

Chinese Photovoltaic Market and Industry Outlook (Part 1) ♦

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Summary

In China over the recent years, wind power, solar energy and other renewable energy sources have been expected to become not only promising tools against climate change but also a key economic growth driver. Particularly, growth of Chinese photovoltaic cell makers has attracted global attention. However, the Chinese government has been unable to provide sufficient support for them because of huge fiscal costs. China's PV market is still inactive. As PV costs are expected to decline substantially due to a silicon price fall in 2008, however, the Chinese PV market is projected to achieve dramatic growth.

In early 2009, the Chinese government came up with measures to subsidize and promote PV. In December, it became clear that the country will revise its PV generation target for 2020 upward to 20 gigawatts. While giving positive considerations to the exploration of the domestic PV market and the development of relevant industries, the Chinese government has recognized the domestic industries' technological capacity shortages, overheated investment and other problems and indicated a cautious attitude.

Part 1 of this paper outlines China's PV projects, focusing on the PV market and PV promotion measures.

1. Introduction

On September 22, 2009, Chinese President Hu Jintao delivered an attention-attracting speech at the U.N. Climate Change Summit held at the U.N. Headquarters in New York. China would incorporate climate change measures into its economic and social development plan and take more effective measures for the promotion of renewable and nuclear energy, he said. Specifically, the president offered to give priority to the development of renewable and nuclear energy and boost non-fossil energy's share of primary energy consumption to about 15% by 2020. Over the recent years, particularly since the global financial crisis, wind power, solar and other renewable energy technologies have growingly been expected to function more not only as measures to combat climate change but also as a new engine boosting the world economy growth.

Meanwhile, photovoltaic cell demand declined fast in the second half of 2008 as PV projects were stalled due to the financial crisis and major European countries revised downward feed-in tariffs for PV electricity. The demand fall dealt a severe blow to China's PV industry that had depended heavily on overseas markets. Many small and medium-sized enterprises went bankrupt and surviving large companies logged serious profit drops or losses. In response, the industry has growingly looked at the domestic market, the huge potential of which is still unreleased because the cost of PV is too high. It had been economically unreasonable for the government to subject the PV industry to fiscal spending. However, with the improvement in PV cell efficiency and the decline of silicon price since 2008 the domestic PV market (as well as industry) is expected to take off with supports by the government.

Under such situation, the Chinese government came up with one policy measure after another to subsidize and promote PV. In less than four months after announcing the introduction of subsidies for PV systems for buildings in March 2009, the government offered the "Golden Sun" program to subsidize pilot PV projects. These measures have paved the way for the domestic PV market to launch full-fledged growth.

Part 1 of this paper deals mainly with China's PV market and PV promotion policies. It first introduces the present state of and future plans for the domestic PV market as one of the keys to the development of China's PV industry. Next, the Chinese government's PV policies and their impact on the PV industry are outlined. Finally,

♦ Part 2 is planned to analyze details of the industry.

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challenges for the diffusion of PV in China are summarized.

2. PV market in China

While China is rich with solar energy resources, the present installed PV capacity in China is quite small compared with countries advanced in PV installation. China's cumulative installed PV power capacity as of 2008 totaled 150,000 kW amounting to only 7% of Japan's¹. Even under the Medium to Long-Term Renewable Energy Development Plan announced in 2007, cumulative installed PV power capacity was planned at 0.3 GW for 2010 and 1.8 GW for 2020, far less than Japan's target of 28 GW for 2020.

In 2009, meanwhile, the National Energy Administration drafted a new energy industry development plan² and submitted it to the State Council. The plan is designed to accelerate the development of the clean energy industry, enhance efforts to improve and upgrade existing energy technologies, and put solar energy into a clean energy priority list (including wind power, solar energy, nuclear and clean coal). In line with the plan, the government will set specific targets for renewable energy power capacities for 2020. In December 2009, a National Energy Administration official in charge of new energy unveiled a plan to raise China's cumulative installed PV power capacity target to 20 GW for 2020 (although details were not made available)³.

Since the geographical distribution of solar energy resources has deep influences on the development of China's PV market, solar energy potential and its geographical distribution will be outlined before introducing China's domestic market.

2-1 Solar energy potentials in China

China's solar energy resources distribution is indicated in Figure 2-1 and Table 2-1. In the 30 years between 1971 and 2000, China's annual solar radiation ranged from 1,050 kWh/m² to 2,450 kWh/m². Areas with annual solar radiation at 1,050 kWh/m² or more accounted for more than 96% of China's national total. Annual solar radiation energy received on the ground in China totals 1.6 trillion TCE⁴, 654 times as much as China's primary energy consumption in 2008⁵.

As indicated in Figure 2-1, Zones I, II and III account for more than two-thirds of China's national total area, featuring excellent solar energy utilization conditions including 5,000 MJ/m² or more in annual solar radiation and more than 2,000 sunshine hours per year.

¹ According to the IEA-PVPS report, Japan's cumulative installed PV power capacity reached 2,144,189 kilowatts by 2008.

² The Plan is as part of a package to enhance global warming measures and stimulate the economy

³ The official unveiled the new target at the fourth international forum on China's energy strategy. The wind power generation capacity target for 2020 was given at 150 GW.

⁴ TCE: Ton of Coal Equivalent

⁵ China's primary energy consumption in 2008 totaled 2.6 billion TCE.

