

# A wind of change for energy production

Sustainable energy for the future

Markku Rissanen, Aiken-Xuan Liu

Demand for energy is ever increasing, especially in fast-growing economies like China. Such heavy demand is frequently at odds with the environment. Pressure to reduce greenhouse gas emissions has created the impetus to use existing energy more efficiently and to explore alternative, more sustainable energy sources. ABB is active in the areas of both energy efficiency and renewable energy, operating under the philosophy that the greenest energy is the energy saved.

Increased worldwide awareness that human activities affect the environment has led to a greater interest in renewable energy, an area that has been a focus of ABB's work for some time. The oldest and best established renewable energy source is hydroelectric power, but more recently other sustainable energy sources have been developed, the most popular being wind, solar and the expanding use of biofuels. Tidal and geothermal energy are also gaining popularity; however, these are less likely to play a significant role in the immediate future.

### Wind power

It is not generally known that ABB is a major supplier of components to many wind-power construction projects, supplying almost everything except rotor blades and towers **1**. ABB is a large supplier of generators in the range of 1 to 5 MW. The wind turbines drive the generators, converting kinetic energy into electrical energy.

ABB's motors, drives, transformers, switchgear, converters, low-voltage equipment and power-plant solutions all contribute to the efficient production and management of high-quality electricity.

## ABB is a major supplier of components required for wind farm construction projects.

Before leaving the tower, a transformer steps up the voltage produced by the generator from 690 V to more conventional voltage levels, eg, 33 kV for transmission. ABB is a world leader in the supply of these transformers. Low-voltage equipment provides relay protection and converters within the towers are used to improve the quality of the electricity generated and reduce stress on the gear box.

**1** ABB – the world leader for products and systems for the wind power industry



Frequently, wind farms are in remote regions, far away from the consumer. This is particularly true for offshore wind parks. The electricity generated in such isolated regions must be transported efficiently over long distances to consumers on land, sometimes many miles from the coast. ABB supplies both AC and DC cables to deliv-

#### Factbox Reactive power compensation

Reactive power describes the loss of power in a system resulting from the production of electric and magnetic fields within it. Reactive loads in a power system drop voltage and draw current, which creates the impression that they are using up power, when they are not. This "imaginary" or "phantom" power is measured in Volt-Amps-reactive (VAR). It is significant because it must be present to ensure a continuous, steady voltage in transmission networks. If elements of the power grid have an inadequate supply of reactive power from nearby sources, they will pull it across transmission lines, destabilizing the grid. Correct management of reactive power is essential to maintain grid stability and avoid potentially widespread major blackouts.

er this electricity. The wind turbines are connected to a platform housing switchgear, medium-voltage switches, additional transformers and control equipment, where the electricity is stepped up to an even higher voltage. It is then transported onshore, either by a three-phase AC cable or, after an additional conversion to DC, via a HVDC Light® transmission system<sup>1</sup>.

Generally, AC is used for shorter transmission distances and smaller wind-turbine installations, while DC is used for longer distances and larger wind parks. HVDC Light provides additional benefits when transmission is required to join remote power generators to their nearest associated grid, perhaps several hundred kilometers away.

To maintain power quality and reduce voltage flicker (AC voltage fluctuation) often associated with renewable power, ABB offers for AC transmission, static VAR compensation (SVC)<sup>2</sup> equipment, which can provide fast-acting reactive power compensation **Factbox**. Furthermore, ABB's Network Manager™ Supervisory Control and Data Acquisition (SCADA) system provides a means by which to survey and manage the ever-changing demands of today's complex power networks. ABB personnel can assist planners with pre-studies and cost calculations for the installation of individual wind towers or whole wind parks, as well as providing other support services.

ABB's strength lies in its ability to offer complete solutions for the technical and electrical challenges that wind power creates, especially to harmonize their connection to the electricity grid. One of the challenges is that wind power creates an uneven electricity supply – no wind, no electricity

#### Footnotes

<sup>1</sup> HVDC – high-voltage direct current

<sup>2</sup> A static VAR compensator unit uses circuit breakers to regulate voltage, absorbing or supplying reactive power to provide system stability.

## Powering the economy

– and that wind turbines are sensitive to disturbances at the often unstable extremities of the grid, which can cause them to shut down.

Wind power is important for the global environment. In countries like China it is essential to encourage the development of sustainable energy sources from the outset to meet increasing demands for energy.

The Jiangsu Longyuang wind farm north of Shanghai was initiated in 2005 and has 67 wind turbines linked to the grid **2**. The location was chosen for its sparse population and for its exposure to persistent coastal winds. From an early stage in this project, ABB provided practical advice, drawing on its long years of experience in the wind farms of Europe. ABB supplied power equipment for the Chinese wind farm, including a compact secondary substation with distribution transformers and a ring main unit, manufactured in China by the ABB Shanghai Transformer Company, Ltd and the ABB Beijing High Voltage Switchgear Company, Ltd. This equipment is used to feed electricity from the farm into the local transmission network, generating around 230,000 MWh of clean electricity each year. By replacing the volume of fossil-fueled power generation, the wind farm avoids almost 200,000 tons of carbon dioxide emissions every year.

