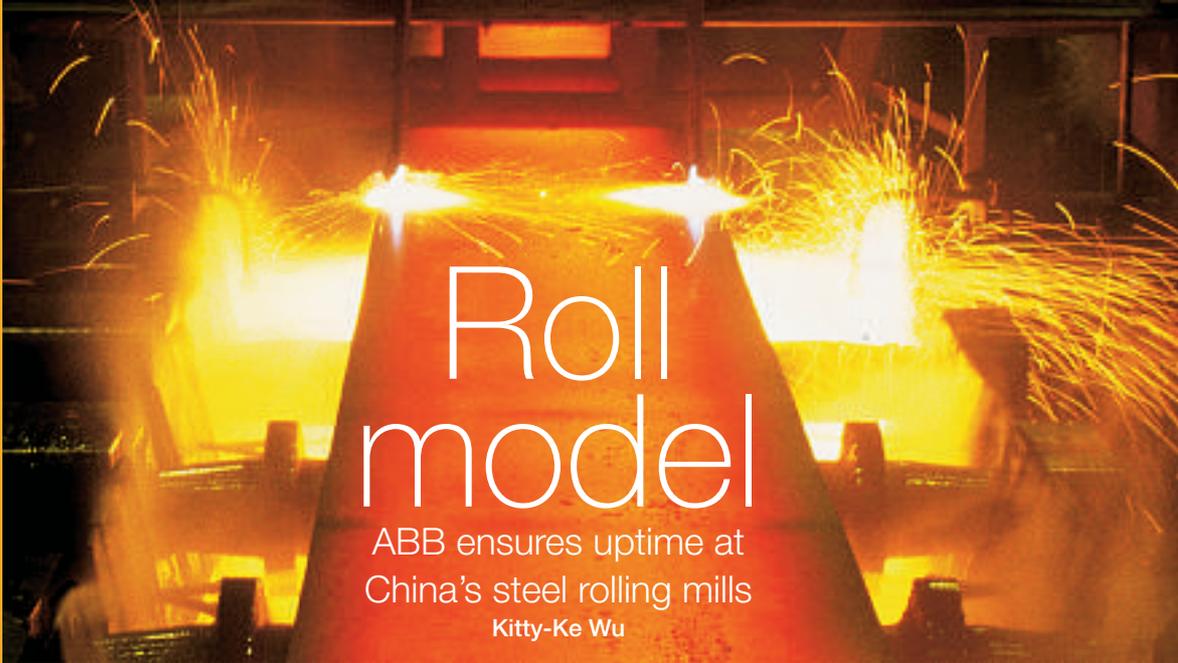


### References:

- [1] Statistical Bulletin 2004, issued by National Bureau of Statistics, China
- [2] Xinhua News Agency, September 16, 2004
- [3] Report presented by The Development Research Center of the State Council on March 20, 2005.
- [4] People's Daily, February 15, 2003
- [5] Institute of Energy Economics, Japan
- [6] National Economy and Social Development Bulletin by National Bureau of Statistics of China
- [7] China Daily, 9 May, 2004 "China's steel sector still red hot"
- [8] National Economy and Social Development Bulletin by National Bureau of Statistics of China
- [9] China Cement Association
- [10] Institute of Energy Economics, Japan
- [11] China Paper Association
- [12] National Economy and Social Development Bulletin by National Bureau of Statistics of China
- [13] National Statistical Year Book 2003
- [14] 2004 National Economy and Social Development Bulletin by National Bureau of Statistics of China
- [15] Chen, Yuanlong, China's Transport Prospect
- [16] The Ministry of Railway, Newsletter
- [17] The Real Estate Climate Index by National Bureau of Statistics of China, March 8, 2005

### Peter Lennhag

Asia Pacific Executive Advisors  
peterlennhag@compuserve.com



## Baosteel Group Shanghai No. 5 Steel Co. Ltd

The Baosteel mill rolls rods and bars. Products include bars of 15 to 50mm diameter, rods of 5 to 20 mm diameter and coils of 14 to 40 mm.

These parts are processed from steel slabs delivered from the foundry. A series of rolling stages form this slab into a rod or bar of the desired length, profile and mechanical properties. The process consists of the following steps:

- Reheating furnace
- Roughing mill
- Intermediate mill
- Pre-finishing mill
- Kocks rotating mill
- Wire outlet with sizing block
- Garret line
- Bar line

ABB supplied the automation package and drive system equipment including its Advant control system, the level 2 system, the motors and the ACS600 and ACS6000 drives.

### Software for productivity

ABB's Advant control system is based on a proven control strategy and contributes to a high yield through reduced scrap, improved quality and higher mill productivity.

The Advant Controller 450 system software includes a real-time operating system. This is programmed in the ABB Master Programming Language

(AMPL). Programs are executed cyclically on three priority levels.

Operate<sup>IT</sup> is the basis of the human machine interface. The primary interface units are the graphical display screens and the keyboard. All displays in the mill can be accessed from all operator stations.

ABB's Advant control system is based on a proven control strategy and contributes to a high yield through reduced scrap, improved quality and higher mill productivity.

Operate<sup>IT</sup> provides the following functionality:

- Views of displays and lists.
- Dialog for manual control.

- Alarm management.
- Diagnosis and self diagnosis of automation system.
- Status display.
- Third party software can be integrated.
- Object oriented architecture facilitates customization.

The functionality of this package makes it easy for planners, managers, operators and inspectors to see exactly what the mill is doing. Diagnosis, fault finding and planning are greatly facilitated.

### Driving for efficiency

The ACS 600 multi-drive is a new member of the ACS 600 family. It is optimized for demanding and highly dynamic applications. The ACS 600 multi-drive optimizes cage induction motor performance and offers direct torque control, while offering all the revolutionary motor control options of the ACS 600 family.

The adoption of power-saving drives, and the common busbar between them keep energy consumption low.

### ABB-the natural partner

ABB's extensive experience in rolling mill applications and the high quality of the company's products were important factors for the customer in the decision to adopt the company's drive and automation systems.

TPCO plant in Tianjin



Rolling steel rods in the Baosteel plant.



China's booming manufacturing economy has a huge appetite for steel. In 2003, consumption hit the 250 million ton mark, accounting for some 30% of global consumption. At growth rates of some 15%, this figure is set to surge further.

This demand is placing pressure on production. To increase output, steel plants must improve uptime and reduce waste. Motors, drives, control and diagnostic systems from ABB are helping manufacturers to enhance productivity and meet these goals. In this article, two rolling mill applications are presented.

## Tianjin Pipe Co. Ltd (TPCO).

The process of making steel pipes is essentially similar to that of making rods. Pipes, like rods, are rolled in a multi-stage process in a mill. Again, ABB's hands-on experience in tube rolling mills gave the company an advantage in winning and executing this order.

A steel mill has many complex parts, which must be coordinated and work together seamlessly. The example of the retainer motor is considered. The work-piece is firmly held by a device called the mandrel. This is mechanically coupled to a pinion-driven rack. Every pinion is driven from a retainer motor via a gearbox.

### Milling with the mandrel

Fresh shells arrive at the mill's entry roller table. Before rolling of the shell commences, the mandrel is inserted. The purpose of this device is to retain the shell during rolling and to return it to its home position. The retaining speed and position are determined by the mill set-up (which depends among other things on the shell's length). The retaining speed is normally lower than the speed of the first rolling stand; so as soon as rolling commences, the mandrel's motor switches to retaining or generative operation.

The retainer motor and its drive must be very robust and highly dynamic. They must deliver the right torque to hold the desired speed and to handle rapid changes in torque and speed –

while meeting high reliability and availability expectations.

Mr. Liu Yunsheng president of TPCO says, "We see ABB as our strategic co-operation partner. Our phase two, the first PQF tube mill in the world, is a success. We hope to maintain our friendship and co-operation with ABB in future".

### Key parameters of Tianjin Pipe Co. seamless steel pipe mill

#### General information

- Mechanical Supplier: SMS MEER.
- Capacity: 350,000t/a.
- Initial Material: Billet (d = 200mm, weight max. = 645kg).
- Final product: tube (diameter = 48cm, 32cm inside to 168cm).
- Commissioned: June to Oct. 2003.
- Start Up: Sept. 2003.
- Arrangement of the mill: piercing mill, PQF mandrel mill, stretch reducing mill.

#### Main drive system

Following equipment was delivered by ABB:

- Piercing mill: 2×4000kW, 750 min<sup>-1</sup>
- PQF (premium quality finishing): 9×400kW + 6×600kW

- Retainer: 4×300kW + 1×75kW
- VRS: 3×70kW
- Extracting mill: 9×70kW
- Stretch reducing mill: 3×900kW, 2×280kW, 1×630kW
- Motor: HXR, M2BA, AMB, AMZ
- Drive: ACS 600, ACS 6000

#### Electrical Equipment

The following equipment was designed, delivered and erected by ABB:

- Transformer & Motor
- AC Main Drives & Aux. Drives
- Advant Control System with AC450 RMC & Operate<sup>IT</sup>
- Main Control Pulpits

#### Automation System

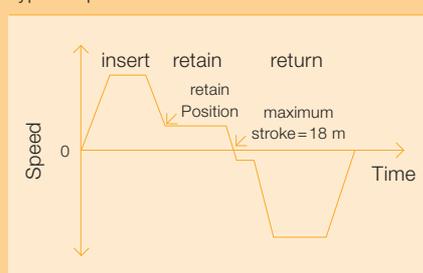
The following equipment was delivered by ABB:

- Advant Controller AC450 RMC
- Industrial IT operator station
- AC80 controller
- Main control pulpits
- Level 2 system

#### Characteristics of mandrel drive

- Speed control: During rolling, the retaining speed has to be constant.
- Position control: There are normally three positions: home position, retain position and maximum stroke position.
- Load sharing control: All drives (normally 2 to 8) have to provide equal torque.
- Backlash compensation control: Reduces noise and wear between pinions and rack caused by torque steps.

Typical operation of mandrel motor.



Kitty-Ke Wu

ABB China Ltd.

kitty-ke-wu@cn.abb.com

# Lifted productivity

ABB Crane Systems lift business in Qingdao  
Stephen-JiHao Zhu



Crane control systems from ABB are hard at work throughout the world. They are used by ports, shipping lines, power stations and steelworks – and assure a reliable and fast turnaround, speedy forwarding, and are a cost effective way of moving containers, bulk material and steel products. ABB works together with crane builders or directly with end users – supplying electric equipment, motion control, automation and information systems.

Following China's economic growth of recent decades, the demand for cranes has also grown. ABB is an important supplier in this market. Most of these systems are used in bulk material and container terminals from Dalian in the north to Beihai in the south. ABB's extensive knowledge and experience is helping these customers leverage their productivity. The port of Qingdao is a prime example.

Qingdao is an important hub of international trade and sea-going transportation. It is located in the Yellow River basin on the western Pacific Rim. In 2004, the port handled a record volume of over 161 million tons of goods. Its foreign trade volume surpassed 120 million tons – the second largest figure in Mainland China. Besides its large-scale container handling activities, the port also has a first-class iron ore terminal.

Using the cranes equipped with ABB's system, the Port of Qingdao frequently sets new world production records both in ore-unloading and container handling.

Starting in 1997, ABB delivered two control systems for grabbing cranes used to unload ships in the port. Satisfied with the excellent performance and strong service support that was received with ABB's systems, ABB was appointed crane control system supplier to continually provide systems to the port. Since then, ABB had delivered an additional three grab crane systems for unloading ships, 18 ship to shore crane systems and 16 rubber tyred gantry crane systems.



## Grab crane ship unloader

A grab unloader is a crane fixture used to unload loose bulk material (such as coal or iron ore) from a ship.

ABB's GrabControl system controls the work of the grab by regulating the different control modes of the drive system to ensure that the grab bucket is always filled to its optimum level. The operation of the grab is controlled so that it is automatically stopped when the bucket is approaching the material. An automatic digging sequence is then initiated.

When the bucket is almost fully closed, the hoisting of the grab begins automatically. This ensures the best possible closing of the bucket and minimizes spillage. The operator has only to supervise the operation. The GPO (Grab Pendulum and Performance Optimizer) ensures that the GSU meets the calculated productivity by minimizing unloading time.

The system controls the unloading cycle to a performance equal – or better than – the most skilled crane operator.

The control system takes the momentum of the bucket into account. This means that time is saved at unloading. The bucket can be opened before it has come to a standstill because the control can predict the trajectory of its load and so ensure that no material is lost. This leads to faster turn-around times and for the crane and hence for the ship.

Using the cranes equipped with ABB's system, the Port of Qingdao frequently sets new world production records both in ore-unloading and container handling. Numerous awards have been won.

The following quotes are from announcements of the Port of Qingdao: "At 18:20 on October 10, Qingdao Port again broke its own world record while working on the ship 'Maersk Dortmund'. reaching a net rate of 474 boxes per hour and a berth rate



of 380 boxes per hour. After Qingdao Port accomplished 2,035 TEU (twenty feet equivalent units) in under 2.67 hours, Maersk, the world's largest shipping company, was so impressed that it sent a letter of thanks."

"At 18:00 on December 19th 2004, the imported-ore unloaded to date this year at Qingdao Port stands at 40,069 million tons, an increase by 18% compared to the previous year. This further consolidates Qingdao's position as the largest ore-handling port in China and also makes it the largest ore unloading port in the world."

The report on productivity of docking from Maersk says, "since the beginning of the year 2004, the average hour effectiveness of Qingdao Port has been 126 boxes with a peak of 167 boxes reached – the highest among all of Maersk's docking ports and by far surpassing all the big ports in the world".

