2. Januar 2008

Powering China's development: The role of renewable energy

As the second largest energy consumer in the world, China's need for secure, affordable, and environmentally sustainable energy for its 1.3 billion people is palpable. In the space of just a few years, China has become a global leader in renewable energy investment and industry, and much more growth is expected, write Eric Martinot and Li Junfeng, authors of a new Worldwatch Institute report.

In June 2004, Germany hosted an international meeting of energy leaders - dubbed 'Renewables 2004' - intended to accelerate the development of renewable energy globally. At that event, China announced an ambitious national commitment, including the goal of obtaining 16% of the country's energy from renewables by 2020. Three-and-a-half years later, China's policy machinery for renewable energy is in high gear and its renewables sector is booming, presenting a picture that is far more diverse, fast-changing, and complex than any of those assembled in 2004 could have imagined.

A comprehensive national law for renewable energy, building on previous policies, was enacted in 2005 and took effect at the start of 2006.Among many other provisions, the law provides a feed-in tariff for biomass power and pricing guidelines (some would say a quasi-feed-in tariff) for wind power. In September 2007, final numbers were announced for a series of individual technology targets by 2020 (see Table 1). That same announcement specified much-anticipated mandatory requirements for China's utilities to produce 3% of their power from non-hydro renewables by 2020, and also meet 8% of their total power capacity from non-hydro renewables.

China has already become a global leader in renewable energy investment and industry, and is poised to hold this lead. Investment in new renewables capacity (excluding large hydropower) exceeded US$12 billion in 2007, second only to Germany. Most of this was small hydro, solar hot water, and wind power, all of which have been booming in recent years.

Investors have flocked to China's solar PV manufacturing industry, which saw billion-dollar IPOs on public markets during 2005-2007, and which became the third largest global producer, behind Japan and Germany. Indeed, the success of China's Suntech is legendary - growing from just 20 employees in 2002 to a market value of $6 billion, making its founder the richest man in China.

Total wind power capacity doubled in 2006 and almost again in 2007, with a number of foreign subsidiary manufacturers and one major Chinese producer capturing most of the market. Along with the US, Germany, Spain, and India, China is now solidly in the top-5 globally in terms of annual wind power market volume. Solar hot water capacity continues to grow at 15%-20% annually, involving more than 1000 manufacturers employing some 150,000 people, and China now accounts for three-quarters of the global market for solar hot water.

China currently gets 8% of its primary energy and 17% of its electricity from renewable sources, mostly large hydropower. Given that domestic energy consumption is expected to almost double by 2020, the government's goal of doubling the renewable energy share to 15% (revised slightly from the 2004 announcement) means that the absolute amount of renewable energy will more than triple. Some experts anticipate that this target could be exceeded, and that the share will keep rising beyond 2020.

WIND POWER

Wind power is the fastest-growing power-generation technology in China. Capacity additions were expected to exceed 2 GW in 2007, after total capacity doubled to 2.6 GW in 2006. Early in 2007, developers ordered an additional 8 GW of turbines for future installation, and about 200 project development companies were actively pursuing or implementing projects. Recent trends mean that the national target of 5 GW by 2010 is likely to be exceeded by 2-3 GW.

Wind power development has proceeded along two separate, but interconnected, avenues. The first is the government's national 'concession' policy of annually awarding competitively bid blocks of capacity to be installed by both private and state-owned developers. The concession policy resulted in 2.5 GW of awarded capacity during 2003-2006, with more initiated in 2007. (Although the first operational projects resulting from awards only started appearing during 2007.) So far, only Chinese companies have won awards, partly because low bid prices have left little room for profits and foreign companies have not participated. The concession policy also requires utilities to pay for the costs of transmission interconnections, an important provision for reducing costs.

Secondly, private project development has taken place through individually negotiated projects, with prices determined on a case-by-case basis by provincial pricing bureaus. In this second case, prices are 'guided' by the results of the concession bidding, according to the 2005 national Renewable Energy Law and associated regulations. So far, these individually negotiated projects have been limited to 50 MW each, but nevertheless have proven to be the main avenue for new installations.

In addition, separate provincial initiatives for supporting wind power have taken hold, and more are expected. Gansu province was the first to enact a provincial-level bidding policy, in parallel with the national policy, with its first tender for 150 MW. Other provinces were moving towards provincial- level (de facto) feed-in tariff regimes, with Guangdong the first to do so.