Table 2-1 Solar Energy Resources Distribution Zones in China

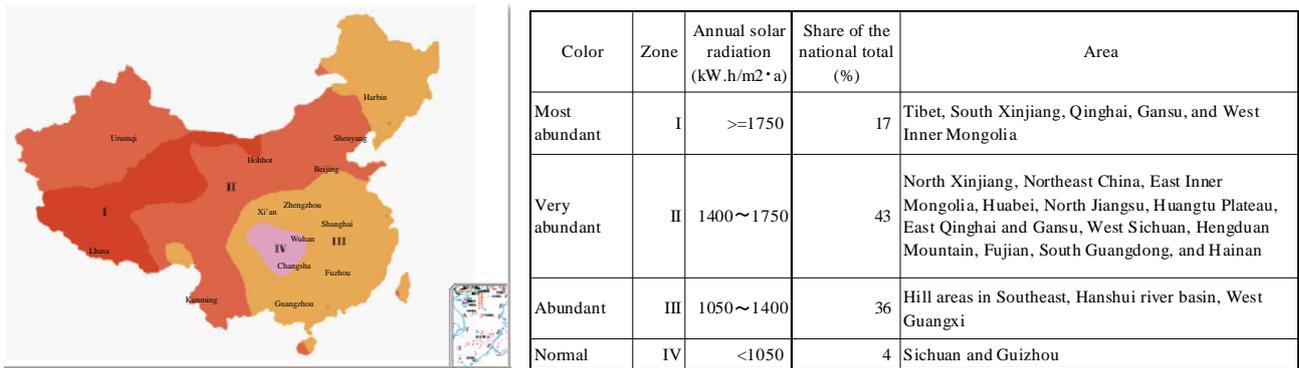


Figure 2-1 Solar Energy Resources Distribution in China

Source: China Solar PV Report-2007

2-2 PV market in China⁶

China launched research on PV cells in 1958, used them for the Dong Fang Hong-2 satellite in 1971 and started their application on the ground in 1973. In and before the 1980s, China’s annual PV cell production was limited to 10 kWp⁷. Because of their high costs, PV cells were used only for satellites and small electricity sources. Under the sixth five-year development program (1981-1985) and the seventh one (1986-1990), the central and local governments provided financial support for the promotion of the PV industry and market and built PV systems in a wider range of areas. According to the above figure of the solar energy resources distribution, the Midwest features the most abundant solar energy resources in China. In this region where less populated farming villages are dominant, their electrification has long remained as a challenge. PV has been used to address this issue. In the mid-1990s, the Chinese government put forward the Brightness Project to electrify the Midwest with PV systems, giving momentum to the diffusion of PV systems in China. Under the Song Dian Dao Xiang rural electrification program (xiang is the terminal administrative unit in China) led by the Chinese government from 2002 to 2005, small independent PV systems diffused on a full-fledged basis⁸. Examples of independent PV systems are shown in Figures 1-2 and 1-3.

The Chinese PV market breakdown in 2006 is given in Figure 2-4. China has so far introduced primarily independent PV systems. Because of high costs and technological constraints, mega solar and building integrated PV systems for interconnection with the electric grid are still subject to pilot projects or demonstration programs. At the end of 2008, China’s cumulative installed PV power capacity stood at 150,000 kW, of which independent systems accounted for 55%.

⁶ Reference 1
⁷ Reference 1
⁸ Reference 2

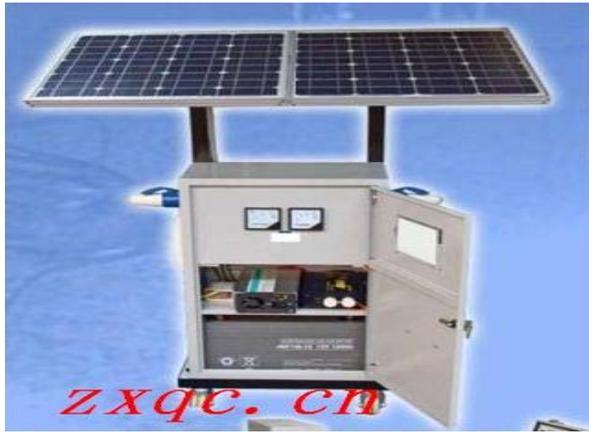


Figure 2-2 Independent Home PV System⁹



Figure 2-3 Independent PV Plant¹⁰

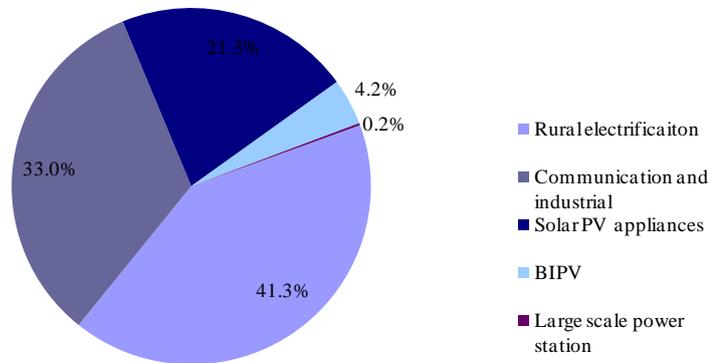


Figure 2-4 Market Shares of PV Power in China in 2006

Source: China Solar PV Report-2007

2-2-1 Rural electrification

The most important PV application in China is rural electrification. In the future, rural electrification will continue and account for a large share of China's PV market. The 2007 Medium to Long-term Renewable Energy Development Plan also gave priority to rural electrification, projecting that the scale of this sector will be made to 0.15 million kW in 2010 0.3 million kW in 2020, which accounts for a large part of the country's whole PV development target (0.3 million kW for 2010 and 1.8 million kW for 2020).

In rural electrification, however, optimum energy technology options differ from region to region. Suitable PV locations are limited to Tibet, Qinghai, Xinjiang, Gansu, Yunnan, Sichuan and other provinces where solar energy resources are abundant. In this sense, the PV market for rural electrification is limited.

2-2-2 Building integrated photovoltaics (BIPV)

In the Midwest where solar energy resources are abundant, the time is not ripe for the BIPV development

⁹ <http://hd2.315.org/finddate/pic/a2004/219495.jpg>

¹⁰ <http://info.tibet.cn/news/xzxw/shjj/200801/W020080116629720927058.jpg>

because of the stalled local economic development. In contrast, BIPV is now developing mainly in affluent urban regions such as Beijing, Shandong, the Pearl River Delta including Guangzhou, and the Yangtze Delta including Shanghai.