It is reported that for the past several years, the container business of Qingdao Port has been enjoying an increase of over 30% in traffic for such companies as QQCT.

Last year's container throughput exceeded 5 million TEU, achieving the box volume standard of an international shipping center. This year Qingdao Port has set a higher target. Qingdao wants to become the international shipping center of China's north.

## Container Handling

ABB Advant® Crane Control System is a complete toolbox for efficient control and operation of container handling cranes. Standardized packages are available for electrification and automation of both new and existing installations. ABB's palette includes a wide range of proven software and hardware blocks that can be modularly combined to meet the customer's specification.

ABB Advant® Crane Control System provides:

- Basic drive & control systems for individual cranes, as well as for advanced port automation systems.
- Systems proven in ports of all sizes all over the world.
- Unmanned automation solutions.
- Efficient systems for higher productivity.

ABB is looking forward to contributing further to the port's success!

**Stephen-JiHao Zhu**  
ABB Engineering (Shanghai) Ltd.  
Shanghai, China  
stephen-jihao.zhu@cn.abb.com

# In total control

ABB technology brings precise positioning and high fuel efficiency to marine applications

Julia-Wei Cai



Until recently, most ships were powered by large propellers, driven from diesel engines using shafts. Connecting the propeller to the engine in this way also coupled their working speed ranges. For ships which spend a lot of time maneuvering or station-keeping, this means the engine is often working at low speed – which doesn't make for good fuel efficiency.

All this has changed since shafts have been replaced by electric transmission. The additional flexibility means the prime mover can be operated in a smaller dynamic range. Furthermore, by dispensing with the rigid transmission, the thrusters can be oriented for optimal maneuvering – so saving time and boosting productivity. All these advantages were built into the new Field Support Vessels (FSV) supplied by Zhejiang Shipbuilding Co. in cooperation with ABB Marine.

China's booming economy has, without doubt, made it one of the most exciting spots on the globe. This is no less true of its marine industry. As a leading supplier of electric power and propulsion plants, ABB is at the forefront of delivering innovative solutions and efficient operations to the marine market.

A good example are the FSVs being built by Zhejiang shipyard. A FSV is a ship used to support offshore engineering and logistic activities. High maneuverability, precise positioning and large and easily accessible payload areas are characteristic of this type ■.

## Zhejiang FSV application

Until the mid 1990s the majority of FSVs used direct diesel mechanical propulsion systems. Comparison of operational profiles and parameters with other vessel types led to design principles from these being adopted for FSVs. The result was a higher FSV productivity. For example, comparison with diving support vehicles equipped with ABB electric propulsions showed this technology offered clear advantages in terms of fuel efficiency, and the ability to maintain a precise position in strong currents or on rough water. These principles were adopted by FSVs and all expectations fulfilled.

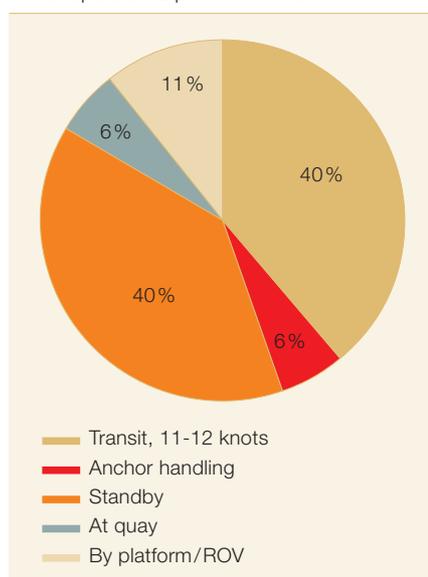
Zhejiang Shipbuilding Co. Ltd. is using ABB technology in its delivery of ten GPA670 type FSV ships to Bourbon Group (France). The first of these, M/V Bourbon Helios, was launched on Oct. 28 2004 and will be delivered in June 2005. The last of the batch will be delivered in August 2006. Parameters of this type are shown in /sidebar.

The electric propulsion system supplied for these vessels includes remote control for the propulsion system, the DP-II dynamical positioning system, alarming and monitoring equipment, the plant management system (PMS), auxiliary equipment control and information management and remote diagnosis. Other key equipment supplied includes the 440 V main switch board (MSB), the power drive transformers, the motor control center (MCC), compact 24-pulse marine drives, a pair of 1,920kW propulsion motors, and a pair of 746kW bow thruster motors.

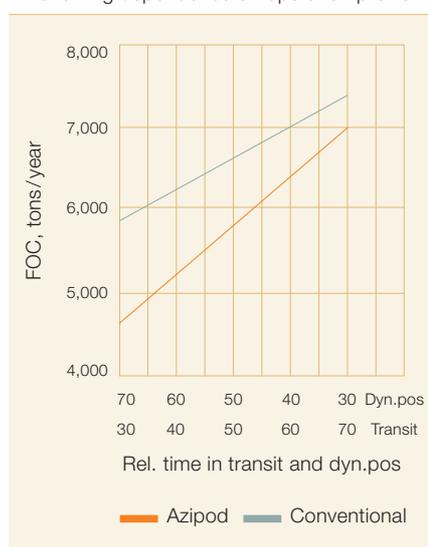
### Why ABB electric propulsion?

Electric propulsion systems are used in numerous variants and configurations on ships of all types and sizes.

1 An operational profile for a FSV.



2 Comparison study of annual fuel oil consumption (FOC) for the FSVs in 1, showing dependence on operation profile



In this technology, the power is supplied by gas turbines or diesel engines and transmitted to the propellers by cables rather than through direct transmission shafts.

The introduction of thrust units not mechanically connected to the engines provides greater flexibility in identifying optimal positions for these respective parts – so providing more usable space for the payload. More significantly for FSVs, however, it makes movable thrust units an option – so enhancing the ship’s maneuverability. The arrival on the market of these azimuthing thrusters and podded thrust units has led to the convergence of transit, maneuvering, dynamic positioning and station keeping configurations for several types of ship. The development permits FSVs to use state-of-the-art thrust units derived from those designed for other ship types.

The advantages of electric propulsion for this type of vessel are numerous: The dynamic range of the prime mover is reduced and the load optimized, leading to higher fuel efficiency 2, lower maintenance requirements and the possibility of using lighter engines. This in turn reduces life cycle costs, especially in applications with a large load demand variation. Fixed speed operation of the prime mover also reduces noise and pollution. The absence of long shaft drives reduces vibrations. The failure vulnerability of the system is reduced by the greater redundancy. Payload space is increased through a more flexible and distributed positioning of components 1. Maneuverability is revolutionized through the use of azimuthing thrusters or podded propulsion, and the pulling type propellers give rise to a more uniform water flow and thus less cavitation.

Studies have shown that there is a significant potential for reducing operating costs for vessels whose operational profile consists of a combination of high load requirements and a significant portion of operations at low load – such as standby and dynamic positioning. For the operational profile in 2, this will result in an annual saving of approx 900–1000 metric tons of fuel (or 16% for a vessel with 2×3500 kW propulsion power). The savings increase with the time spent in station keeping operation, and reduce with time spent in transit.

### Main Technical Parameters of GPA670

Loa:	73.2 m
Lbp:	70.76 m
Breadth molded:	16.5 m
Depth molded:	6.8 m
Draft:	5.3 m
Displacement:	5,028 t
Deadweight:	3,230 t
Main engine:	Cummins 3 × 1865 kW / 1,800rpm
Speed:	13 kn, no-load
Liquid/mud tank:	1,347 m <sup>3</sup>
Fuel oil tank:	948 m <sup>3</sup>
Fresh water tank:	641 m <sup>3</sup>
Accommodation:	24 persons
Classification:	BV

Studies and field measurements report fuel savings of up to 40% in station keeping mode.

### Summary and outlook

In the successful completion of the first large order of electrically propelled FSVs to be placed in China, ABB provided assistance from the design phase through to the final delivery.

In recognition of ABB's qualified system solutions and excellent services, Zhejiang Shipbuilding Co. Ltd. and its parent company, Pacific Heavy Industry Group, wish to establish a long-term strategic partnership with ABB. They intend to use ABB technology for a 44 further FSVs currently on the group’s order books.

Over the last two years, ABB Marine (China) has gained 17 references on six types of vessel, ranging from Yanda Train Ferries to an SOA (State Oceanic Administration of China) Research Vessel and from gas tankers to FSVs.

FSV equipment is just one example of ABB solutions and technologies benefiting local customers. ABB Marine intends to continue to play a leading and active role in the exciting and promising field of marine developments on the Chinese market.

#### Footnote:

See also “Turning Point, CRP Azipod gives a boost to marine propulsion efficiency”, Tomi Veikonheimo, Matti Turtianen, ABB Review 1/2003.

#### Julia-Wei Cai

ABB China Ltd.  
Shanghai, China  
julia-wei.cai@cn.abb.com



# Ancient traditions, modern tools

Modern manufacturing methods are reviving  
China's ancient papermaking tradition.

Jane-Zhen Yu

China counts among the world's largest pulp and paper markets. Since 1993, ABB Pulp & Paper has been placing its advanced technology at the service of China's papermaking industries – helping companies uplift quality and productivity.

The Lee & Man Group, now one of the top ten paper companies in China, commissioned its first paper machine in 1996. The company's total capacity in 1997 was 200,000 tonnes/year. In 2001 Lee & Man signed a contract with Voith for a paper machine, PM4, for installation in Changshu, Jiangsu province. The high speed and high volume paper machine

required a high quality automation system for its intricate process – and this in a short delivery time.

After an extensive performance analysis, Lee & Man selected ABB's most advanced integrated control system the time. This centralized the complex control of the paper machine, the processes and the motor drive to a

1 All processes are controlled and monitored from a central control room



single control room **1** supported by ABB's Distributed Control System (DCS).

The integrated solution and the powerful ABB controllers permit different PLC (programmable logic controller) functionalities and ABB's DCS functions to be realized in the same controller. This approach optimizes the structure of the entire control system, eliminating the PLC and DCS communication bottleneck, while incorporating the conventional body of the paper machine into the DCS. This way the users access the process through a uniform, ergonomic interface, which creates improved information transparency and makes control optimization possible.

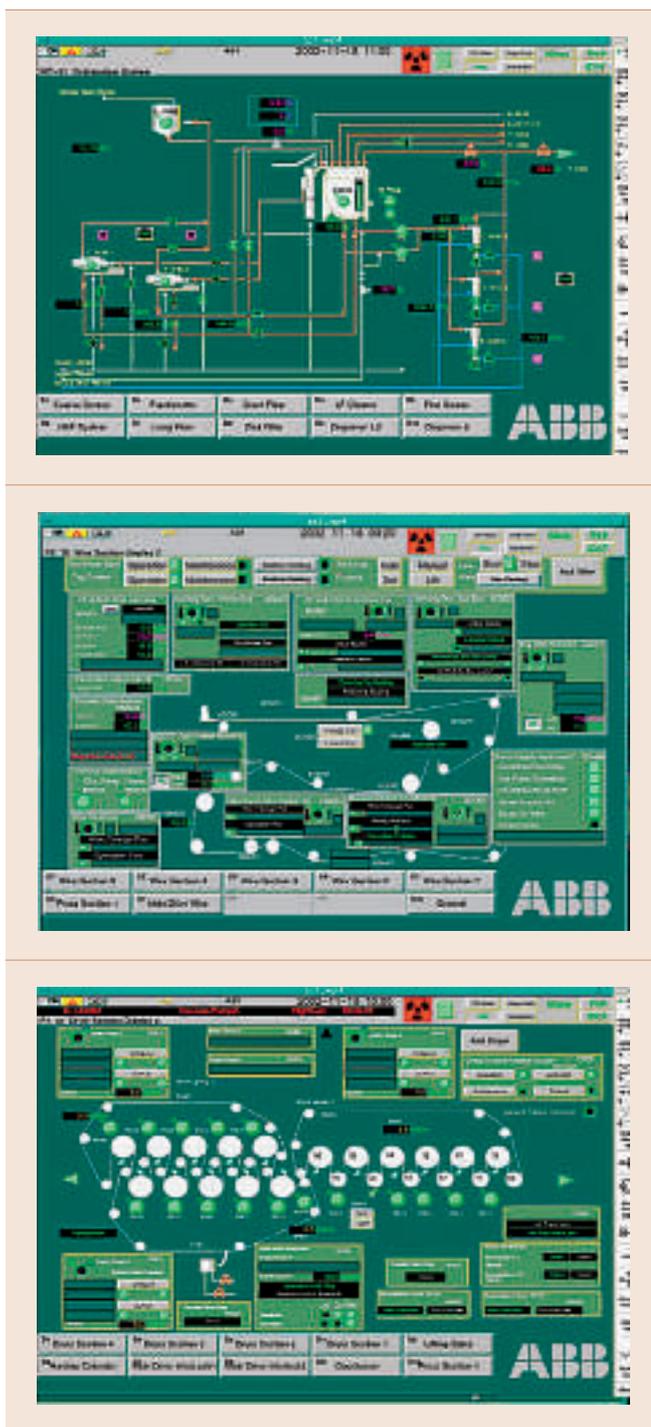
Additionally, both the quality control system and ABB's paper machine drive system are based on the DCS platform and use the same programming and configuration languages – facilitating data exchange between these sub-systems. A glance at the fully centralized control structure shows the strength of this approach in action. Control panels are moved from the heat and noise of the factory floor to the comfort of the control room – improving working conditions and worker health and safety.

ABB's integrated system solution enables smooth and fast communications and true automation. All system components use the same configuration and maintenance tools, simplifying information management and tracking and contributing to production optimization and the stable running of the paper machine.