The country now has four Chinese commercial manufacturers of wind turbines, another six foreign subsidiary manufacturers, and more than 40 firms developing prototypes and aspiring to produce turbines commercially. In general, Chinese firms have not yet caught up to foreign levels of technology, in part because foreign firms are reluctant to license their latest technologies. But Chinese firms are working hard to catch up and amass a domestic 'homegrown' base of skilled engineers and technologies. Indeed, China's primary domestic manufacturer, Goldwind, has been aggressively developing new technology and expanding its share of the overall Chinese market, which rose to 33% in 2006. However, Goldwind still lags behind its European counterparts in both technology and scale. Three other Chinese turbine manufacturers had small market shares in 2006: Huarui (Sinovel) (6%), Zhejiang Windey (1.5%), and Dong Fang (0.8%).

Foreign subsidiary and joint venture turbine manufacturing in China has accelerated in part due to a 'localization' provision of the national concession programme, which requires that 70% of the value of turbines installed under the programme be manufactured domestically. Foreign wind manufacturers now operating in China include Vestas of Denmark (with a 24% market share in 2006), Gamesa of Spain (17%), GE of the United States (13%), Nordex of Germany (2%), and Suzlon of India (1%). These firms are bringing new competencies to the market, including technology, finance, marketing, and production scale. Most have established wholly-owned subsidiaries with large investments in new production facilities. Acciona of Spain is an exception, and established a joint venture with a Chinese partner.

Aside from a shortage of skilled personnel and specialized engineering knowledge, one of the problems facing China's domestic wind industry is the need for operational experience, testing, and redesign cycles.This process can take several years, and US and European manufacturers have a long head start. This means that uncertainties about quality and technical performance will continue to plague Chinese producers for many years unless shortcuts to employing foreign expertise can be found.

SOLAR POWER

Solar power markets are still in their infancy in China. Just 80 MW of solar photovoltaic (PV) capacity existed in 2006, compared with more than 7700 MW globally. About half of China's capacity is employed in rural off-grid applications, a market that is increasing at around 5-10 MW per year. The rest is used for communications, industry, and consumer products. Grid-connected solar PV is still marginal, at just a few megawatts. In total, China's domestic PV market grew by about 10 MW in 2006, just a fraction of the 370 MW produced by China's solar PV manufacturing industry, whose output was thus virtually all exported.

A large grid-connected market is still several years away, as the cost of solar PV declines further and as conventional power costs rise.The large subsidies required to support solar PV have made the government reluctant to provide them. Nevertheless, there are promising developments for grid-tied or building- integrated solar PV. For example, the Jiangsu provincial government is working on the first phases of a 10,000-roof programme and has started to discuss a feed-in tariff policy with local utilities.The city of Shenzhen has built a 1 MW grid- tied solar PV plant on its World Garden Expo building. And, demonstration projects are being constructed for the Beijing 2008 Olympics and the Shanghai 2010 World Expo.

Yet while the domestic market is cool, the manufacturing sector is boiling. Led by a number of high-profile initial public stock offerings (IPOs), some valued in the billions of dollars, global attention has been riveted to the growth potential and expansion plans of the Chinese solar PV industry. More than 15 major solar cell manufacturers employed over 20,000 people in 2006, and new companies were appearing monthly during 2007. Solar PV cell production capacity jumped from 350 MW in 2005 to over 1 GW in 2006, as virtually every player in the industry announced further capacity expansion, some planning to double or triple capacity in just a few years. Production capacity was expected to reach 1500 MW in 2007, and as much as 4000 MW by 2010, higher than today's global figure.

Leading Chinese producers are Suntech, China Sunergy, Jiangsu Linyang, Ningbo, Baoding Tianwei-Yingli, Trina Solar, and Solarfun, all with ambitious expansion plans to 2010.Total investment by just three of these companies - Suntech, China Sunergy, and Tianwei Yingli - might exceed $1.3 billion by 2008-2010. Suntech is already the world's fourth-largest producer of solar cells and may gain in position by 2010. Another company entering the picture is Jiangxi LDK Solar, a wafer manufacturer which plans to expand production capacity to 1000 MW by 2010.