Although the portion of the total electricity generated by wind farms worldwide is currently small, rapid growth is underway. China is the world's fastest growing wind-energy market, where the average growth rate has been 56 percent a year for the past

seven years **3**. The installed capacity was 5.9 GW at the end of 2007 and is expected, according to the Chinese Renewable Energy Industries Association (CREIA), to grow to 50 GW by 2015.

### ABB China supplies equipment used to feed electricity from wind farms to their local transmission networks in China.

Although most wind farms are currently on land, the most effective wind parks are offshore, where the wind is stronger and more persistent. The popularity of such offshore wind farms is increasing and ABB's expertise and advanced technology will continue to play an important role in the efficient transmission of electricity from wind parks to the grid.

The largest wind-park project in Europe is the Borkum E.ON scheme off the north coast of Germany. The wind park, comprising 80 turbines located about 130 km from the coast, will generate 400 MW. The power will be fed into the German electricity grid using ABB's HVDC Light technology **4**.

Similar large offshore wind parks are projected in China, close to the densely populated electricity load centers in the east of the country, where supplies of clean power will reduce the number of conventional power stations needed. Of course China is no stranger to ABB's HVDC Light technology. The State Grid Corporation of China (SGCC), together with ABB, has built four HVDC power transmission

systems since 1989, connecting the coastal cities of Shanghai, Guangdong and Changzhou to clean hydropower generated at the Three Gorges hydroelectric power plant some 1,000 km to the west.

Recent technical advances have increased long-distance power transmission. Together, SGCC and ABB, are building the fifth high-voltage DC line – an 800 kV ultra-high-voltage direct current (UHVDC) transmission link to connect the Xiangjiaba hydropower plant in southwest China to Shanghai, more than 2,000 km away. This will create the longest transmission line in the world, connecting a remote hydroelectric power plant to the densely populated regions of eastern China. Such use of sustainable power production will avoid the combustion of 40 to 50 million tons of coal and 100 million tons of CO<sub>2</sub> emissions annually.

#### Solar power

In addition to wind and hydroelectric power generation, China is active in solar-energy production. According to the China Association for Standardization, about 90 percent of all the hot water used in the Olympic village is solar heated, and 80 to 90 percent of the streetlights around the Olympic venues are solar powered. Although currently on a small scale, such initiatives are planned across the nation, with projected plans for solar streets in major cities.

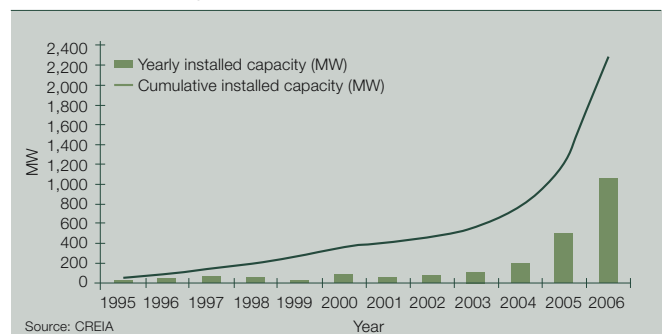
Solar energy consists of three main technologies:

- Solar thermal heating: Solar collectors are used to heat a fluid, which in turn is used for heating purposes.

**2** The Jiangsu Longyuang wind farm on the eastern coast of China



**3** Wind power energy market China





4 Offshore wind turbine connected by ABB submarine cabling



5 Parabolic troughs in fields facing the sun



- Photovoltaics (PV): Solar cells are used that convert solar radiation directly into electricity.
- Solar thermal power generation: Focused solar radiation provides the energy to turn water into steam, which then drives a turbine to generate electricity.

The power generated at solar plants can be delivered to the local grid via ABB power transformers, converters, motors and other substation equipment.

Although solar energy lags behind wind-power and hydropower production, there is huge potential to generate clean solar energy in China. Two-thirds of China's land mass receives more than 2,000 hours of sunlight annually, more than many regions of the same latitude in Europe. This equates to an estimated potential solar-energy reserve equivalent to 1,700 billion tons of coal.

China is already a major player in the solar-energy market. The latest market surveys concluded that Chinese solar cell production surpasses that of both Japan and Germany, and its products dominate the global solar market.

Although most solar-energy installations are less than 100 kW, there are some larger installations in the MW range. In fact, plans to install solar plants in the range of 300 to 500 MW were announced recently in the United States, to be completed around

2011. ABB is well placed to assist with such projects with its broad portfolio of power and automation products and systems.