Following the successful operation of the PM4, the Lee & Man Group has purchased all their control systems from ABB.

On Sept 14, 2004, the ABB system was awarded the Excellent Industrial Con-

**2** The user friendly interface of the operator stations.



trol System Award of the year by the Technology Prizes of China Instrument & Control Society at the Multinational Instrumentation Conference and Exhibition (MICONEX).

From 1994 to 2003, approximately 300 projects have been executed by ABB China. ABB's automation and drive systems enjoy a very extensive installed base in the pulp and paper making industry in China and have been deployed in many large and medium-sized paper mills. Over 60 dedicated pulp and paper experts from ABB are

now helping paper-making companies to achieve modernization required for them to be able to raise their productivity and profit levels.

#### Customer quote

Looking back on two years of experience with the system, Fan Sheng, Project Manager of Lee & Man, said, "Installation and commissioning time was short. Technical staff and the equipment operators were able to quickly understand and master this system. We were able to start producing quickly. Secondly, the system hardware is very stable. It provides high operational reliability in a harsh environment, which leads to high availability and productivity. Thirdly, the system simplifies access to information, which helps both diagnosis and planning. In particular, the integrated system can produce various reports and messages covering both the interlocking functionality and the drive system through the DCS. As a result, the information is integrated, the operation and maintenance staff's work reduced and the productivity improved. Last but not least, the shortened maintenance time reduces and avoids down time. All in all, the integrated system improves the productivity while allowing management to focus on higher level issues and monitor production and quality effectively."

#### ABB system configuration

- 8 operator stations for centralized control.
- total 7,500 I/Os install in different control rooms.
- 5 sets high performance ABB controller (AC400) for Process DCS and Voith machine logic function.
- ABB QCS integration.
- ABB drive integration.

**Jane-Zhen Yu**

ABB China Ltd.

Shanghai, China

jane-zhen.yu@cn.abb.com

# Robots confine hazards

Fanny-Yi Wan



It may seem paradoxical at first, that a country such as China with its relatively low labor costs should be a robotics market. Robots, however, can work in environments that are too hazardous for people and will achieve an accuracy and reproducibility beyond that of humans.

The following two examples show robots at work in two totally different environments. In the first article, robots are seen painting consumer electronics enclosures. Such items as mobile phones, laptops or electronic piano keyboards are produced in very large numbers. By carefully optimizing workflow, waste of paint and sub-standard paintwork can practically be eliminated.

In the second example, metal enclosures are welded. The hazards of a laser welding environment, and the precision required of the welding make robots the natural choice also in this application.

1 An ABB painting robot for Flextronics

## Painting robots

The realization of Flextronics Zhu Hai's Painting Shop for Dell laptop covers is undoubtedly the biggest challenge and the most successful implementation that the company's manufacturing industry department has ever experienced.

With its headquarters in Singapore, Flextronics is the world's leading elec-

tronics manufacturing services provider. It is focused on delivering innovative design and manufacturing services to technology companies. With a revenue of US\$ 14.5 billion in the fiscal year 2004, Flextronics is a major player in global technology manufacturing. It provides assistance to electronics manufacturers by supporting design, building, shipping and service processes. Flextronics has facilities in 32 countries on five continents.

In expectation of the increasing production of laptops, Flextronics Enclosure (Zhu Hai) signed two contracts with ABB to supply 14 painting robots forming seven lines for its Dell laptop cover painting shop.

### An ultra-clean environment

The paint shop is separated into two portions: a loading/unloading area with normal air conditioning and a painting area with a class 100K<sup>1</sup> clean room. All cast deflashing

zones<sup>2)</sup>, ovens and cooling zones are on the second floor. The air contamination at the process equipment reaches class 10K.

The most significant items of the supply contract concerned robots, spray booths, air conditioning devices, ovens and conveyors. Because of the unique strengths of ABB's robots, the robot contracts were secured in a highly competitive market environment. ABB's advantages include the robots' advanced handling capability, their proven operational flexibility and robustness and the advanced professional simulation software – Robot Studio, which accompanied the delivery. Further strengths include conveyor tracking, paint saving technology, short delivery time and a competitive price.

Besides the strengths of ABB's robots, the ingredients of success were embodied in the experienced team leaders and design engineers.

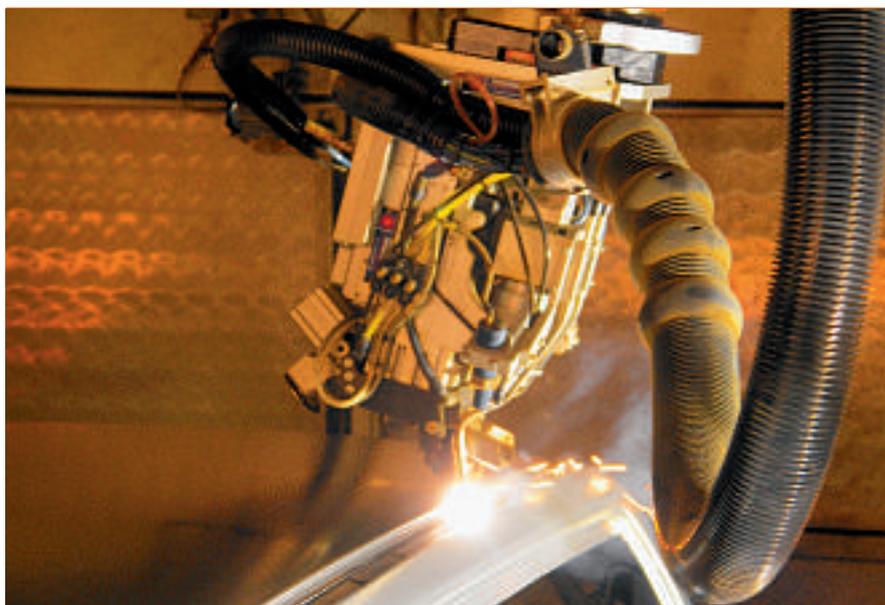
The main requirements for automated manufacturing are higher productivity at lower cost, environmental compliance, increased flexibility and shorter execution cycles. Besides the strengths of ABB's robots, the ingredients of success were embodied in the experienced team leaders and design engineers: The people who endow those cold robots with soul and power.

#### Painting the way for future success

This pioneering success helped build a healthy mutual partnership, leading to Flextronics intention of purchasing further ABB painting robots in the following 2 years. These include the paint shop for Casio electronic piano keyboards in Dong Guang and the paint shop for Sony Ericsson mobile phone covers in Malaysia.

Mr. J.D. Yang, Quality Manager at ComPal, Flextronics' Kun Shan plant says, "We believe this is the beginning of a long lasting good relationship between ABB and ComPal. We are part of the same value chain and form a most competitive team".

2 A high precision laser welder at work.



## Welding robots

A customer in China uses a robot laser welding system for manufacturing several types of stainless steel boxes <sup>2</sup>. The requirements placed on the welding equipment are very high because no oxygen may leak into the boxes. The flexibility of ABB's robots and the precise coordination made possible due to the IRC5 controller made ABB the natural partner for this high-precision job<sup>3)</sup>.

#### Safety first!

The light from such a powerful source as a welding laser diode can cause permanent blindness. Hence, greatest

care is taken to ensure the safety of staff at all times. Even reflected light is hazardous; with this in mind, the cell <sup>3</sup> is uncompromisingly implemented to eliminate risk of contact. The enclosure is made of multiple layers of sheet metal supported by a steel frame. According to risk-analysis recommendations, various sections may be additionally reinforced.

Robust automatic doors are provided for work-pieces to enter and leave the cell. Additionally, a service door is provided for staff to access the cell. A safety mechanism monitors these openings and ensures welding cannot take place while any door is not completely shut and locked. Any attempt

3 The laser can cause blindness – the cell is totally enclosed.



to open a door during operation stops the process instantly.

### The uptime conundrum

Another major challenge in robot welding is mastering the uptime of the welding laser. The efficiency of an Nd:YAG (neodymium yttrium aluminum garnet) laser source is limited to around 2–3%. To offset the low laser efficiency, the technology must strive for the highest possible productive laser uptime. This is achieved using a mirror that switches the ray between cells: ideally, one cell starts welding the moment the other cell stops – and the light is never wasted!

The new IRC5 industrial robot controller provides unparalleled capabilities with its MultiMove functionality<sup>4)</sup>. This not only precisely synchronizes multiple robots or positioners with extreme accuracy, but also controls the mirror that switches the ray, ensuring that this perfectly matches the movements of the robot.

The welding laser used is stationary, and the light led to the seam by flexible fibre optic lasers. This saves on time-consuming alignment and adjustment work when the welding source is changed.

### Seam tracking

In Seam Tracking, the robot “sees” and follows the intended welding seam using a focus optic. This optic is the same that is used to focus the main welding beam (Beam Path Integrated Vision). The lack of additional camera optics leads to a compact tool design.

Seam tracking is supported by powerful software that analyzes the pictures fed to it by the camera and adjusts the spot position accordingly. A cycle time of about 40 ms leads to an exceptional responsiveness.

A roller positions the welding tool on the seam line and presses the two pieces of metal together at a defined pressure to assure optimal bonding. The pressure is pneumatically regulated and adjustable. The roller angle is fixed but the optics tilt to follow the contours of the workpiece. Filler wire, protective gas nozzle, welding beam focusing unit and workpiece sensor are all attached to this press device module, assuring they are always in the intended positions, and that they all “float” along the seam together.

4 A look inside the cell of 3.



### The application

The robot cell 4 contains two welding stations. Each has its own door for loading and unloading work-pieces 4a 4b. A welding robot is located between the stations 4c and can access either station through door-protected openings in the walls of the workstation 4d 4e.

Seam tracking is supported by powerful software that analyzes the pictures fed to it by the camera and adjusts the spot position accordingly. A cycle time of about 40 ms leads to an exceptional responsiveness.

In one station, the boxes are welded 4f. To assist this process, an adjustable positioner orients the workpiece 4g. While this station is being loaded or unloaded, the robot switches to the other station 4h, where other assembly parts and fastening elements are laser welded. Using this technique, complete subassemblies can be laser welded, providing savings in assembly work and logistics.

The laser beam from a single 3300 W diode pumped Nd:YAG laser is guided

through a flexible optical fiber to the welding tool. The laser output is switched between the stations in the cell, so making optimal use of laser uptime, and accomplishing two tasks in a single work cycle.

The cell is equipped with a Permanova WT03 Laser Welding Tool and an ABB robot. The system uses Seam Tracking technology and the AW hybrid-welding feature with a MIG power source.

Using a laser for welding assures tight seams while causing very little heat deformation. It also only requires access from one side, so reducing handling requirements.

### Fanny-Yi Wan

ABB China Ltd.  
Shanghai, China  
fanny-yi.wan@cn.abb.com

### Footnotes:

- 1) Class 100K is a classification of air contamination in a clean room according to US Federal Standard 209E. Class 100K indicates that there are no more than 100,000 particles larger than 0.5 micron per cubic foot of atmosphere. For class 10K this reduces to 10,000 particles.
- 2) Deflashing is the process of removing flash, the excess material that casting leaves on a cast item.
- 3) The laser welding story uses material from “Welding sees the light” by Fabrice Legeleux, ABB Review Special Report Robotics (2005), pp20–22.
- 4) See also „Team-mates“ by Christina Bredin, ABB Review 1/2005 pp 26–29.

# Energy efficiency

Energy efficiency in industry is a priority around the world – including China. A significant indirect benefit is CO<sub>2</sub> reduction: This is of importance in the light of global warming and the Kyoto protocol. The following short articles give an overview of several typical applications in industry where drives technology in combination with electrical motors result in energy savings and CO<sub>2</sub> reduction.

## Under pressure



The use of variable speed drives for flow and pressure control of electric motors results in very definite energy and cost savings. A pump, controlled by a variable speed drive, running at half speed consumes only about one-eighth of the energy compared to one running at full speed!

De-scaling pumps in a hot-rolling mill are used to remove scale from the surface of hot steel. They work by taking the low pressure water from the water supply plant and creating the high-pressure water that is sprayed onto the surface of the hot steel, which in turn removes the scale. These pumps are placed before the mill stand and operate when steel passes through the rolling mill. It is only during this phase that the high-pressure water is needed.

To regulate the pressure of the water fed to the de-scaling pumps, a Taiwanese steel company used a mechanical return (bypass) valve controlled by an external PID controller. When peak pressure was required, the return valve was closed and the maximum amount of water was fed to the de-scaling pumps. When de-scaling was not required, the return valve was opened to reduce the water supply. But because the system had fixed-speed booster pumps, they operated at full speed irrespective of the water pressure needed. Because of this,

huge amounts of energy were being totally wasted. A solution was needed whereby the speed of the motor was reduced so that no more energy than necessary was consumed during peak pressure times.

The solution came in the form of ABB's ACS1000 variable speed drives which were retrofitted to the fixed speed booster pump motors. This means that high-pressure water is now supplied only when needed. In addition, the use of drives makes the system response faster than a traditional system with return valves. This stabilizes the water pressure bringing improved steel quality. On top of this, maintenance costs are lower and product quality has improved considerably.

Energy and water costs have been reduced significantly: estimated energy savings (to date) are in the region of 2,930,000 kWh; estimated annual water savings amount to approximately 65,000 tonnes; and CO<sub>2</sub> emissions have been cut by about 1,465 tonnes.