One of the uncertainties for the Chinese solar PV industry is the availability of polysilicon feedstock.This 'silicon shortage' has been much discussed in the industry worldwide since 2004, and was expected to continue through 2008. China had virtually no domestic silicon producers in the earlier years, but in response to the rapid rise of the solar PV industry, new sources of silicon are emerging. Chinese silicon production for PV use was just 340 tons in 2006, compared to demand of over 3000 tons. However, over 4000 tons of new silicon production capacity was under development and expected to come online in 2007-2008.

Chinese solar PV manufacturers seem confident they can out-compete foreign manufacturers. Lower labour costs may play a part, as some production equipment is marginally substituted with cheaper manual labour. Firms are also working on their own R&D programmes - such as a new thin- film research and production facility by Suntech - although breakneck expansion of production capacity has tended to put technology innovation at a lower priority for most firms.This situation could change if the technology landscape changes and Chinese firms face more pressure to innovate.

SOLAR HOT WATER AND HEATING

While China has only limited experience with solar power, it is already a global leader in taking advantage of solar hot water. The country is now the world's largest market for solar hot water systems, with nearly two-thirds of total global capacity (excluding systems used to heat swimming pools). Growth has been rapid, rising from 35 million m2 of installed capacity in 2000 to 100 million m2 by the end of 2006 and representing perhaps 40 million systems, perhaps 10% of all Chinese households. China added 20 million m2 of new capacity in 2006 alone and avoids more than 15 million tons of carbon dioxide emissions annually with solar hot water systems alone.

Historically, solar hot water found favour in rural areas, but recent growth has been driven by urban installations. Solar heating systems can be found everywhere in urban China - on homes, apartment and office towers, schools, and hotels - particularly in the southern provinces. By 2005, more than one- third of the national market was in urban areas, and this share continues to grow. Increasingly, Chinese view solar water heaters as desirable appliances that rank high on their lists of priorities. System costs have fallen dramatically over the years and solar heating is relatively affordable today, thanks to a combination of low-cost labour, cheap materials, and competition among a large number of domestic solar companies. Chinese companies now produce solar hot water heaters at costs that are one-fifth to one-eighth those found in the United States and Europe.

Most growth to date has occurred with minimal government involvement. Increasingly, however, national and local government departments, architects, and real estate developers are paying attention to solar hot water and working to promote its use. In mid-2007 the National Development Reform Commission issued a 'Plan on Enforcement of Utilization of Solar Energy Heating Nationwide' that will soon mandate solar hot water heating in new construction (expected to apply to hospitals, schools, and hotels). It is also expected to require new construction to allow space on rooftops for the addition of solar hot water heaters and to encourage retrofits of existing government buildings. In 2006, the booming southern city of Shenzhen mandated solar hot water in all new residential buildings below 12 stories in height. New policies and building practices mean that 20%-25% annual growth rates should continue - with domestic production expected to increase to 30 million m2 per year before 2020.

The Chinese solar hot water industry is fragmented, with only a few major players, and lacks a strong technology and economic underpinning. However, several prominent household appliance makers, including Haier, Ocma, and Huati have recently entered the solar hot water market.The largest solar hot water manufacturer in the world is Himin Group, located in the city of Dezhou in Shandong Province. With 50,000 employees worldwide, Himin produces over 1 million solar hot water systems annually. Most of these are for the domestic market, but Himin has more recently targeted export markets.Assuming Chinese industry can overcome challenges associated with quality, technical standards, and distribution channels, there is enormous potential for exports - which may ultimately transform markets worldwide.

BIOMASS POWER AND BIOFUELS

Most of China's existing 2 GW of biomass power capacity comes from combined heat and power (CHP) plants in the sugar industry, with sugar cane waste (bagasse) being the primary feedstock. Rice plantations also use waste rice husks in such plants. China's biomass power capacity has not changed appreciably in recent years, though a new generation of biomass power generation is now getting started in two primary categories: 'industrial-scale' biogas power plants that burn gas generated from industrial and animal wastes; and large-scale power plants that burn a wide variety of agricultural crop wastes. There are now more than 1600 industrial-scale biogas plants operating in China and the government expects 3 GW of power generation from biogas by 2020.