Urban buildings' floor areas total 40 billion m² and their roof areas aggregate 4 billion m². Of these areas, those available for BIPV are estimated at about 5 billion m². If PV systems are installed for 20% of the available space, PV capacity may total 100 million kW. The 2007 Medium to Long-Term Renewable Energy Development Plan set the urban solar roof installment target at 1,000 units with a total capacity at 50,000 kW for 2010 and 20,000 units with 1 million kW for 2020. As present PV costs are too high even for residents in large cities, BIPV is mostly used for public facilities, new luxury houses, commercial buildings and symbolic buildings. A subsidy system released in March 2009 for PV systems in buildings subjects 50 kW or larger PV systems to subsidies.

2-2-3 Mega solar systems

Large-scale PV power stations in deserts represent the most promising market. Deserts, and present and potential desertification areas in China total 2.5 million km² accounting for a quarter of the country's territory. If 1% of these areas are used for PV the total capacity is supposed to reach 2.5 billion kW generating some 3 trillion kWh electricity amounting to China's total electricity generation at present.

Under such conditions, mega solar systems represent the most attention-attracting market for China's PV industry. In 2009, the Chinese government offered to further promote the domestic PV market of which the central part is for mega solar systems. A 10 MW national PV power plant project in Dunhuang, Gansu Province, for which a tender started in March 2009, has become a kind of milestone project. Future feed-in tariffs are expected to be based on a successful bid price for this project. In September 2009, major U.S. thin film PV cell manufacturer First Solar Inc. announced it had signed a memorandum of agreement with China's central government and Ordos municipality to build the world's largest PV plant with capacity at 2 million kW in a desert suburb of Ordos, Inner Mongolia.

The largest obstacle to the mega solar system development is the uncertainties about policies. For example, feed-in tariffs for PV electricity have yet to be specified. If China specifies a PV feed-in tariff system and tariff levels, its mega solar system market is expected to accelerate its development¹¹. There are other problems regarding China's mega solar system development. While China's Midwest is rich with solar energy resources and less populated and can be characterized as the most suitable for large-scale solar system locations, China's electricity consumption is concentrated in the East. Therefore, the selection of specific mega solar system locations and the construction of relevant electricity transmission/distribution systems are very significant.

2-2-4 Other applications

PV is used as power sources for equipments and devices as well as for electricity supply for daily human life. PV-powered products include telecom gadgets, solar street lights, solar traffic lights and PV-powered toys. Industrial and commercial PV applications other than telecom gadgets are not subjected to government subsidies. Chinese companies have been strong in commercializing solar street lights, solar traffic lights and PV-powered toys. As of 2007, about 200 Chinese companies were producing these products. In this field, China's domestic demand for 2010 is estimated at 5-10 MW. Cumulative installed domestic capacity is projected at 200 MW for 2020¹².

In a bid to promote renewable energy uses, the Chinese government has implemented many projects and support measures since an early stage. A common key word for these projects and support measures is "rural development." Most of them have been closely linked to rural economic development. The expansion of economic disparities between urban and rural regions since the initiation of the reform and opening policy is a serious destabilizing factor in the Chinese society. The central government has cited the resolution of the so-called three agricultural problems

¹¹ The next chapter explains details of China's feed-in tariff system for renewable energy.

¹² Reference 1

as a top-priority challenge. It views the promotion of renewable energy utilization as an effective means for improving rural living standards¹³. This is because solar energy, wind power, geothermal energy and other new energy sources are suitable for small-scale, scattered electricity consumption in farming villages that have easy access to and massively consume of such energy resources as firewood, charcoal and straw.

Over the recent years, shortages of energy supply to support fast economic growth have become a serious problem in China. It has also been plagued with environmental pollution due to its heavy dependence on coal. Wind power, solar energy and other renewable energy sources have attracted attention as contributors to resolving these problems. In February 2005, the National People's Congress adopted the Renewable Energy Law, which took effect in January 2006. Then, the promotion of renewable energy was expected to improve rural living standards and simultaneously resolve two challenges – solving energy shortages and easing environmental problems. Under such situation, it has gradually grown clearer that China's PV promotion weight is shifting from independent electricity generation systems for rural electrification to mega solar systems. Mega solar systems were involved in a tender for a national power plant project in Dunhuang, Gansu Province, and a program for the construction of the world's largest PV plant in a desert zone of Inner Mongolia, which attracted attention in China's PV industry in 2009. Over a long term, BIPV is expected to accelerate growth if more efficient and cheaper PV cells are developed.

As PV costs more than conventional electricity sources, government subsidies are indispensable for expanding the PV market. Since the Renewable Energy Law took effect in 2006, China has introduced a fixed feed-in tariff system for electricity generated with wind power and some other renewable energy sources. In the next chapter, the recent developments of this system and the specific rules and regulation on PV will be discussed.

3. PV promotion policy and new developments

3-1 Renewable Energy Law

At present, China's renewable energy promotion policy is implemented under two frameworks. One framework is the National Energy Development Plan, under which the government announced renewable energy development schemes including the Medium to Long-term Renewable Energy Development Plan and the 11th Five-Year Renewable Energy Development Plan. Another framework is the Renewable Energy Law that took effect in 2006¹⁴. The law is the base for the renewable energy promotion policy. Based on the Renewable Energy Law, the government has implemented renewable energy development promotion measures one after another. Regarding the electricity pricing problem seen as an obstacle to renewable energy development, particularly, the government has made legislative efforts. In October 2007, the National Development and Reform Commission and the State Electricity Regulatory Commission announced the Provisional Administrative Measures on Pricing and Cost Sharing for Renewable Energy Power Generation and the Temporary Measures of Regulation on Renewable Energy Surcharge, establishing a fixed feed-in tariff system for renewable energy power generation. Based on the Renewable Energy Law, the government also set conditions and management methods for participation in renewable energy development projects, fixed priority areas for support, specified relevant administrative authorities and enhanced application, approval, control, monitoring and other relevant procedures. PV-related policies taken since the effectuation of the Renewable Energy Law are listed in Appendix Table 1.