## As brass as you like

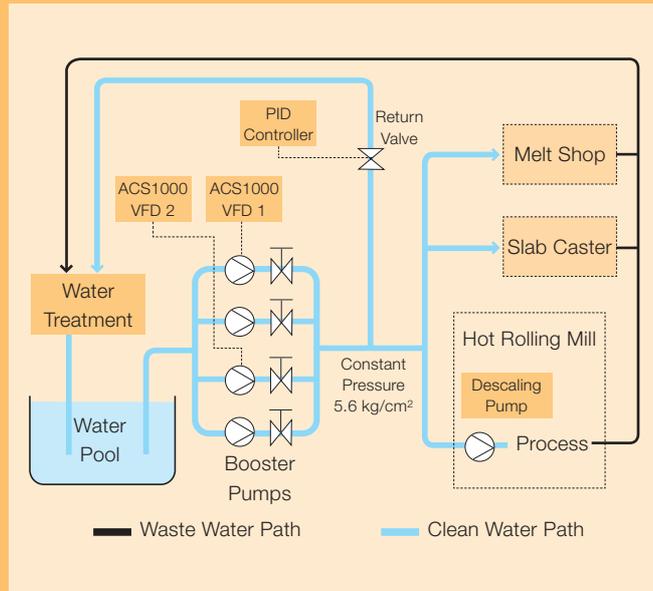
With an estimated 65% of industrial electrical energy used by electric motors, it is no wonder major energy users in industry increasingly see energy reduction as a key to increasing their profitability and competitiveness.

Central Electrical, one of ABB's channel partners in the UK, carried out an energy audit on the filtration plants belonging to Boliden MKM (a leading manufacturer of brass and copper products) by measuring the energy used during a typical working week. The audit mainly covered the fume extraction filter plant for the brass casting process, which consists of two Luhrfilter filtration plants, one with a 250kW fan and the other with three 132kW fans. The airflow from the fans was controlled by using dampers as restrictors.

The results pointed to potential energy savings with ABB drives of at least £25,000 (\$44,650) a year on a 250kW fan, and £15,000 (\$27,300) a year for each of three smaller fans – a saving of £70,000 (\$127,300) a year and a payback period of just 9 months. In any case, the total savings achieved for the installation proved to be much higher, some £130,000 (\$236,500) a figure verified by Boliden's own energy measurement system.

Ian Davey, Engineering Manager for Boliden, outlined the problems caused

by the old system: “The orifice dampers employed had to be closed to start the motors and then gradually opened to the right position for operation. This was a complex method of control that led to considerable energy loss in the system. As we have a variable rather than a fixed load, we decided to employ variable speed drives to regulate the speed of the fans.” It only took two months to replace the old damper system with ABB variable-speed drives and since then estimated energy savings (to date) are in the region



of 3,250,000 kWh (assuming 4 pence per kWh electricity price).

Fitting the drives also had other benefits besides energy saving. The swarf drying plant is served by three 132 kW extraction fans. A pressure transducer, mounted in the ducting, feeds information back to each variable speed drive. This not only controls the drive’s operating parameters but it also tackles environmental issues by helping to control emissions. In fact, avoided CO<sub>2</sub> emissions amount to approximately 1,625 tonnes.

## Increasing generation capacity

**One way of saving money is by saving energy. And the rewards are not too bad either.**

Kainuun Voima Oy’s 240 MW CHP (Combined Heat and Power) plant is located in Kajaani, Finland. In 2003, ABB delivered its medium voltage drive, the ACS1000, for a new feed-water pump application in the plant.

Kainuun Voima’s criterion for energy-efficiency investments is that the pay-back calculation has to indicate a full return on investment in less than two years. That being the case, since its installment, Kainuun Voima estimates that the ACS1000 has saved about

1 GWh of energy annually (enough for 50 electrically-heated or 200 centrally-heated households) and reduced CO<sub>2</sub> emissions by about 500 tonnes per year. On top of this, the reduction in operating costs has more than justified the company’s investment in electrical variable speed drives.

The Kyoto protocol took effect in the middle of February and since then, spot trading of CO<sub>2</sub> emissions has been picking up. Kainuun Voima’s energy efficiency improvement scheme recently qualified for investment support from the Ministry of Trade and Industry.



## Drinking and “driving” in Bangkok

**Supplying a city of 11 million people with clean water is no easy task. The fluctuating demand must be met uncompromisingly and equipment must perform as expected.**

**ABB technology is keeping the water flowing.**

MWA (Metropolitan Water Works Authority), a Thai state enterprise charged with operating the world’s biggest tap water treatment plant, supplies the drinking water for Bangkok’s 11 million plus citizens. It has a total treatment capacity of 4.3 million cubic meters per day. The treated water is distributed by three transmission pumping stations and 20

distribution pumping stations through a 20,000 km pipeline network.

Most of MWA’s pumping stations were equipped with eddy current coupling drives that controlled the speed of the treatment plant’s water pumps. Even though they operated with varying speed, MWA had excess energy losses of almost 15–30% because of the outdated technology. As electricity costs amount to almost 50% of their production cost, MWA was looking for

ways to increase the efficiency of their pumping stations.

It was decided to replace the coupling drives with ABB's ACS1000 medium voltage drives and by doing this, the treatment plant's system efficiency has increased by 15–30% (depending on the required operating speed). In the first year of their operation, the first two ABB drives have contributed more than \$120,000 to energy cost savings. This figure translates into monthly energy savings of approximately 180,000 kWh and does not take into account any additional savings from improved maintenance.

CO<sub>2</sub> emissions have been reduced by about 90,000 kg per month.

Other practical plusses include a more flexible pump operation, increased lifetime of motors and pumps, easier maintenance and full automatic control.



## Wheels of steel turn energy into gold

**Over 1,000 MWh of energy is being saved each year at Magnetto-Topy's steel wheel manufacturing plant in Coventry following the installation of seven ABB drives.**

Magnetto-Topy's outstanding energy saving, which translates into 500 tonnes of avoided CO<sub>2</sub> emissions, was achieved with a £23,000 investment that will provide pay back in just over one year. In addition, the pump noise has been significantly reduced and this will help the former Dunlop company meet new health and safety levels set at 80 dbA!

Four of the drives, rated from 37 to 55 kW, are used on water pumps within four cooling towers. Two 37 kW drives are used on filtration paint line pumps within the company's wheel paint line and a further 37 kW drive controls a compressor house pump.

The cooling tower drives have replaced star-delta switching which was used to turn the pumps on and off.

With this arrangement, the pumps ran at full speed (on 50 Hz) regardless of production needs. Now Magnetto-Topy is able to reduce the running speed on one pump, rated at 55 kW, to 35 Hz, resulting in a 53% energy saving. On three other pumps the running speed has been reduced to between 40 to 45 Hz, reducing energy consumption by between 33% and 46%.

Pump house noise is reduced by an average of 10% by operating the drive at a higher switching frequency. Using this switching frequency, the motors are perceived to be operating silently, because the sensitivity of human hearing decreases rapidly above 15 kHz.

Magnetto-Topy is the UK's only producer of steel wheels and it presently produces up to 100,000 wheels each week. Dave Pound, Operations Manager, says "the electricity costs alone needed to make each wheel is estimated at 14p. The energy reduction saves at least 1p. This may not sound much, but when we are producing so many wheels and with pressure on to reduce overheads, then 1p per wheel mounts up to a tidy sum."

One of the overhead costs under scrutiny is the maintenance budget. "Apart from energy saving, the drives

bring much greater reliability to our process. Star-delta starting stresses the motor, whereas the smooth start of variable speed drives has a direct impact on maintenance costs," says Phil Smith, Maintenance Services Administrator. "Pumps will run longer as they are running slower and with less vibration. The reliability of the drives now means I rarely go near the system."

Keeping up to date with the demands of the environmental system, ISO 14001 is a key factor in choosing variable speed drives. In addition, Magnetto-Topy aims to claim its Climate Change Levy (CCL) allowance, for which it needs a 10% saving over 10 years. "We are on target to achieve it this year, which means we won't have to buy carbon permits" says Pound.

Paul Stafford, Director of Drives at Sentrige (ABB Drives Alliance partner) concludes: "In a time of economic uncertainty, costs saving procedures are usually implemented on the factory floor, therefore why not reduce long-term costs through energy conservation? Installing a variable speed drive not only lowers energy bills and pays for itself in about a year in our case, but it also conserves the valuable energy needed on a daily basis".

## Pump it up

**An ABB AC drive has been used to upgrade the water supply system at a pharmaceuticals plant in the Czech Republic. The upgrade has produced estimated annual savings of around € 100,000 through reduced energy consumption and major improvements in the reliability and operating lifetime of electrical and mechanical components.**

The pumping station at the plant has three pumps: two 70 liters per second and one 50 liters per second. The supply system pipework has a maximum capacity of 70 liters per second. Prior to the upgrade, the pumps were used in on/off mode with control provided by two pressure switches, with a minimum of 300 kPa and maximum of 600 kPa). Only one pump – selected manually – was run at a time. The system was subject to very frequent start and stop sequences (the maximum time between start and stop

being less than 10 minutes) resulting in damaged motor windings, burnt-out contactors, and deterioration of pipe seals.

The upgrade project, implemented in close co-operation with ABB's local Drives Alliance Partner, involved replacing the existing direct motor control with an ABB variable speed drive.

Following the upgrade, one of the 70 liters per second pumps is kept in reserve. Of the two pumps controlled by the drive's PFC macro, the second 70 liters per second pump is run as a variable speed unit, while the 50 liters per second pump is run at constant speed. Overall control and monitoring is performed by an SLC 500 A-B PLC unit. The InTouch software program provides a screen display of the system's operation. All the features of the PFC macro, including the sleep function and autochanging, are utilized, as is the drive's PID controller.

Operation is now fully automatic and parameters can be set and changed quickly and easily. The pressure in

the system is held constant, there has been a significant reduction in vibration and noise levels, and reliability has improved dramatically. At the same time wear and tear has been minimized.

The use of the AC drive has also provided considerable financial benefits. In the six months before the project, an average of 0.417 kWh of electricity was consumed for every cubic meter of water pumped. This figure fell to 0.299 kWh/m<sup>3</sup> (a fall of 28.3%) for the six months after completion of the project. Total electricity savings in the first year have been estimated at around € 3,800 or 96,000 kWh, and CO<sub>2</sub> emissions are down by 48 tonnes.

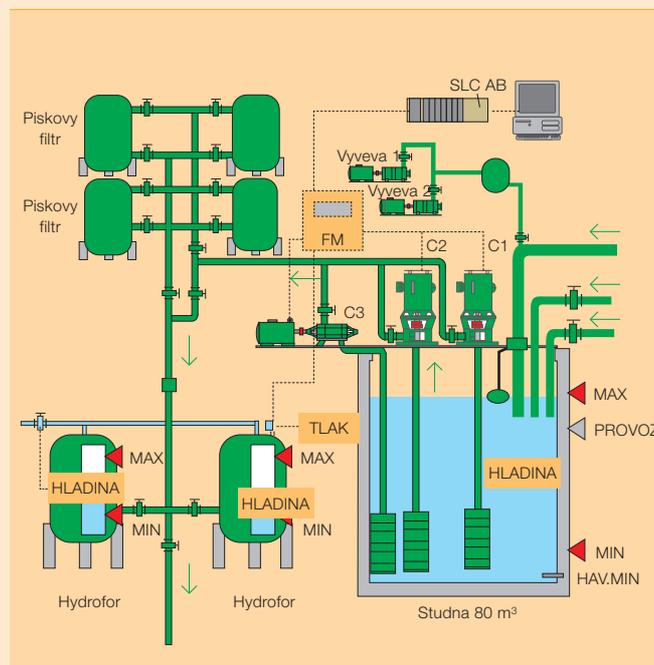
The indirect savings resulting from the upgrade are even greater – in the case of one end user, about € 100,000 per year. This figure is a result of reliable motor operation, significantly reduced contactor failure rate, increased reliability in the pipe system and other components, and reduced maintenance and servicing costs.

## Triple punch

**What do you get if you combine an AC motor, drive, and load cell from ABB? The answer is a new era of electronic, integrated web speed and tension control for small-horsepower unwind applications.**

The products and expertise of three ABB business units – Motors, Drives and Load Cells/Tension Control – have been combined so that an AC motor can be used to replace a traditional mechanical-brake-and-air-supply system. For any processor unwinding paper, film or foil, this solution is a quantum leap in operating, maintenance and cost benefits.

According to Bob Sarnelli, product manager, ABB Inc., Automation Technologies, Web Tension Products, "All the mechanical considerations of



keeping an air-powered brake, and the air line and air supply to them functioning are gone. In addition, the electronic control replacing it erases all those mechanical headaches and provides superior unwind control." The function of the brake is to control the tension of the unwind material in-

to the process. Most configurations use load-cell systems to monitor the web tension, and a setpoint controller that feeds the difference between the desired unwind tension (setpoint) and the measured tension from the load cells to the air-brake control. Air brakes, however, and their air-supply system have many application shortcomings and invariably become problematic as they age.

Since the basic operation of the brake is to apply hold-back force (torque), why not use a motor in a mode that requires force (torque) to turn it? The idea of using a motor as a brake is not entirely new and has been used

successfully in unwinding applications, but mostly in large applications that require high horsepower, ie, above 25hp, such as paper manufacturing where the rolls are extremely large.

Historically, the biggest obstacle to using a motor as a brake on small-

horsepower unwinder applications has been cost. “But with all the recent leaps Variable Frequency AC Drive (VFD) technology has made, the AC drive/motor solution now provides performance and control superior to the traditional DC installations,” notes Chuck Hollis, manager of system integrator sales, ABB LV Drives, New Berlin, Wisconsin.