Biomass power generation from large-scale combustion of agricultural wastes, typically in a 25 MW size plant, is now emerging. Theoretically, there are 400-800 million tons of agricultural and forest wastes in China to supply such plants. Practically, however, such a plant can require collection and transport of agricultural waste from a wide area, so transport costs typically limit collection distances to within 30-50 km. In addition, agricultural waste must often be purchased from many small farmers to supply a single plant. And there are competing uses for the wastes, including biomass pellet and briquette production and potentially cellulose-to-ethanol technology when it becomes commercially available. China's first 25 MW biomass power plant went into commercial operation in 2006 in Shandong province, burning a combination of cotton stalks, tree branches, orchard waste, and forestry waste. A few more plants began operation in 2006-2007, and the government plans 30 more plants.

TRANSPORTATION FUELS

In addition to biomass for power generation, liquid biofuels for transportation have received attention in China in recent years as alternatives to oil imports. Ethanol is currently produced in modest quantities from corn in some parts of the country. Nine provinces now mandate 10% blending of ethanol with all gasoline sold. For some years, the national government has provided production subsidies of RMB1300 ($170) per ton of ethanol to selected producers, equivalent to about 12 US cents per litre, about the same subsidy that US ethanol producers receive. However, China declared a moratorium on expanded ethanol production from corn in 2007, due to concerns about competition with food supplies.

Thus, further expansion of Chinese ethanol production will depend on dedicated plantation crops. The government in 2007 announced it would focus attention on sweet sorghum and cassava plantations as the main feedstocks for ethanol. However, plantation crops may prove too expensive in the short-term, and there are also serious concerns about environmental degradation, water resources, and competition for land. Beyond such crops, the prospects for ethanol expansion in China rest on the future of cellulose-to-ethanol technology from agricultural and forest wastes. Pilot celluloseto-ethanol plants are expected in China in the coming years.

Biodiesel can be produced from waste vegetable oils or oilseed plantations. Currently, the amount of biodiesel produced in China is small and derived mainly from waste cooking oil.There is a large potential supply of such waste oil if it can be collected and processed cheaply enough. Up to 4 billion litres per year of biodiesel might be produced from waste cooking oil in China. There is also potential for producing biodiesel from oilseed crops, the cheapest of which is Jatropha. Other potential biodiesel feedstocks include soybeans, peanuts, rapeseeds, cottonseed, and sunflower, although all of these are food crops in high demand. A wide variety of pilot efforts to convert various oilseed crops to biodiesel are ongoing in several provinces. Imported palm oil from Southeast Asia is another feedstock being employed by a growing number of Chinese biodiesel producers, although this can be associated with tropical deforestation.

CHINA'S RENEWABLE ENERGY FUTURE

China's need for secure, affordable, and environmentally sustainable energy for its 1.3 billion people is palpable. China is already the second largest energy consumer in the world, having nearly doubled consumption over the past decade. With both energy-intensive industry and high-tech manufacturing, China now serves as factory to the world. Rising living standards mean more consumption, such as automobiles, with annual vehicles sales expected to exceed the United States by 2020. While most of China's electricity comes from coal and hydropower, the growing use of oil for China's burgeoning vehicle fleet is adding greatly to concerns about energy security - China already imports nearly half of its oil. Concerns about energy security, power capacity shortages, and air pollution are all adding urgency and pressure to switch to alternative technologies and fuels, including greater energy efficiency, 'clean coal' technologies, nuclear power, and renewable energy. Climate change also adds pressure - China will soon surpass the United States as the world's largest producer of carbon dioxide emissions, some say it already has.

These issues mean that China's renewable energy development will almost certainly remain at the forefront of national policy attention, as well as remain in the global spotlight. China is likely to achieve its target of obtaining 15% of its energy from renewables by 2020, and may well exceed this goal. China's total power capacity from renewables could reach 400 GW by 2020, triple the 135 GW seen in 2006, with hydropower, wind, and solar photovoltaics making the most important contributions. By 2050, this renewable power capacity might reach 2000 or even 3000 GW.This would yield a reduction in carbon emissions of 3.5-5 billion tons of carbon dioxide (CO_2), equivalent to China's total CO_2 emissions in 2005. Specific technology prognoses are:

Wind power. Many believe the government's target of 30 GW of wind power by 2020 will be exceeded, perhaps reaching 60 GW. Beyond that, wind power could reach 100-200 GW by 2030 and as much as 600 GW by 2050. Progress will depend on the speed of domestic industry development and technology cost reductions, the evolution of government policy (including renewable portfolio requirements for the national generating companies), power pricing levels, and the prospect for offshore wind.