3-1-1 Latest developments regarding renewable energy

Since the Renewable Energy Law was put into force, China's renewable energy development has made rapid progress. In the PV area, cumulative installed PV power capacity in China stood at 70,000 kW at the end of 2005 and doubled in only three years after the effectuation of the Renewable Energy Law, reaching 150,000 kW at the end of 2008.

¹³ The three agricultural problems are related to agriculture, farming villages and farmers. In China as an agricultural power, two-thirds of its total population lives in farming villages. The three problems are the low productivity of agriculture, exhausted farming villages and farmers' slack income, imposing constraints on China's economic development.

¹⁴ The National People's Congress considered and passed the law in 2005.

In the three years, however, various problems regarding renewable energy development emerged, including excessive investment, blind construction, insufficient electricity transmission/distribution capacities and the not so successful implementation of the feed-in tariff system. The financial crisis since 2008 has also had an impact on the renewable energy development. Being aware of these issues, the Chinese government has launched efforts to revise the Renewable Energy Law hoping to resolve existing problems and enhance future renewable energy development.

The Environment and Resources Committee within the National People's Congress surveyed and assessed the implementation of the Renewable Energy Law and drafted a revision to the law. The revision was proposed to the 11th National People's Congress Standing Committee at its 10th meeting on August 24, 2009, and was finally passed December 26 of the same year.

The revision features the following three key points:

- State-level programs and the central government's leadership will be enhanced.
- The creation of a renewable energy development fund supported by special fiscal fund allocations and the renewable electricity surcharge.
- To guarantee that all renewable energy-based electricity will be subjected to purchases under the feed-in tariff system. The central government will set targets for such purchases. Specifically, the central government will set an annual target for renewable energy-based electricity purchases target and an implementation plan to allocate portions of the target to electricity transmission companies based on the renewable energy resources and developing status of renewable energy in the specific province. In this way, minimum purchases will be fixed for each province's electricity transmission company.

The most attention-attracting point is the enhancement of the feed-in tariff system. This system is one of the keys to the expansion of the market for renewable energy power generation that costs more than conventional power generation. In the following section, the whole picture of the feed-in tariff system for renewable energy in China and the latest developments regarding the enhancement of the feed-in tariff system for renewable energy-based power generation including PV will be discussed.

3-2 Feed-in tariff system¹⁵

The Renewable Energy Law has secured the implementation of the feed-in tariff policy for renewable energy-based electricity generation. Rules for implementation of the policy are spelled out in the Provisional Administrative Measures on Pricing and Cost Sharing for Renewable Energy Power Generation and the Temporary Measures of Regulation on Renewable Energy Surcharge, as discussed above.

Under the Provisional Administrative Measures on Pricing and Cost Sharing for Renewable Energy Power Generation, a price management organization of the State Council fixes feed-in tariffs, or prices for purchases of electricity from renewable energy that is connected to the grid, based on the principle of cost plus profit. Electric power transmission companies are required to purchase all electricity from renewable energy at the fixed prices. Under the feed-in tariff system, renewable energy surcharges are collected along with electricity charges throughout the country (except the rural areas) to cover the excessive cost of purchasing electricity from renewable energies compared with the price of local coal-fired thermal power. According to an electricity charge coordination draft in 2009, the renewable energy surcharge on electricity bills remained unchanged at 0.001 yuan/kWh for ordinary households and small to medium-sized chemical fertilizer plants and was to be raised to 0.002 yuan/kWh for other electricity consumers.

3-2-1 Latest developments regarding the feed-in tariff system

In China, the specific ways to set the tariff for renewable energy power are different for different technologies.

The feed-in tariff for biomass electricity is a province-by-province price of electricity from coal thermal power

¹⁵ Subject to the feed-in tariff system here are power plants connected to transmission systems. For rural regions' independent PV systems that are not connected to transmission systems, the government covers initial investment costs (excluding those for home power generators) and offsets operation and maintenance costs' excess over electricity charge income with renewable energy surcharges.

plants in 2005 plus a premium price of 0.25 yuan/kWh. The subsidization period is set at 15 years. But subsidies for new projects in and after 2010 will decline 2% from the previous year.

As for wind power generation, feed-in tariffs had been set at successful developer-bid prices in tenders for individual projects until 2009. In July 2009, however, the National Development and Reform Commission modified the rule to fix the tariff which is calculated based on the past bidding prices for wind power generation projects. The country's territory was divided into four zones in terms of the conditions of wind resources and tariffs were set at 0.51, 0.54, 0.58 and 0.61 yuan/kWh for each zone respectively.

The number of grid-connected pilot PV plants has been limited to two in China. Feed-in tariffs have been set separately for the two. For the future, however, the government is expected to set feed-in tariffs for PV plants in the same way as for wind power plants. A successful bid price for a 10 MW national PV power plant project in Dunhuang, Gansu Province, for which a tender started in March 2009, is expected to become the base for setting future feed-in tariffs for PV plants. The National Energy Administration requires the successful bidder to complete the project in 18 months and have an exclusive right to operate the plant for 25 years. In June 2009, the administration said an alliance of China Guangdong Nuclear Power Holding Corporation (CGNPC), (a state-run electric company), Enfinity (a Belgian power plant developer) and Jiangsu Baishide Solar Energy High-tech Company (a unit of LDK Solar Co.) made the second lowest bid¹⁶ (at 1.09 yuan/kWh¹⁷) and was chosen as the successful bidder. A joint venture is planning to set up (that is 51% owned by Zhongguang Nuclear Energy Development, 29% by Enfinity and 21% by Jiangsu Baishide Solar Energy High-tech) to construct and operate the PV plant.