Because AC drives and motors have continued to add performance features while reducing price per horsepower, AC drive/motor solutions have, according to Hollis, become “extremely competitive with mechanical brakes.”

The performance and cost advantages of using an AC motor-brake system have been proven in a plastic film application. IR Industries in the state of

New York had a two-roll unwinder with two, ten-year old mechanical air brakes and a host of repeating problems. Product quality and production were suffering. Rather than replace the mechanical brakes with a new, more modern mechanical brake, ABB was contracted to install a 5hp AC four-pole motor, a 4:1 gear reducer, and an ABB ACS800 Direct Torque Control (DTC) drive with built-in flux braking.

## Upgrading without investing

**In the city of Turku (Finland) many heating, ventilation, and air-conditioning (HVAC) systems in many of the city’s municipal buildings have been upgraded using an Energy Saving Company (ESCO). In 2004, the HVAC systems in the office of the city’s harbor were also revamped but this time, ABB technology was fundamental to the project’s success.**

Also called “performance contracting” or “third-party financing”, an Energy Service Company (ESCO) de-

velops, installs and finances projects designed to improve the energy efficiency and maintenance cost for facilities over a several-year period. YIT Building Services is such a company and was contracted to do the HVAC projects in Turku. The city itself is not investing anything into energy efficiency, but is paying a service fee – in proportion to the energy cost savings achieved – to YIT.

YIT modernized the air-conditioning system of the city’s harbor office in 2004. Many system improvements were done, but central to energy efficiency improvement was the decision to install ABB drives and eff1-rated motors to the air handling units. The drives enable the ventilation fans to operate at a suitable air flow based on

demand, and eff1 motors guarantee high electrical-to-mechanical power conversion efficiency.

The drives not only save electrical power in part load ventilation conditions, but they also allow for substantial heating energy savings. This becomes possible because the office’s exhaust fan can now be operated at the smallest capacity needed for any situation. During the first five months of the operation, YIT Building Systems recorded a thermal energy saving of 97,865 kWh (234,900 kWh over a 12 month period) which represents a 40% saving in heating costs. Corresponding CO<sub>2</sub> emissions were reduced by 67.2 tonnes.

## Impressive compressor functions

**ABB’s ACS800 drive and custom software is a unique solution when it comes to energy savings and operation efficiency in screw compressors.**

St. Louis-based Curtis-Toledo Inc. is a 150-year-old OEM of industrial air compressors (in the range 5–300 hp) used to power equipment and operations in a variety of applications and industries.

With energy savings a top priority, Curtis-Toledo wanted to upgrade its screw compressors with adjustable-speed drives to provide and control airflow supplies in direct response and proportion to real-time operating (load) conditions. To satisfy the com-

pany’s needs for energy efficiency and ease of use, ABB created a unique control package: the ABB ACS800 drive was built into the compressor and coupled with customized software that controls the system pressure, air delivery, oil temperature and duty cycle directly from the drive.

This innovative approach eliminated separate logic controllers and uses the ACS800 drive to control the speed of the motor. At the same time, its processing power and extensive I/O act like a traditional programmable logic controller.

With a drive built into the compressor as an integral part of the machine, the compressors operate at greater efficiencies. This includes matching air volume to demand as the variable-speed slows the motor down when air demand decreases. Software control enables the drive to regulate and change speed to match the exact air

demands from the plant or process. The ABB drive software was designed to include a formula that continuously calculates the energy savings so the end user can see the dollar savings on demand by viewing a touch screen. “This whole application is about saving energy, so having a touch screen that displays the calculated energy savings as the machine is running is the biggest benefit, followed by its ability to monitor the working conditions of the compressor,” says Jerry Elson, national sales manager for Curtis-Toledo.

End users can expect annual energy cost savings with a 12 to 18 month return on investment on the drive. With a 75 kW machine running 5000 hours per year, energy savings of about 200,000 kWh (50%) have been recorded. This figure may be exceeded depending on the air demands of the facility. Avoided CO<sub>2</sub> emissions have amounted to 100 tonnes.

# Manufacturing challenge

Manufacturing in China is both a challenge and an opportunity

Anders Jonsson

China as a global manufacturing hub is today a concept which many suppliers have taken advantage of, not least ABB. With a century long active relationship with China, ABB today has more than 20 legal entities, of which 17 are joint ventures with local partners. ABB is well established throughout the country. Some XX factories produce high quality industrial and power products for both our divisions – Automation Technologies and Power Technologies.



Thirty-five percent of the Chinese GDP comes from the country's manufacturing sector, which is expanding at a rate of ten to 12 percent annually. (Similar figures for Japan: 23 percent; Germany: 23 percent; and the U.S.: 17 percent). ABB's two divisions in China, are both participating in this sector with several manufacturing sites each <sup>1</sup>. The automation business alone produces and delivers nearly 100,000 products per day through channel partners to the building, transportation, power and industrial sectors of the economy. Its large, engineered automation solutions support productivity improvements and reduce environmental impact in industries such as automotive, chemical, mineral, marine, and pulp and paper. Each of ABB's 8,000 employees is aware of the importance of achieving profitable growth while contributing to economic progress, environmental stewardship and the social development of the country.

In a fast moving economy like China's, remaining competitive is the manufacturing challenge, upon which management must be focused at all times. Operational processes such as sourcing, marketing and distribution, quality and productivity in manufacturing, and cost structures in all aspects of the business must constantly be monitored, optimized and fine tuned for performance to provide superior value to customers and stay ahead of the competition.

In order to stay competitive, ABB concentrates on two major areas:

- To deliver on time and to deliver the functionality that the customer expects.
- To create simplicity, which includes minimizing the number of variants in both purchased components and finished products, while further reducing the number of process steps.

#### Customer choice

Most ABB product areas have been designed in modular fashion, allowing the majority of our customers' wishes

<sup>1</sup> ABB manufacturing sites in China.



<sup>2</sup> ABB has developed educational programs in some factories, giving employees continued on site education.



to be met by combining standardized modules. This approach improves quality and reliability, reduces variants in stock and matches most applications. Wherever possible, variants representing a very small percentage of sales are being replaced by other module or subassemblies.

#### Manufacturing in China

ABB's manufacturing program in China is primarily aimed at fulfilling local demand for products and services. For only a few product areas is export part of the strategy.

The objective is to achieve the right balance of available skills, labor and material costs, logistics, and market demand for every product. It is simply good business sense to put manufacturing and logistic operations as close to customers as possible .

The comparative advantage of China's labor force can be exemplified by hourly pay in the textile business: the hourly wage is \$12 in the U.S., \$5.5 in

Hong Kong and Taiwan and \$0.5 in China. By strengthening skills in low-cost, high productivity countries like China, a new vitality and flexibility is created in ABB's value chain, which helps to meet the local-content requirements that customers in the emerging markets expect from their suppliers.

Any new factory that ABB opens is provided with the latest manufacturing methodology and benchmarked processes so that it can achieve the quality, productivity and energy efficiency goals established for it.

In a country with the world's largest labor force it is a conundrum that it appears that a shortage of skilled labor is emerging, especially in the southeastern coastal provinces. To counter this, some ABB factories offer an educational program allowing selected employees to receive continued education on site <sup>2</sup>.

In this section of this Special Report on ABB in China, articles cover different aspects

of our product portfolio, including a few channel partners. Some success stories are also included, for example, a decade of low-voltage motor manufacturing was recently celebrated.

#### Success factors

Internal simplification and pragmatic approaches combined with responsibility, respect and determination for our customers' needs have created a solid base for future growth in China. A comprehensive portfolio of locally manufactured products, combined with local engineering and service capabilities, ensures ABB's long-term future in China as a key supplier of productivity solutions with low environmental impact.

#### Anders Jonsson

ABB (China) Ltd.  
Shanghai, China  
anders.jonsson@cn.abb.com

# Transformed

ABB's power transformer factory in Chongqing

Anders Lindroth

Chongqing is a modern city with an ancient history spanning more than 3,000 years. Known by many as the "River City", Chongqing is where ABB produces the largest 500 kV power transformers for the domestic market in China. This ultra modern factory has been supporting China's fast growing electric power industry since beginning production in 1998. In addition, it has developed into one of the largest power transformer factories in the world – in just six short years



The electric power industry in China has grown impressively since the 1980's. In particular, economic development in the area around the Pearl River and Yangtze River Deltas has contributed enormously to the quick expansion of the electric power grid. The eastern and southern coastal areas continue to consume the largest amount of electricity, while abundant energy resources are located in northern and western China. It is this that is driving the construction of 500kV power transmission lines between those regions.

As power transformers are key equipment in any electric power systems, the demand for exceptionally good quality products is naturally high to support the extension of power grids

and power plants. This became especially evident at the start of the Three Gorges project in the Yangtze River in 1992 where large, high voltage power transformers with high reliability were needed.

In a region with huge market potential, the necessity of creating an advanced transformer factory in an area with river and sea access soon became clear in order to meet the demands for these types of large power plant projects.

As a renowned supplier of transformers, coupled with its reputation and experience in transferring transformer technology – for example to Canada and Brazil – ABB was selected as one half of a partnership, or joint venture,

to set up a 500kV power transformer factory in the city of Chongqing, in southwest China.

Chongqing is situated on the upper branch of the Yangtze River and is one of the most important industrial centers in western China. In choosing Chongqing as the location for this big transformer factory, the plant is well positioned to supply large power transformers to the coastal areas via the Yangtze River as well as to hydropower stations in southwestern China.

#### Formation of the joint venture

ABB, with the help and support of the Chinese government, set up a production base for 500kV power transformers in Chongqing to support the Three

Gorges project and other big power generation and transmission projects in China **1**. Now known as ABB Chongqing Transformer Company Ltd., it is the only joint venture for the manufacture of 500kV transformers approved by the Chinese central government, and is owned by ABB and Chongqing Transformer Company Ltd.

In operation since January 1998, the plant utilizes the land and buildings of a former state-owned local transformer factory in Chongqing.

**Transfer of technology and training of employees**

Perhaps the biggest factor that has contributed to the overall success of the company has been the successful training of employees and the subsequent transfer of technology. Most of this work, together with internal support for this project came from ABB's transformer factory in Ludvika, Sweden.

Training was carried out in Ludvika in parallel with investments in factory upgrades in Chongqing. An intensive and effective training program, based on the manufacturing of transformers from design to final testing for Chinese customers, was used as a learning tool for managers, engineers and operators from ABB Chongqing. The Chinese personnel, under the guidance of Swedish experts, completed the program in a "100 percent ABB atmosphere". The exercise was known as "CPiL", an abbreviation for "Chinese Production in Ludvika".

As training progressed in Sweden, the old workshops in Chongqing were being revamped to bring them into

line with the latest ABB specifications. A 500 kV transformer assembly workshop was added to the existing factory buildings and a high voltage test hall, with modern equipment to test 500 kV and 750 kV class products, was erected **2**. All manufacturing facilities were up-graded with state-of-the-art manufacturing equipment and tooling, and the workshops were equipped with air conditioning and humidity control. All this work was completed in 2000. In 2001, the road to Chongqing harbor was prepared for heavy transport and the harbor was equipped with a 400 ton floating crane to support the shipment of products to the customer **3**.

The final part of the CPiL program was completed in the upgraded facilities in Chongqing. In addition to CPiL, many other training programs, managed by ABB, have helped the employees in the Chongqing factory adopt ABB management principles and processes.

**From 800 to 25000 MVA annual transformer production**

In December 1998, the design, manufacture and testing of the first 110kV TrafoStar transformer in Chongqing was completed. The following year saw the delivery of the first six 220kV transformers, and in 2000 the first four 500kV transformers were delivered. After that, volumes started to rapidly increase. The table below details the annual production volumes during the short history of the company.

In 2003, high voltage shunt reactors were added to the production program and the first twelve 500kV reactors were manufactured. Over the last

six years, the company has developed into the largest power transformer manufacturing company, counted in MVA production volume, within the ABB group.

year	Production volume MVA	Production volume units	500 kV units
1999	842	14	-
2000	3665	50	4
2001	5540	53	9
2002	10183	70	29
2003	16807	89	56
2004	23968	102	66
2005	29921*	127*	75*

\* According to production plan 2005

**Quality**

The focus for ABB Chongqing was to establish a factory that manufactures large power transformers to the highest international quality level. Quality control has therefore been a top priority during the investment and technology transfer phases. In 1999, ABB Chongqing passed a quality audit performed by the international auditors Det Norske Veritas, and in December of the same year the company was awarded its ISO 9001 Quality System Certificate. Since then ABB Chongqing has also been certified according to the environmental standard, ISO 14001, as well as to the Chinese occupational health and safety standard, OHSAS 18001.

Like all ABB power transformer factories, ABB Chongqing is using the Six Sigma methodology to measure and control the quality of its operations. Using this methodology:

- The quality of the product is measured in a large number of the production steps.

**1** ABB's power transformer factory in Chongqing, China.



**2** A high voltage test hall for 500 kV and 750 kV class products.



3 A 400 ton floating crane at Chongqing harbor to support the shipment of customer products.



- The measured quantities are compared against target values to determine the given tolerances and the DPMO-value (defects-per-million-opportunities).
- These DPMO-values can then be converted into Sigma values to give an overall measure of the quality level of the product.

4 shows the development of the Sigma value for ABB's Chongqing operations from 2000 to 2003. With an industrial standard value of typically 3.5, it can be seen that the quality level of the ABB Chongqing operations shows very good improvement over time and is currently well on par with other industrial leaders.