Solar PV. Estimates for the future of solar PV vary widely, but 2-10 GW by 2020 is not an unreasonable goal if expected cost reductions in technology occur in the coming years. Beyond that, 20-40 GW could be installed by 2030, and 500-1000 GW by 2050. By comparison, global grid-tied solar PV reached 5 GW in 2006. Key factors include the speed of technology cost reductions, new policies to support building-integrated PV and other grid-connected applications (including feed-in prices or construction standards and policies), and the speed with which electric power utilities choose (or are required) to accommodate distributed generation.

Concentrating solar thermal power. The future of concentrating solar thermal power generation is still uncertain. It is currently experiencing a renaissance in the United States and Europe. China has extensive desert areas that are well suited to solar thermal power generation, so if technology costs fall, it is possible that hundreds of gigawatts of solar thermal power plants could be installed in the coming decades.The first such plant, for 200 MW, was just announced for the Inner Mongolia region of China by 2012 as a partnership of German and Chinese companies.

Biomass power. It is unlikely that biomass power will make a major contribution beyond the government's target of 30 GW by 2020, as the resource is limited and collection of widely dispersed agricultural waste for use in centralized plants is problematic if transport costs and logistics are considered. Given that there are only a few such plants yet running, the prospects of achieving even 30 GW by 2020 are uncertain. Other factors include the potential for developing industrial- scale biogas technology, the continuation of feed-in tariffs for favourable power pricing, and new technology development, such as biomass gasifiers.

Solar hot water. Some experts suggest that China could achieve 400 million m^2 of installed capacity by 2020 and 800 million m^2 by 2030. It is likely that more than one-third of China's households will be using solar hot water in the 2020-2030 timeframe if current targets and policies are continued. Growth depends on policies and incentives for solar hot water and space heating, particularly integration into building codes and standards and construction practices. Other important needs are quality standards and consumer information. These are challenges not just for the national government, but for municipal and provincial governments. The potential for export-led growth of the solar hot water manufacturing industry is large, but remains untapped.

Biofuels. Biofuels production may grow from plantations of cassava, sweet sorghum, and oilseed crops, although the long- term potential is limited, perhaps to 20-60 billion litres per year by some estimates. The greatest promise lies with cellulosic ethanol, which if produced from China's vast resource of agricultural and forest wastes might become a major source of biofuels, with estimates up to 90 billion litres per year. Future prospects for biofuels depend on oil prices, technology development, and large-scale viability and cost of plantation crops. Biofuels prospects may also depend on progress with coal-to-liquids and electric vehicles as competing alternatives for increasing energy security. Prospects for cellulose-to-ethanol depend on biorefinery sizes that are efficient yet suitable for the diffuse nature of China's rural biomass resources.

Achieving these outcomes will depend on domestic industry development, the availability of skilled personnel, technology cost reductions, continued aggressive government policy, appropriate pricing levels, and allowance for distributed power generation by electric utilities.

Given China's strong commitment to becoming a world leader in renewables manufacturing, as well as concerns about energy security, power shortages, air pollution, and climate change, the future of renewable energy in China appears bright.

This article provides excerpts from the Worldwatch special report Powering China's Development: The Role of Renewable Energy (Washington, DC, November 2007, 50 pp.), available for purchase at http://www.worldwatch.org/node/5491. Full notes and references are available in the report. Authors Eric Martinot and Li Junfeng would like to thank the many co-authors and researchers who contributed to the report, as well as support by the Blue Moon Fund and the Tsinghua-BP Clean Energy Research and Education Center.

Eric Martinot is a visiting faculty member at Tsinghua University in Beijing and a senior research fellow with the Worldwatch Institute. e-mail: contact@martinot.info

Li Junfeng is Deputy Director General of the Energy Research Institute (ERI) of the National Development and Reform Commission and is General Secretary of the Chinese Renewable Energy Industries Association (CREIA). e-mail: li-junfeng@163.com
http://www.renewableenergyworld.com/rea/news/reworld/story?id=51586