The revised Renewable Energy Law left provisions on feed-in tariffs unchanged while changing feed-in tariff settlement procedures. Under pre-revision provisions, collected renewable energy surcharges were perceived as revenue of power transmission companies. Tax accounted for about one-third of the surcharges. In provinces that have introduced more renewable energy power plants than others, the collected surcharge may not be able to cover all the excessive cost for purchasing renewable electricity. In this case, renewable energy-based electricity, the purchasing cost of which cannot be covered by the surcharge in these provinces may be sold in the form of credit to provinces that have unused surcharge income. Surcharges may thus be coordinated (traded) between provinces. In the case of interprovincial surcharge coordination, power transmission companies and renewable energy-based power generators are required to settle their deals within 10 days after such coordination. The problem under pre-revision provisions was that the surcharge coordination process took too much time and thus had a bad impact on the cash flow of the developer of renewable energy electricity. Under the revised Renewable Energy Law, renewable energy surcharges collected throughout the nation will be managed by a renewable energy development fund, which will provide electric power transmission companies with subsidies for purchases of renewable energy-based electricity. This mechanism may shorten these companies' fund-raising processes. The revised law also enhances purchases of all renewable energy-based electricity. Therefore, the policy environment for the promotion of renewable energy is expected to improve further.

Meanwhile, some problems regarding the Chinese PV industry have emerged since the Lehman shock, including a low rate of domestic-produced materials and equipments, blind and excessive investment and the downstream sector's heavily dependence on exports. While promoting the establishment of domestic market to foster the domestic PV industry, the Chinese government also has indicated a cautious attitude toward the industry for its sustainable development. The impacts of recent policy measures on the PV industry will be briefly analyzed in the following chapter.

¹⁶ In the final round of the tender, a group of SDIC Huajing Power Holdings Co., Ltd. (a former Sinopec unit) and Yingli made a surprisingly low bid at 0.69 yuan/kWh. In early June, however, the group said it would withdraw from the tender.

¹⁷ China's average coal thermal power generation cost is about 0.3 yuan/kWh. According to the electricity price standard published in July 2008, a unit electricity charge for ordinary households in Gansu Province stood at 0.51 yuan/kWh.

4. Impacts on PV industry¹⁸

More than 90% of PV cells produced in China are polysilicon cells. The industry chain for silicon-based PV industry chain is given in the Figure 4-1.



Figure 4-1 PV Industry Chain

While more than 90% of PV cells produced in China use polysilicon materials, most high-purity polysilicon for the production of this kind of cell is imported from overseas. In and after 2006, silicon material price hikes¹⁹ boosted the investment in polysilicon production. As cash-rich companies were attracted by huge profit on polysilicon production, a polysilicon investment boom emerged²⁰. Supported by the central government's promotion of domestic polysilicon material technology development, local governments came up with special incentives for polysilicon producers to secure local economic development and employment, adding fuel to the investment boom. As Chinese companies have no core technology for upstream-sector silicon purification process, however, they feature higher production costs and smaller production scales than foreign companies. Chinese silicon producers are in a severe situation as international silicon prices have declined substantially as well as domestic PV cell demand's dwindling due to the 2008 global financial crisis. To regulate the blind and excessive investment, the government has decided to make the conditions stricter for participation in silicon production by companies having no sufficient business plans, while supporting excellent firms rich with technology development and financial capacity.

Appendix Table 2 lists major PV companies in China. The table indicates that Chinese PV companies are concentrated in the downstream sector, namely the manufacture of PV cells and modules. China boasts the world's largest PV cell production. But it exports more than 90% of PV cell output. In fact, Chinese PV cell makers' growth was attributed largely to the fast increasing demand in Europe such as Germany and Spain. The Chinese PV cell industry has thus been vulnerable to overseas' demand changes. This is the reason for the growing requests for the promotion of domestic PV market. In fact, China's Midwest is rich with solar energy resources. Although due to technology and financial barriers this market has not been developed yet, Chinese solar energy experts and companies have placed great hopes on the huge PV market. The industry believes that the assurance of the implementation of the feed-in tariff policy for PV will become the key to release the huge market potential.

Since coal-based electricity prices are artificially set at a very low level (or the grid parity is very low), the required subsidies to cover the gap between a tariff meeting PV costs and a competitive electricity price (coal-fired power price) are still large. Under the current renewable energy feed-in tariff system, the gap is inevitably passed on to electricity consumers throughout the nation in the form of a renewable energy surcharge (see the previous chapter for details of the feed-in tariff system). In fact, the government had been expected to fix a feed-in tariff for PV within 2009. However, the decision has been put off and for the immediate future, the government plans to set PV feed-in tariffs based on successful bid prices on a case-by-case basis in the same way as for wind. Successful bid prices will thus become references for the government to set the PV tariff in the future.

When it comes to the industry and technology issue, China has yet to complete a PV industry chain. It depends on imports for upstream materials and most of the devices and equipments for cell manufacturing, as well as for the balance of system (or BOS, which refers to components except the PV module within a PV system). Therefore, it is difficult for the Chinese industry to reduce PV system costs. For example, China can make monosilicon wafer

¹⁸ See appendix for information about Chinese PV companies LDK, Suntech and Yingli.

¹⁹ Market prices of high-purity silicon rose substantially from a \$25-40/kg range between 2001 and 2003 to a \$200-300/kg range in 2006.

²⁰ According to China's domestic statistics, planned production capacity is expected to reach 100,000 tons in 2010.

production reactors but depends on imports for all polysilicon wafer production reactors. Although China has rapidly expanded silicon ingot and wafer production over the recent years, the productions are mainly for monosilicon ingots and wafers.

Besides the above issues regarding the PV industry, production in China depends heavily on human labor, resulting that the level of automated production is relatively low. China has a cost advantage because of cheap human labor costs. However, thinner cells are difficult for humans to handle and constraints thus exist on the precision of products. Given the future intensification of competition, major Chinese solar cell makers are becoming positive to improve the level of automated production.

As China's PV market is still immature, the PV industry has lagged behind in developing and producing BOS components other than PV modules. For example, domestic manufactures have made progress on the development of storage batteries, but not include the specific storage batteries for PV systems. If domestic demand increases, China will have to step up the development of storage batteries suitable for PV systems. Chinese BOS component manufacturers lag behind their foreign counterparts in product functions and reliability. If the domestic market expands, domestic makers are expected to put more funds and intelligence for BOS components development to enhance product quality and accelerate product development and production.