The real test of product quality is of course its performance during operation. To date, all power transformers manufactured at ABB's Chongqing factory have and continue to perform very well in Chinese power plants and various substations. The high quality and high performance products produced by ABB at the Chongqing plant have given the company an excellent reputation within the Chinese Electric Supply Bureaus and grid business.

**Customer confidence**

ABB Chongqing has today gained the full confidence from its Chinese customers. As a sign of that confidence, the company has been trusted to supply the 12 generator step-up transformers to the right bank of the prestigious Three Gorges hydropower station. The transformers are rated 840 MVA, 550/20 kV.

The company has also been approved as supplier to Singapore Power Grid

company and has got an order to deliver 15 off 400/230 kV single-phase auto connected transformers to be installed in Singapore.

Transformers from the Chongqing factory are today installed in many key substations in China. One of these is the 500 kV substation in the fast growing Pudong economic developing zone in downtown Shanghai. This substation is equipped with two 1000 MVA banks of single-phase auto-transformers. The transformers are rated at 334 MVA, 510/230±2\*2,5%/36 kV. In order to meet strict environmental requirements, the cooling of the transformers is designed as ONAN/ONAF, ie, self-cooling by air up to 67 percent of full load and thereafter forced air-cooling by fans. ABB Chongqing completed this order, from the contract right through to commissioning, within just one year.

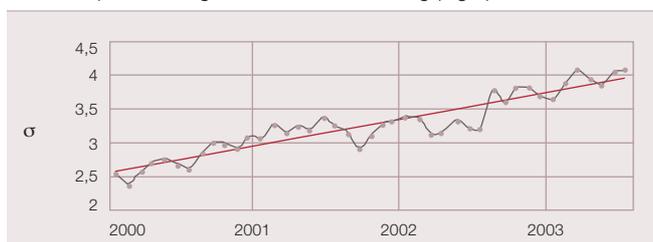
Steam turbine generators produce more than three-quarters of the electricity in China today. Together, 600 MW generators and 720 MVA generator step-up transformers are commonly used in thermal power. Three phase transformers are preferred when transport facilities permits. ABB Chongqing was awarded a contract to deliver 4 units of this type of transformer to a new power plant in the city of Jiaying,

which is situated on the border between Shanghai and the Zhejiang province. Using this project as a reference, ABB Chongqing has received more orders for similar transformers, thus making it one of the major suppliers of large generator transformers in China.

These examples show that, within only six years, ABB Chongqing is now capable of manufacturing transformers of the highest quality up to the highest ratings required in the Chinese power system, using the highest ABB quality level.



4 Development of Sigma value for ABB Chongqing operations.



**Anders Lindroth**  
 ABB Chongqing Transformers Co.Ltd  
 China  
 anders.lindroth@cn.abb.com

This article was first published in ABB Review 3/2004 pp 50-53

## 750 kV generator step-up transformers and shunt reactors made in China



ABB owns transformer factories all over the world. Based on a common pool of knowledge, experience and design guidelines, these factories work synergistically rather than independently. This was clearly demonstrated when the ABB transformer factory at Chongqing was called upon to supply 800kV transformers and reactors: The factory has not produced anything for this voltage class before. By drawing on ABB's global network of expertise, however, it will be able to engineer and build these units without any special development work. A product is created for local manufacturing in China that meets the high quality standards that ABB's customers have come to expect.

The growing demand for transmission capacity in China has led to the decision to build a 750kV grid. A pilot link is under construction and tenders for generator step-up (GSU) transformers and shunt reactors are being evaluated. To encourage the development of the domestic transformer industry, the customer has stipulated that the transformers must be manufactured in China.

#### The project

China's first 750kV AC transmission project is an investment by the central government and is being implemented by the State Power Northwest Company. A grid will be created in five phases over a period of 15 years. When complete, the system will comprise a total of 3813km of lines and a combined transformer capacity of 16.5 GVA.

One of the power sources for the network is the Laxiwa hydro station in Qinghai province – located on the upstream part of the Yellow River. The power station will have six generators. These will be connected to the transmission system by 18 single phase 260 MVA GSU transformers. Three 100 MVAR and three 70 MVAR single phase shunt reactors must also be supplied for this phase of the project.

#### ABB Chongqing

In the last few years, ABB Chongqing Transformer Co. has grown to be one of the major suppliers of 500kV transformers and shunt reactors in China. The factory's reference list includes 184 transformers and reactors delivered for this voltage level. It has more than 70 further units on its order books, including 12,840 MVA GSU transformers for the Three Gorges Right Bank Project.

ABB Chongqing Transformer Co. is one of China's most widely recognized transformer manufacturers and regarded as a preferred supplier by the majority of customers in China.

#### Technology

Although ABB Chongqing has not built 800kV transmission system equipment before, the technology is far from new to ABB. Other ABB factories have built such equipment, and design and dimensioning rules are covered in the ABB transformer design concept: TrafoStar. Having full access to all expertise and the experience within the ABB group, development work is not required at Chongqing. The units are dimensioned and designed by local engineers using ABB design rules. Their work is then checked and the designs verified by experts within the group.

#### Manufacturing and testing

The manufacture of this 800kV equipment does not present any major novelties for the Chongqing factory. The core and winding types used are the same as those of the 500kV equipment. The physical sizes of the components are also within the dimensions of those normally handled. To be able to successfully manufacture transformers and reactors for 800kV, very strict quality assurance procedures are required. However, the factory has already implemented these procedures in order to secure the quality of its 500kV equipment.

The test lab at ABB Chongqing is able to test the GSU transformers for this project and no further investments are required. The 100 MVAR rating of the shunt reactors, on the other hand, is higher than what the present test equipment can handle. To be able to test at the higher rating, a small extension must be added to the reactive power compensation capacitor bank.

#### Summary

Although the requirement for 800kV transformers and reactors is new to China and to ABB Chongqing, the company is able to design and manufacture these products to a high quality requirement.

# ABB intelligent power distribution system

Anny Wang, Anders Jonsson

Due to the relatively stagnant power generation and distribution development in Mainland China, the ongoing economic growth is increasingly leading to power shortages. Traditionally, this issue was addressed by government mandated power outages and consumption restrictions. This led to productivity shortfalls for industry. As liberalization progresses, more user friendly power system management and power distribution technology is required. This does not only apply to power suppliers: Power consumers must be able to control local power distribution. This need led to the development of ABB's intelligent power system (IPD).

1 E-Series switch.



2 S-Series switch.



## Components

The following devices are used in an IPD system:

### intelligent switches

The E 1 series and S 2 series are rated for currents of up to 6300A and 3200A respectively.

### PMC916 power supervision & control device

PMC916 3 is an omni-directional supervision and control device for a single line application.

The PMC916 has four passive relay outputs with which it can directly act on other devices such as switches.

### Distributed RTU

ABB distributed Remote Terminal Units (RTU) 4 collect switch signals, analog signals, relay output and pulse statistics.

### Motor integrated management devices

These units 5 integrate motor protection functions. They recognize motor controls and startup modes and supervise motor operations.

3 PMC916 control device.



4 Remote terminal unit (RTU).



5 Motor integrated management device.



## Configurations

### Typical configurations for ABB intelligent power distribution systems

#### Configuration 1:

**6a** Input lines data passes through the E switch field bus interface. For the S switches (on the output lines) PMC916 units are used.

#### Configuration characteristics:

- (+) One intelligent unit on each output circuit: strong functionality and high distribution efficiency.
- (-) High cost due to large number of components.
- (-) Heavy workload for higher management system due to large number of devices being monitored.
- (-) Some functions unnecessarily duplicated, such as voltage and frequency monitoring.

#### Configuration 2:

**6b** As configuration 1, except that the S switches on the output lines share MC bus interfaces, current signal collection and remote control through distributed RTU.

#### Configuration characteristics:

- (+) Intelligence unit configuration closer to the actual needs of the power system.
- (+) Higher cost-benefit ratio.
- (+) Higher management communication system deals with fewer connections.
- (-) Switchgear shares communications units, so less suitable for distributed applications.

#### Configuration 3:

**6c** When many motor are attached, the higher management system must concentrate on controlling these. A combination of configurations (1) and (2) is applied so that each output line gets the monitoring level it needs.

#### Configuration characteristics:

- (+) Intelligence unit configured according to actual needs of power system.
- (+) More functions and high cost-benefit ratio.
- (+) Concentrated management of the motor systems.

It is the purpose of intelligent power distribution systems to monitor the state of local networks and to autonomously or by operator action take preventive measures when certain parameters are exceeded. In this way local disturbances can be contained. Ideally, a system first tries to remedy the problem, and if this fails, it shuts down a local area of the network. This way, disturbances are prevented from spreading to other processes in the plant.

The components of ABB's intelligent power distribution communicate with a higher level management system. Switching commands can be sent remotely, and device statuses inspected. Besides the operational state and basic parameters, such data covers (where appropriate) measurements of current, voltage, frequency, power factors, temperature and humidity.

The communication uses a bus interface such as RS485/MODBUS, or TCP/IP. ABB's intelligent power distribution system is based on two principles: a reliable power distribution system and an intelligent data collection and control system.

### Application for ABB intelligent power distribution

Intelligent power distribution systems are becoming increasingly common in the power industry as the need for direct power management increases. The strength of ABB's systems is being increasingly recognized by industry. From March 2004, the largest producer of automotive glass in China, Fu Jian Fu Yao Glass Group, placed several orders for ABB low-voltage switchgear incorporating PMC916 (Power Monitoring & Control Unit). In the space of a year, they awarded ABB eleven contracts worth around

US\$ 4 million (RMB 34 million). This equipment is used in the manufacture of high-quality float glass; the main material used in automotive glass.

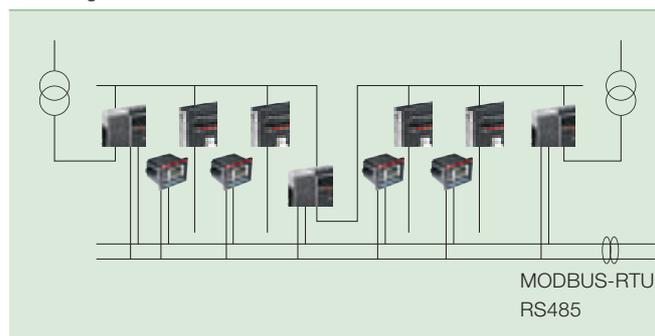
ABB intelligent power distribution systems are also used in many key State projects, such as the Hainan Fertilizer Project, with investors from CNOOC, the Ji Lin Alcohol Project, and many power plants, such as Bei Hai and Yu She.

In all these applications, this technology ensures production efficiency and helps increase the reliability of production equipment.

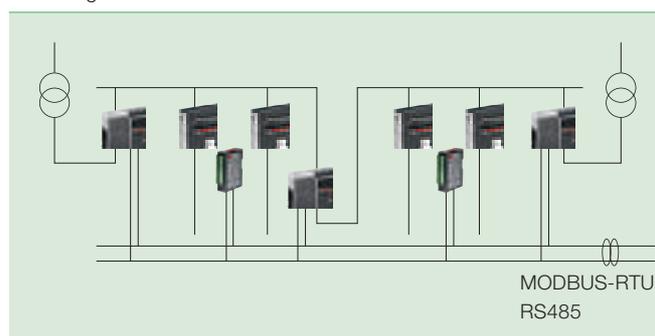
**Anny Wang**  
**Anders Jonsson**  
 ABB (China) Ltd.  
 Shanghai, China  
 anders.jonsson@cn.abb.com

**6** Examples of IPD configurations.

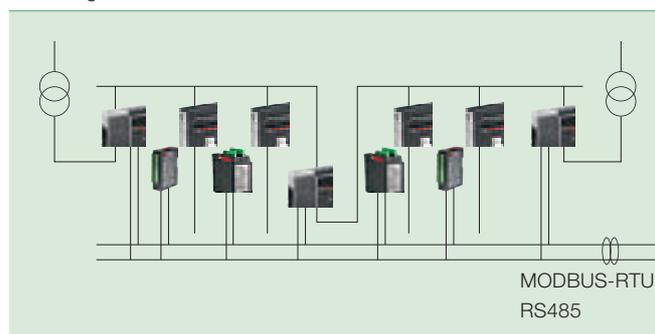
**a** Configuration 1.