One large solar plant for which ABB has supplied products is the Andasol plant in southern Spain. Located in the Sierra Nevada in Andalusia, it will be the largest solar plant in Europe and one of the largest in the world, when completed in 2009. It will be the first in Europe to use parabolic troughs to capture solar radiation and generate electricity on a commercial scale, and only the second in the world to do so <sup>5</sup>.

Andasol 1 and 2 will each generate 50 MW of electricity by concentrating sunlight in two solar fields of trough-shaped parabolic mirrors. The technology collects the solar radiation as heat using mirrors that track the sun and concentrate solar radiation onto a collector tube installed at the focal point of the mirrors. Heat-transfer fluid passing through the tube delivers the heat to produce steam, which drives a turbine to generate electricity. The two plants will produce about 350 GWh of electricity per year, enough to supply 100,000 households and avoid 345,000 tons of greenhouse gas emissions a year. These plants are controlled by ABB's Extended Automation System 800xA and ABB Power Generation Portal software. The power generated at the plants will be delivered to the local grid via ABB power transformers, converters, motors and other substation equipment.

Similar solar energy plants in the 100 to 300 MW range are planned worldwide.

### Biofuels

Biofuels are an additional source of sustainable energy and one of special interest to the automotive industry <sup>6</sup>. The choice of biofuel sources is large, but each source provides different levels of energy efficiency and sustainability.

According to the National Guidance Catalogue of Renewable Energy Industry Development, China is focusing on the development of bioethanol and biodiesel technology, Bagasse combined heat and power (CHP) technology, crop-straw power generation, biomass solidified fuels, landfill gas utilization, medium to large scale biogas projects and small household biogas digesters.

China has the largest bioethanol plant in the world producing 350 million liters of ethanol from corn a year.

With a production of about 14 million m<sup>3</sup> per year, Brazil is currently the largest producer of ethanol from biofuels derived from sugar cane. For a long time, the United States had been the second-largest producer, but is now producing about as much as Brazil using corn. In China, the biofuel industry is expanding, and in 2004 Jilin Fuel Alcohol Company Limited built the largest bioethanol plant in the world, producing 350 millions liters of ethanol from corn a year. In Europe the most active countries in biofuel production are Spain, France and Germany.

## Powering the economy

6 Cars are increasing in number especially in countries like China.



ABB's role in the biofuel industry has been to deliver control systems and instrumentation to plants in Germany, Thailand, Canada and the United States 7. Most of the plants use ABB's Automation System 800xA with AC800M process stations and Profibus for communication.

Biogas is an expanding market in biofuels. In China, the targets for biogas electric power generation with "feed-in-grid" capability are projected to be 0.8GW by 2010 and 3 GW by 2020. In addition, landfill gas is projected to supply an additional 0.2GW by 2010 and 1.0GW by 2020. For China, biofuels are expected to deliver about 18 percent of the country's sustainable

energy by 2010 and are expected to continue to do so until 2020. ABB's technology could provide the process control systems and integrated safety oriented instrumentation to automate the biogas-powered electric generators, as well as the equipment required to connect the electricity generated to the grid.

### China's future renewables market

In 2005, 7.5 percent of energy consumed in China was derived from renewable sources, equivalent to 166 million tons of coal, avoiding 400 million tons of CO<sub>2</sub> emissions. The Chinese government predicts that 10 percent of all energy consumed in China by 2010 will be from

7 ABB's solutions for bioethanol production



renewable sources, reaching 16 percent by 2020 8. This means that by 2010, the consumption of renewable energy will reach the equivalent of 300 million tons of coal, avoiding 600 million tons of CO<sub>2</sub> emissions.

The Chinese government predicts that 10 percent of all energy consumed in China by 2010 will be from renewable sources.

New technologies and innovations will help countries around the world reduce their reliance on fossil fuels. ABB's market leading and award-winning portfolio of energy supply solutions drives the company to a strong active position to help deliver a greener future.

8 Renewable energy in China

Items	2000	2005	2010 (Plan)
Power generation			
1. Hydropower (MW)	79,350	110,000	190,000
2. Grid connected wind farm (MW)	340	1,260	10,000
3. Off-grid wind farm (MW)	30	50	75
4. PV generation (MW)	19	70	300
5. Biomass generation (MW)	170	2,000	5,500
Biomass (billion m <sup>3</sup> )	3.5	8	19
Biomass in rural (M home)	8.5	18	40
Heat			
1. Solar water heater (Mm <sup>2</sup> )	26	80	150
2. Geothermal (k ton standard coal)	1,200	2,000	4,000
Fuel			
1. Alcohol (k ton)		1,020	3,000
2. Biodiesel oil (k ton)		50	200
Total (M ton standard coal)	12	16.6	30

Data source: The Five-Year Plan for renewable energy issued by National Development and Reform Commission

Markku Rissanen

Aiken-Xuan Liu

ABB Corporate Research

Beijing, China

markku.rissanen@cn.abb.com

aiken-xuan.liu@cn.abb.com