The improvement of technology capability is the biggest challenge that the Chinese PV industry must address. Within the following key national research support programs the PV related subjects are also contained.

- National Basic Research Program (also called 973 Program): The program is designed to support cutting-edge PV technologies. For example, it supports the research and development of technologies and basic principles for thin-film PV cells and dye-sensitized solar cells.
- National High-tech R&D Program (also called 863 Program): The program supports research on PV technologies that can be commercialized. For example, it supports research on PV cell manufacturing equipments, CdTe and CuInSe materials, and thin-film cells.
- Gongguang Program (renamed Zhicheng Program in 2006): Since the sixth five-year development plan, the Gongguang Program has supported major PV technology research projects with a fixed amount of funds.
- Industrialization Program: The program provides financial support for the industrialization of technologies that have matured through PV R&D efforts.

In January 2009, the Chinese Academy of Science announced it would launch the Action Plan on Solar Energy. The announcement said that the academy would make all-out efforts to cooperate with relevant science and research organizations throughout the country to achieve the in three-stage solar energy R&D target toward 2035: distributed PV systems before 2015, alternative option of fossil fuels before 2025, and large-scale PV applications before 2035, finally making solar energy China's important energy source by around 2050.

5. Future Challenges

The above discussions indicate that China has three urgent challenges to tackle in order to realize the penetration of PV and other renewable energy sources – (1) clarification of the feed-in tariff system, (2) technology innovation to foster the sustainable development of PV industry, and (3) well-designed action plans. Regarding the three challenges the specific issues and government initiatives are listed below:

- Improvement of feed-in tariff system

The improvement of the feed-in tariff system holds the key to the development of the Chinese PV market. So far, China's PV power plants have been limited to pilot plants, with feed-in tariffs set on a case-by-case basis. These tariffs have failed to be unified. The basic problem is that PV has been too costly or burdensome for both the government and electric power transmission companies. In March 2009 when the government announced the introduction of subsidies for PV systems in buildings, the announcement was viewed as the first step toward the promotion of domestic grid-connected PV systems. At the same time, a tender started for a 10 MW national PV power plant project in Dunhuang, Gansu Province, which is expected to provide references for a future feed-in tariff for PV systems. But the

government has delayed a decision on the PV feed-in tariff and plans to set tariffs through tenders for specific projects. The PV feed-in tariff system, though making progress, is still in a trial and error stage.

While the set of the tariff attracts attention, the government should also pay intensive attention to the clarification and simplification of procedures for connecting PV systems to the transmission grid and on electric power transmission companies' mandatory purchases of all PV electricity. On the latter matter, the government must appropriately consult with electric power transmission companies to secure stable PV system operations upon the installation of massive PV systems.

- Promotion of technology innovation

According to technology limitation, Chinese PV system companies have to depend on imports for supply of purified silicon for cell production. The absence of domestic polysilicon production is seen as a bottleneck limiting the capacity of China's PV industry. China also depends on imports for several types of PV system components as well as for some key equipments for cell production. The Chinese industry should also update current technology level in order to enhance its international competitiveness. The Chinese government and relevant companies have identified constraints on domestic technology development and will continue to invest financial and human resources in basic research and technology development. The "Golden Sun" program, released in July 2009, also contains the support for the industrialization of cutting-edge technologies.

- Development of persistent master plan

In order to reasonably use funds and resources, the central government should enhance its controls and develop a comprehensive plan to promote the PV industry and market which are at their initial development stage. It is important to develop electricity transmission and distribution infrastructure in line with PV power plant construction while preventing excessive investment and waste construction. In fact, the revised renewable energy law indicates that the government would enhance its plans and instructions on renewable energy.

Part I of this paper introduced China's PV market, PV promotion policies and their impact on the PV industry. In Part II, analysis of China's PV promotion policies, the latest developments in China's PV industry and the implications for foreign players will be discussed.

References

1. Li Junfeng, Wang Sicheng, etc., *China Solar PV Report-2007* (in Chinese), China Environmental Science Press, Beijing
2. NEDO Overseas Report No.995, 2007.2.21
3. NEDO Overseas Report No.1015, 2008.1.23
4. Tomoo Marukawa, *Present PV Cell Industry Situation and Suntech's Expansion into Japan*, <http://www.iss.u-tokyo.ac.jp/~marukawa/suntech.pdf>
5. LDK HP (in English) <http://www.ldksolar.com/>
6. Suntech HP (in English) <http://www.suntech-power.com>
7. Yingli HP (in English) <http://www.yinglisolar.com>
8. Wang Zhongying, Ren Dongming and Gao Hu, *The Renewable Energy Industry Development Report 2008* (GOC/WB/GEF China Renewable Energy Scale-up Program), Chemical Industry Press, July 2009, Beijing
9. China National Energy Administration, *China Energy Development Report 2009* (in Chinese), Economic Science Publishing House, 2009, Beijing
10. Chinese Renewable Energy Development Strategy Research Group, *Chinese Renewable Energy Development Strategy Research Series – General Edition* (a key consulting project at the Chinese Academy of Engineering), China Electric Power Press, 2008, Beijing