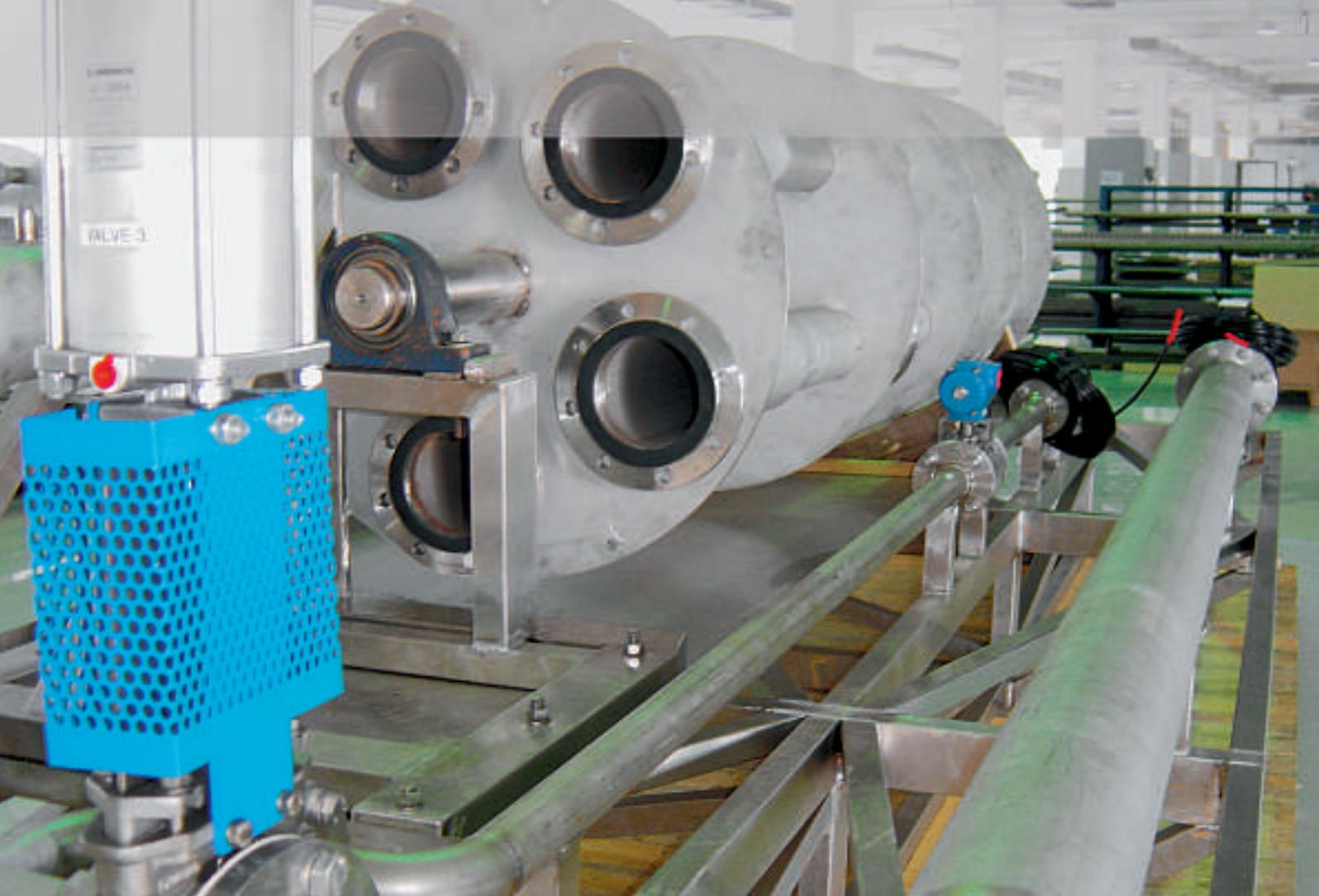


**b** Configuration 2.



**c** Configuration 3.





# Calibrating precision

New flow and pressure assembly lines for ABB Instrumentation China

Richard Suurland

To be effective, a control system requires accurate data on the system parameters. This in turn requires precise process data and reliable measurement and calibration equipment.

When the process involves moving fluids, flowmetering equipment is required. ABB Instrumentation has installed a new PT (pressure transmitter) assembly line and flow production and calibration facilities in Shanghai, China.

The entire pressure production line was imported from Italy. The line produces the 2600T pressure transmitter range including the models 264DS, 264PS, 264HS and 264GS. It delivers up to 900 units per month on a single shift. Critical components such as transducers are imported from Germany and Italy and assembled and tested locally. The first commercial transmitter rolled out in 2004. Now, only a few months later, several hundred local transmitters are serving customers throughout China.

To better satisfy customer expectations, ABB's new assembly plant in China offers customers two-week delivery for the standard version of the 2600T pressure transmitters. David Guan, project supervisor at the new assembly plant in China, proudly points out that the same quality standards are ensured as at the ABB pressure factories in Lenno, Italy and Minden, Germany. Combined with an SAP system, the new PT line supplies "made in ABB" products and services delivering customers advanced solutions for safe, reliable and economical performance.

### Accurate calibration – a quality measure

ABB has just completed the commissioning of three new calibration rigs and flow production lines for the instrumentation plant. The calibration rigs designed at ABB's factory in Stonehouse, UK, are needed in China to help meet the rising demand for flowmetering equipment. Precise calibration is a quality measure hence ABB has decided to keep this important service in-house.

The first unit is due to become operational in early 2005 and will be used to calibrate meters sized between 15mm and 50mm and with a flow volume of 20 liters per second. Although designed to calibrate primarily electromagnetic and vortex meters, it can be used to calibrate almost any type of flowmeter. The second of the calibration rigs will calibrate flowmeters sized between 65 mm and 150 mm and flow rates of up to 200 litres per second. The third and final rig will handle flowmeter sizes of 200 mm to 600 mm.

Built to the same ISO standards as ABB's existing flow calibration rigs around the world, they feature a "carousel" enabling up to three flowmeters to be calibrated simultaneously. The calibration process is fully automatic. Specially developed software runs the process and collects the calibration data. This provides a highly flexible unit loading range and removes one of the potential bottlenecks in typical flow production.

The new rigs incorporate both a master meter and a weigh scale as reference devices. These devices provide a known value against which flowmeter

measurement performance is compared. By calibrating the master meter against the weigh scale, the rig operators can ensure the continued accuracy of the rig. This flexibility in calibration means that the new rigs can meet all of the main global standards for flow calibration.

The weigh scale system on the large calibration rig is 12,000 kg making it the second largest calibration rig / weigh scale system in China. This, coupled with a resolution of 1 kg (can be enhanced) means that ABB China is serving the local market with a world class calibration facility complying with many international standards.

Bernd Kamman, international manager for ABB's flow products unit, explains that the construction of the flow rigs marks the continuing development of ABB flowmeter calibration service around the world. With the construction of these and other new rigs, the company hopes to be able to set a single standard for flow calibration at ABB sites worldwide.

ABB operates some of the world's most accurate flow calibration facilities. A recent visit by the United Kingdom Accreditation Service (UKAS) of ABB's flow calibration facilities at its Stonehouse factory in Gloucestershire, for example, resulted in ABB being certified as the only company in the UK with a calibration rig accurate to within an expanded uncertainty of  $\pm 0.027\%$ .

### Demand for increasing accuracy

The company spends considerable time and money constantly improving the accuracy of its flow equipment in

order to keep up with customer demands. Even though ABB's flow calibration rigs set a global standard for accuracy, the company continues to strive for even better performance.

The reader might be wondering why customers demand more and more reliability and accuracy from their flowmeters. One of the principle reasons is the growing demand for quality drinking water. The demand for water is growing faster than the capacity of the networks to supply it. Also, in many countries around the world, over 60% of drinking water pumped into the distribution network does not reach the user but is lost through leakages. In other words, for every 1000 liters of water treated, 600 are wasted through leakages. The tackling of this issue presents considerable potential for cutting costs and enhancing sustainability while delivering more water to the end user.

ABB is making many contributions towards solving these issues: These range from the Aquamaster – a battery operated flowmeter designed to measure very low flow rates such as those from leaking pipes – through variable speed drives optimizing pump operations to prevent the undue pressure that encourages leakages, to complete control solutions such as the ABB Water Leakage Management System that helps control, monitor and reduce leakage over a complete network.

### Richard Suurland

ABB (China) Ltd.  
Shanghai, China  
richard.suurland@cn.abb.com





# Motors power efficiency

A decade of high efficiency,  
low voltage motor manufacturing in China  
Javis-Li Xu, Ko-Hein Chai

Cutting power consumption in manufacturing is an important objective in relieving pressure on infrastructure and the environment. ABB electric motors are designed for high reliability and efficiency – an example that other motor manufacturers are now striving to emulate.

China's economy is today in the global limelight. It has robustly withstood the Asian financial crisis and is continuing its rapid growth. China's low-cost labor – a competitive advantage – is making China the manufacturing base of the world. The rapidly improving living standards have sparked an increased demand for and dependency on energy. In 2004, China became the largest energy consumer after the United States. Since 2003, China has been struggling with energy shortages on an almost daily basis. Meanwhile, the greenhouse effect and global warming have raised awareness of environmental issues and the need to limit emissions. In accordance with the Kyoto Protocol, which came into effect on January 1st, 2005, China will implement emission limits and take measures to progressively reduce emissions. Energy efficiency and sustainable development have now become government policies.

The electric motor is the most common source of mechanical energy in industry. Motors consume 60% of power generated. Even small gains in energy efficiency thus have an important effect.

After ten successful years of growth and innovation in motors, ABB is looking to the future with confidence.

#### Efficient motors power new trend

As early as 1998, ABB Shanghai Motors introduced the European efficiency level concept. The company developed and launched the M2QA series, which meets the European efficiency 2 standard; its average efficiency performance is 1.5% higher than comparable products from China. The installed base of ABB's LV motor technology saves Chinese customers 1.5 billion kWh of energy annually.

In recent years, ABB Shanghai Motors has been increasing its market share in China. It is also exerting a stronger influence on energy- and environmental-conscious thinking. Chinese motor manufacturers are following this lead and they are currently developing and launching high-efficiency energy-saving products.

ABB Shanghai Motors is continuing to introduce advanced designs and new concepts. It is creating a general platform for design and production. This will combine the standardization and generalization of motor parts with the special demands of customers. Step by step, motor design and production will evolve towards a modular platform. This will shorten production times and thus better meet customer needs. This approach permits standard motors to be modified to meet special customer needs, while also increasing the efficiency of logistics and distribution. The latter leads to improved internal operational efficiency.

#### Motors life cycle cost

ABB Shanghai Motors upholds a core company culture policy: To create value for customers and to commit to a continuous improvement of quality. It is a well known fact that the motor's purchase price accounts for only a small part of its life cycle cost, including the costs of malfunctions. This is even more correct when the motor is used in a highly critical application. For an OEM (Original Equipment Manufacturer), the good name of a brand and the quality of the product is closely linked with the reliability of the motors used. ABB Shanghai Motors always chooses high quality raw materials: silicon steel, enameled wire, shaft steel, high grade casting iron, L1 bearing, environment-friendly insulation varnish and surface painting. This combined with the advanced manufacturing technology and strict quality control lead to the high reliability of ABB's motors.

With the expanding reputation of ABB motors in China, more and more motor manufacturers are attempting to follow ABB's example: They are moving towards energy-efficient, energy-saving and high quality motors. Meanwhile a consensus is being reached that production processes must comply with the requirements of OSHMS/EMS (Occupational Safety and Health Management Systems / Environmental Management System). Motor manufacturing in China is on track for sound and sustainable progress!

Javis-Li Xu

Ko-Hein Chai

ABB Shanghai Motors Co. Ltd.  
javix-li.xu@cn.abb.com

## 10 years of ABB motors in China

On April 25th 2005, ABB celebrated the tenth anniversary of its motor activities in China. 350 participants – 250 of them customers – took part in the festivities. These included tours of the factory, a series of seminars on covering different aspects of ABB motors and their applications, and a banquet to round off the day.

Some customer quotes obtained during this event are reproduced below:

Sato Shigeru of Japanese Daikou Mechanical Equipment said "[This] factory is not that large. It is, however, very orderly despite the hundreds of customers visiting simultaneously. I am impressed that despite them, the plant is keeping production at the usual level."

Xun Jingcheng of General Motors in Yunnan Sitaicheng said "the event reflects well on ABB's as a motor manufacturer."

After ten successful years of growth and innovation in motors, ABB has firmly established itself in this business and is looking to the future with confidence.



# Low voltage equipment

Modern LV energy efficient equipment is finding a home in businesses and residences.

Growing domestic welfare is contributing to a growing demand for distribution-side electrical infrastructure. The following three stories are examples of ABB low-voltage technology at work in China.

## Meeting customer requirements with an automated manufacturing process

**Customers expect consistently high quality products at competitive prices and short delivery lead-time. ABB Xinhui is making this possible by developing automated production lines with fast version change capabilities.**

The automated production line for magnetic cores, which is used in the manufacture of ABB's A-series contactor, clearly demonstrates the production capabilities created at ABB Xinhui low voltage switchgear factory. During the design phase, considerable

attention was given to ergonomics and to creating a working environment that minimizes workers' fatigue. This led to customer benefits by raising production volumes, while at the same time improving yield and quality and so keeping re-work costs low. Many customers order several product models and versions with a requirement of the same delivery date for their entire order. The ability to change versions quickly on the production line has placed ABB in a position to fulfill these expectations.

The core competency of manufacturing A-contactors relies heavily on the process of manufacturing the magnetic circuit core.

In-house production investment has improved the stability and reliability of the supply chain. Reduced need for transportation reduces delivery times while also avoiding the risk of damage to components during shipping.

The automated production line was completed three months ahead of schedule – in only five months – surpassing all expectations.

ABB's top-selling products such as Contactor, ArTu, Pilot devices, and Circuit Breakers see widespread use and are in great demand. A quick turnaround with the highest quality is needed to satisfy customer expectations. By continually monitoring and improving production processes ABB has been able to maintain quality standards and meet customer needs.

**Johnson JuanSheng Kee**  
johnson-juansheng.kee@cn.abb.com



## MNS increasingly appreciated by customers

The MNS system fully meets IEC Type Test requirements – as certified by the National Switchgear Quality Control and Inspection Center in Tianjin. The switchgear, which is rated to 6300A, was subjected to and passed tough tests including the temperature-rising test, the arc-fault proof test,

**Low voltage MNS switchgear is finding more and more applications in China's growing industrial base ABB Xiamen Low Voltage Equipment Co. Ltd. has been producing MNS-type low voltage switchgear since 1994, based on the latest technology from ABB in Germany. This product has gone through 10 years of technological evolution advancing to its current highly sophisticated and intelligent design.**

vibration test, aging test, saline humidity test and insulation materials test. Moreover, besides these remarkable strengths, the intelligent MNS switchgear allows customers to maximize productivity through its reliable operation, safe production, ease of operation and maintenance and com-

pact configuration options – saving space and reducing installation costs.