Appendix Table 1 PV Policies since Renewable Energy Law Implementation

Year	Organization	Policy	Key Points
2005	National People's Congress	Renewable Energy Law	The NPC passed the law in 2005 for its implementation in 2006.
2005	National Development and Reform Commission	Renewable energy industry development instruction list	The list spells out 88 renewable energy areas (including 35 PV areas) subject to support.
2006	National Development and Reform Commission	Provisional administrative measures on pricing and cost sharing for renewable energy power generation	The document covers how to calculate feed-in tariffs for renewable energy and the feed-in tariff system.
2006	National Development and Reform Commission	Administrative provisions for renewable energy power generation	The document specifies the scope of management responsibility for the central and local governments, the scope of responsibility for central government organizations, and the responsibilities and obligations of electric power generation and transmission companies.
2006	Ministry of Finance	Provisional administrative measures on the Renewable Energy Development Fund	The document specifies the scope for support from the Renewable Energy Development Fund and explains the procedures for applications for financial support and their acceptance. It also clarifies financial support methods and the scope of their applications and specifies the responsibility for monitoring and reporting uses of the fund.
2006	Ministry of Finance and Ministry of Construction	Provisional administrative measures on the fund for renewable energy applications for buildings	The document specifies how local government regulatory organizations should consider applications for subsidies for projects to use renewable energy in buildings and how they should appropriate those subsidies.
2006	Ministry of Finance and Ministry of Construction	Instructions on deliberation process of pilot projects for renewable energy applications for buildings	The document specifies how local government regulatory organizations should deliberate pilot projects. Approved projects will be announced annually.
2007	Ministry of Science and Technology, National Development and Reform Commission	Renewable energy and new energy international cooperation plan	The plan promotes international cooperation in research on renewable energy and new energy priorities.
2007	National Development and Reform Commission	Temporary Measures of Regulation on Renewable Energy Surcharge	The document provides for how electric power transmission companies should collect and use renewable energy surcharges.
2007	National Development and Reform Commission	Medium to Long-term Renewable Energy Development Plan	The plan sets renewable energy development goals for 2010 and 2020.
2008	National Development and Reform Commission	11th Five-Year Development Plan for Renewable Energy	Based on the Medium to Long-term Renewable Energy Development Plan, the document sets renewable energy development goals (including modified ones) for 2010 and provides for specific action plans.
2009	Ministry of Finance and Ministry of Construction	Building PV Subsidy Policy	A subsidy of 2.90 U.S. dollars per watt (in 2009) is provided for large-scale (50 kW or larger) PV panels that meet minimum conditions (energy conversion efficiency at 16% for monosilicon PV cells, 14% for polysilicon PV cells and 6% for non-silicon PV cells).
2009	Ministry of Finance	Golden Sun pilot project	The document provides for subsidies to be given to 500 MW or larger PV plant projects in the coming two to three years. A subsidy will cover 50% of a total project investment amount in principle. The percentage may be raised to 70% for some unelectrified regions.
2009	National People's Congress	Revision of the Renewable Energy Law	The revised law was passed on December 26, 2009.

Source: "China Energy Development Report 2009" and other data compiled by the author

Appendix Table 2 Major PV Companies in China

Company name	Wafer and ingot	PV cell/module	PV system assembly	Notes
Beijing CORONA Technology Company Ltd.			○	Controlled by the Chinese Academy of Sciences
Beijing New Energy Technology Development Co.			○	Controlled by the Energy Research Institute, National Development and Reform Commission
Soltech Corp.		○		A China-U.S.-Taiwan joint venture
Beijing Yiwei Fengda Electronic Technology Co.			○	
Hebei Jinglong Group	○	○		A JA Solar shareholder
Baoding Tianwei Yingli New Energy Resources Co.	○	○	○	Yingli
Hebei Ningjin Songgong Semiconductor Co.	○			A Hebei Jinglong Group member
Tianjin Jinneng Solar Cell Co.		○		A pilot enterprise approved by the State Development Planning Commission to produce thin-film non-silicon PV cells
Jinzhou Xinri Silicon Materials Co.	○			Monosilicon/ingot
JA Solar Co.		○		JASolar
LDK Solar Energy High-Tech Co.	○		○	
Jingxing Electronic Material	○			A Hebei Jinglong Group member
Linuo PV High-Tech Co. (Shandong)		○		
Suntech Power Co.		○	○	Suntech
Trina Solar Energy Co. (Changzhou)		○		
Nanjing China power PV Ltd.		○		
Solarfun Co. (Jiangsu)		○		Solarfun
Shanghai Solar Energy Science and Technology Corp.		○		
Shanghai Chaori Energy Science&Technology Co.		○		
Shanghai Linyang Solar Energy Science & Technology Co.		○		Solarfun
Zhengjiang ReneSola Co.	○			Renesolar Ltd.
Ningbo Solar Electric Power Co.,		○		
Shenzhen Topray Solar Co.		○		Products include solar water heaters as well.
Shenzhen Chuangyi Science & Technology Development Co.		○		Thin-film non-silicon cells, BIPV
Shenzhen Jiawei Industries Co.		○		Products include solar lamps as well.
Yunnan Tianda Photovoltaic Co.		○		
China Xinjiang SunOasis Co.		○	○	Cooperating with Tsing Hua University

Sources: The Renewable Energy Industry Development Report 2008 and various other documents

Appendix: Introduction to PV companies in China

LDK Solar Co., Ltd

LDK Solar Co. (hereinafter referred to as LDK) is cited as the most attention-attracting Chinese silicon wafer maker. In 2005, Mr. Peng Xiaofeng founded LDK for the production of wafers for PV cells under the support by the Xinyu city government in China’s Jiangxi Province. LDK was listed on the New York Stock Exchange in June 2007 and has since then grown rapidly. It has set and achieved ambitious business targets (Figure 1).

According to published information on the Internet, about 80% of materials for wafer production were silicon scrap collected at lower cost in 2007. In addition to cheap labor, this is one factor behind the low production cost at LDK. As silicon scrap alone could not cover LDK demand for silicon materials to meet the company’s ambitious production capacity expansion target, LDK put its eye on polysilicon production and launched the construction of a 15,000-ton polysilicon production plant in August 2007. But the global recession forced LDK to postpone the completion until the second quarter of 2009 for Phase 1, the second half of 2009 for Phase 2 and 2010 for Phase 3 (each phase involves a production capacity of 5,000 tons). Meanwhile, LDK planned to double the production capacity of a small plant to 2,000 tons by the end of 2009. Over the immediate future, this small plant will play a central role.