Besides meeting the IEC Type Test requirements, ABB's MNS system was the first such system to be awarded the China Compulsory Product Certification (CCC) – in December 2002.

MNS has achieved a reputation for reliability and dependability in the low voltage market. It is widely applied in the field of power generation, distribution and transmission in industries such as nuclear applications, metro, chemical, oil & gas, pulp & paper, electronics, telecommunications and commercial construction – applications where ABB China has accumulated extensive and profound experience. Using the latest network and communication technology know-how, ABB has developed an Intelligent Motor Control Center System (INSUM) and the ABB power distribution Control & Energy Management System (ESD) to meet the automation needs of customers. A combination of MNS+INSUM or MNS+ESD provides an attractive and reliable package that is increasingly appreciated by users.

The BP Zhuhai Petrochemical Project is a good example of such a combination, in this case MNS+INSUM. The project represents a key investment by BP in the Chinese petrochemical sector. The main product is PTA with a designed annual production capacity of 450,000 tons. This will meet the bulk of the increased market demand following China's entry into the WTO. The intelligent system used in this project was the INSUM system, which integrates with MNS withdrawable switchgear to ensure fast, safe and reliable communication. In addition, the close coordination of INSUM and the customized DCS gives the operators the power to easily control continuous production from the control room.

Besides supplying high-quality products, ABB is dedicated to providing an all-encompassing service portfolio. Following the commencement of the BP Zhuhai Project in 2000, ABB engineers worked at the Zhuhai site for 3 years – until the project was complete. They supplied technical support for the customer and assistance including installation guidance, design modification, emergency handling preparation and energy commissioning. ABB China is highly appreciated by the contractor, Technip, and the end user, BP Zhuhai, for its excellent products and service.

Furthermore, China National Offshore Oil Corporation (CNOOC) and Royal Dutch Shell Ltd. also chose the MNS+INSUM intelligent system for their US\$ 4 billion investments in manufacturing petrochemical and chemical products (see also “ABB Xiamen Switchgear receives award from Shell”, page 26 of this Special Report). When all intelligent low voltage equipment was delivered on time by the end of 2004, ABB was awarded a project appreciation certificate by one of its contractors, the JGC Company. Mr. K Yamazaki, a project manager from JGC said, “ABB is a worldwide brand, and we are very pleased with ABB's performance. The best technology available along with good service we have gotten from ABB was the key to the successful completion of the project”. Meanwhile, the MNS + ESD intelligent system combination is also finding new applications. Beginning in March 2004, the largest producer of automo-

tive glass in China, the Fu Jian Fu Yao Glass Group placed several orders with ABB for low-voltage switchgear incorporating ESD Power. In the space of one year, they awarded ABB eleven contracts worth around US\$ 4 million (RMB 34 million).

In China, there is at present rapid growth in automobile production. Accordingly, the demand for high-quality float glass is increasing sharply (a large proportion of automotive glass is float glass). To meet this mounting demand and to break into the international market, Fu Yao Glass Group will invest about US\$ 2 billion to set up three float glass production lines. The MNS+ESD systems will go to two of Fu Yao Glass Group's float glass lines with a daily output of 600 tons each.

The MNS+ESD combination is also used in many key State projects, such as the Hainan Fertilizer Project, with investors from CNOOC, the Ji Lin Alcohol Project, and many power plants, such as Bei Hai Power Plant, and Yu She Power Plant. Many customers, such as the Fu Yao Glass Group, are returning ABB China patrons.

From the market feedback received, the intelligent combination of MNS and INSUM or MNS with ESD is in line with the development of the power industry, and ABB believes these combinations have bright application prospects.

**Anny-YaHui Huang**  
anny-yahui.huang@cn.abb.com

MNS + INSUM switchgear.



MNS + ESD switchgear.



## Improving the power supply to homes in China

**It is not only China's industry that is undergoing rapid development. Improved affluence and higher standards of living are leading to higher electricity consumption in households. To meet the demand and handle the growth sustainably, innovative technology is being developed by ABB: An IC card equipped electricity meter is permitting accurate billing. A new generation of low-voltage breakers is making electrical installations safer and more reliable.**



**D**rawing on its advanced technology in the field of miniature circuit breakers (MCB), ABB is supporting the Beijing Electric Power Corporation (BEPC) in the upgrading of their electricity network. ABB designed the S250S+TS series MCB for an IC card equipped electricity meter. Cooperating with BEPC, ABB completed the project of using the meter to upgrade domestic installations, so facilitating measuring and billing in residential buildings and small businesses.

The continuous rise in living standards in China has caused the demand for domestic electricity to rapidly increase. In 1998 BEPC faced two major challenges in domestic electricity distribution. The first of these concerned the ageing of cables which was both leading to dangerous situations and to a reduced network capacity as compared to modern installations. The second problem concerned metering. With several families sharing one meter it was difficult to bill each family fairly.

As a well-known manufacturer of low-voltage electrical equipment, ABB was selected as leading supplier. The company's advanced technology, reliable quality and dedicated service contributed to this decision. The S250S series MCB, manufactured by ABB LV Installation Materials Co. Ltd. Located in Beijing, is designed for over-current protection on consumer electricity systems. Early in the development

process, BEPC encountered the problem of contact point melting or burning in the relay, when short circuit currents were conducted through the meter. ABB and BEPC engineers performed a detailed analysis of the entire design project. They suggested a solution using a specially designed MCB. Under defined conditions, the meter sends a signal to the MCB causing this to switch off. BEPC accepted this scheme. ABB completed the prototype design, sample products and type testing in a very short time. In this way, a special MCB design came about; designed specifically for the electricity meter with break delay



function. A national patent for this product and the break delay function was applied for in July 1999 and granted in July 2000.

In the following years, and in the light of experience gained with the system, several design improvements have been implemented. Until now, these products remain unique among all the offerings for the electrical supply of urban residential buildings and small businesses in Beijing. Until the end of 2004, 2.17 million poles of the S250S +TS miniature circuit breaker were manufactured by ABB and used to upgrade existing installations or installed in new buildings throughout Beijing.

About 80 years have passed since ABB STOTZ invented the MCB. ABB is still leading in the development of domestic distribution equipment of which the MCB is a typical example. With their unique design and good performance due to the use of, eg, highly insulating thermosetting materials, highly reliable metal integrated tripping mechanisms and ergonomic wiring terminals, ABB products bring safety and convenience to electricity installations across the globe.

**HongYu Hu**  
hongyu.hu@cn.abb.com

# Committed to China

ABB's new corporate research center  
Christian Rehtanz

Research and development is the lifeblood of any technology company. ABB has throughout its history shown a strong and uncompromising commitment to research. The company understands that today's R&D is tomorrow's market success. But success in research does not come from spending alone; research must be focused on the products and markets of tomorrow. By establishing a research base in China, ABB is better equipped to understand and serve China's future.



新的集团研究中心成立——ABB对华发展承诺的里程碑  
New Corporate Research Center: Underlining Our Commitment to China

ABB invests around 5 percent of its revenues on R&D every year. That means about \$1 billion in 2004. A significant amount of this goes to the various corporate research centers in Europe, the US and Asia. On March 30, 2005, ABB opened its newest research center – in China.

**Research in China – for the world**

The attractively low operating costs of research in China were a factor influencing the decision to open a research center here, but this was not the most significant reason. ABB is firmly committed to being part of China’s economy. To be able to maintain and improve its position, the company must both support and benefit from the country’s highly qualified brainpower: ABB was able to recruit top graduates from China’s leading universities.

Success in China requires innovation across the whole spectrum: new ways of working with partners, new concepts of value chain management, new assessments of materials, intelligent application of design for manufacturability, system design with high functionality at low cost, and much more.

A more market-oriented approach to R&D means ABB is working more and more closely with its customers to jointly develop new products and services. This permits ABB to respond to customer needs quickly and with

1 The presentation of ABB scholarships at the opening ceremony of the new research center.



commitment. Given the increasing quality of production facilities in China, it makes sense to conduct process R&D close to these facilities. It also allows ABB to develop solutions tailored to local needs and to understand local challenges and contribute to the emergence of suitable standards.

**University and international collaboration**

The new research center has already initiated several collaboration projects with Chinese universities. Some of China’s brightest young brains are helping define ABB’s products of tomorrow.

During the center’s inauguration ceremony, three ABB international post-doctoral scholarships – permitting Chinese graduates to spend between six and 24 months in one of ABB’s other Research Centers – were presented. This underlines the company’s commitment to international cooperation and knowledge sharing.

Business increasingly demands the integration of different disciplines. Continuous collaboration and exchange of information with ABB’s other research centers around the world mean ABB’s China researchers remain part of the company’s cutting edge technological development with-





out losing sight of the local application.

### Innovation – the lifeblood of ABB

The most important driver for opening a Research Center in China, however, is innovation. Innovation is the lifeblood of ABB and the key to its success. Innovation means doing things in a different, and a better way. Simply transferring R&D concepts from Europe to China cannot always lead to the desired results. Cultural differences are both a challenge and a source of inspiration. They should be – and are being seen as a strength and not a hurdle. The potential of China's highly motivated and well educated researchers is tremendous.

The new Research Center is active in the areas of power systems, manufacturing technologies and robotics. The first two departments are located at the ABB China headquarter in Beijing, the last one is in Shanghai. The mid-term target is to build up a team of around 100 researchers. Half of these will be recruited by the end of 2005. More than every second researcher recruited so far has at least a Ph.D., and almost all are graduated from Chinese Universities. Additionally, there are numerous ABB technology centers throughout China that are doing specific high level product development.

### Power system research

The decision to operate perform R&D in China in the power systems area is motivated by China's fast growing electricity sector. Helping to expand the power system as a backbone of for China's economic growth while meeting ecological requirements is a fascinating engineering challenge. For example, ABB researchers support system and network studies related to the Ultra High Voltage AC and DC developments in China. This research is pushing the envelope of today's

technologies. Other research areas include wide area monitoring and control systems that will, together with power electronic network controllers (FACTS-devices), permit networks to be operated closer to their limits, thereby raising their productivity and their return on investment.

### Manufacturing research

In a country with the biggest and most modern factories, research in manufacturing technologies is a must. This activity supports ABB's ambitious growth plans and business potential by strengthening the company's operational excellence in this sector. To deliver an optimal process, local requirements must be taken into consideration. Specific guidelines and product designs are being developed to simplify manufacturing while raising quality.

**Innovation means doing things in a different, and a better way.**

### Robotics research

Robotics research is required by the large customer base and local robot production in China. The research center performs first rate R&D for future products and applications for China – and, in dedicated specific areas, the world.

### Research in China – the right decision for ABB

Building up the new Corporate Research Center to the level of ABB's other research centers is a challenging and inspiring task. ABB is firmly committed to this new Center and to the Chinese economy.

ABB is taking the opportunity to work with extremely bright and well educated people in a highly dynamic market; a market that demands the highest quality products at the lowest cost and delivered as fast as possible – all this while being easy to install and use. Meeting these demands is indeed a unique challenge – a challenge that cannot be found anywhere else in the world.

### Christian Rehtanz

Director, ABB Corporate Research (China)  
Beijing, China  
christian.rehtanz@cn.abb.com

## ABB Review Special Report ABB in China July 2005

### Editorial Council

Peter Leupp  
*Chairman and President, ABB (China) Ltd.*

Daniel Assandri  
*Head of Power Systems,  
Power Technologies Division,  
ABB (China) Ltd.*

Anders Jonsson  
*Head of Automation Technologies division,  
ABB (China) Ltd.*

Wylie Rogers  
*Corporate Communications,  
ABB (China) Ltd.*

Nils Leffler  
*Chief Editor, nils.leffler@ch.abb.com*

### Publisher's office

ABB Schweiz AG  
Corporate Research  
ABB Review / REV  
CH-5405 Baden-Dättwil  
Switzerland

Partial reprints or reproductions are permitted subject to full acknowledgement. Complete reprints require the publisher's written consent.

The ABB Review is free of charge to those with an interest in ABB's technology and objectives. For a free subscription please contact your nearest ABB representative or the publisher's office.

### Publisher and copyright ©2005

ABB Ltd. Zurich / Switzerland

### Printers

Vorarlberger Verlagsanstalt AG  
AT-6850 Dornbirn / Austria

### Layout

DAVILLA Werbeagentur GmbH  
AT-6900 Bregenz / Austria

### Disclaimer

The information contained herein reflects the views of the authors and is for informational purposes only. Readers should not act upon the information contained herein without seeking professional advice. We make publications available with the understanding that the authors are not rendering technical or other professional advice or opinions on specific facts or matters and assume no liability whatsoever in connection with their use. The companies of the ABB Group do not make any warranty or guarantee, or promise, expressed or implied, concerning the content or accuracy of the views expressed herein.

ISSN: 1013-3119

[www.abb.com/abbrevreview](http://www.abb.com/abbrevreview)

# Don't let your city lose its shine.



© ABB 2005

## Proven power technologies integrated in record time

ABB's cutting edge technologies for grid reliability include HVDC and FACTS: High Voltage Direct Current (HVDC) technology by ABB has built-in overload control and can be loaded fully without increasing the risk of cascaded line tripping. Our Flexible AC Transmission Systems (FACTS) allow more power to flow on existing lines with minimum impact on the environment, substantially shorter project implementation times, and this at lower cost.

**Contact the worldwide market leader in power technologies:**

**[www.abb.com/poweroutage](http://www.abb.com/poweroutage)**

The ABB logo, consisting of the letters 'ABB' in a bold, red, sans-serif font.