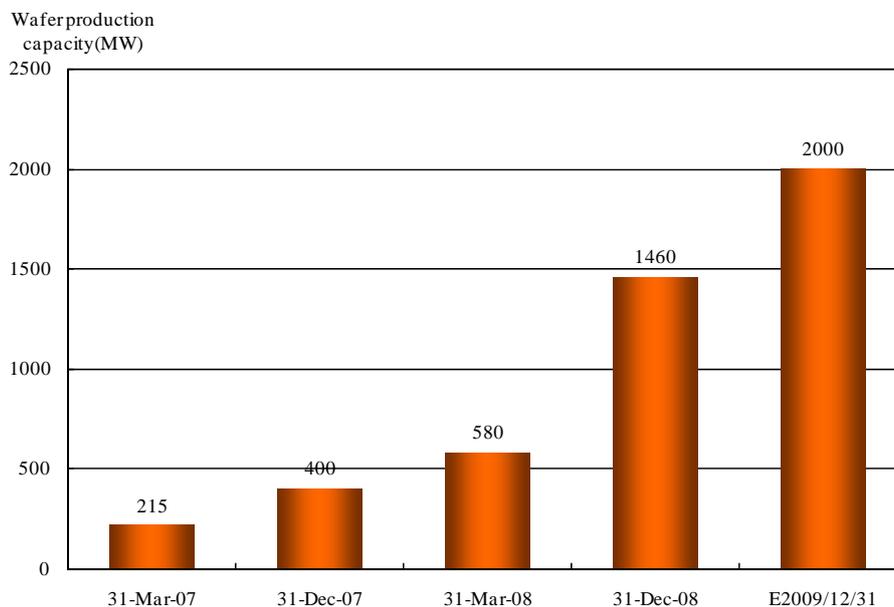


Figure 1 Changes in LDK’s Wafer Production Capacity²¹

Source: LDK website

Hit seriously by the financial crisis, LDK posted net losses in the first and second quarters of 2009. As the Chinese government has released several policies to support the domestic PV industry, however, silicon wafer demand is expected to gradually recover. In March 2009, an LDK-affiliated PV cell maker formed an alliance with a major Chinese electric power company and a large Belgian power system developer to make a bid for a 10 MW PV plant project in Gansu Province in March 2009. The alliance’s bid turned out successful in June 2009. In April 2009, LDK said that it would form a joint venture with the German PV giant Q-Cells to develop PV plants in Europe and China. In July 2009, LDK announced its acquisition of an Italian PV system developer Solar Green Technology S.p.A. (SGT). Later, it unveiled domestic PV plant construction projects one after another. LDK has made a clear commitment to its strategy for expanding into the PV system business as well as organizing a vertically integrated business group undertaking from

²¹ E for December 2009 indicates “estimated.”

material production to power generation.

Suntech (Wuxi Suntech Power)²²

Outline

Suntech was founded in 2001 under the support by the local government Wuxi city in Jiangsu Province. Its founder Dr. Shi Zhengrong graduated from the Changchun University of Science and Technology in China in 1983 and received a Master degree in laser physics from the Shanghai Institute of Optics and Fine Mechanics, the Chinese Academy of Sciences, in 1986, before entering the University of New South Wales in Australia. He received a Ph.D. in electrical engineering under the direction of globally famed solar cell researcher Prof. Martin Green at the Australian university. Mr. Shi later led a thin-film PV cell research group at the University of New South Wales in Australia and served as a director at Pacific Solar Pty., Ltd., an Australian firm pursuing commercialization of thin-film technology, until 2001. Mr. Shi has obtained 11 patents in PV technologies. Suntech, though registered in the Cayman Islands, is based in Wuxi. It launched production in September 2002. In March 2005, PHOTON International ranked Suntech as one of the world’s top 10 PV cell manufactures in fiscal 2004. Supported by the Wuxi city government, Suntech was listed on the New York Stock exchange in December 2005. A state-run corporation then released its 70% stake in Suntech, completing Suntech’s privatization. With enhanced financial resources, Suntech has been expanding production further. As indicated by the figure below, Suntech’s PV cell production capacity reached 540 MW at the end of 2007 and was planned to expand to 1,000 MW by the end of 2008 (Figure 2).

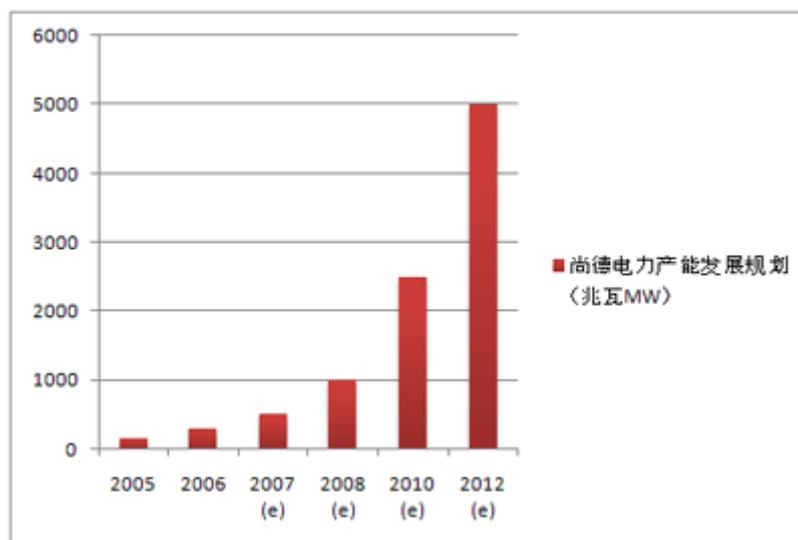


Figure 2 Suntech Production Capacity Development Plan

Source: Suntech website

To reduce silicon consumption, Suntech has tried to produce PV cells using thinner silicon wafers. Suntech’s annual report says the silicon wafer thickness has been reduced to a 180-220 micron range. It is also tackling research on next-generation thin-film (silicon) PV cells. On May 9, 2007, Suntech launched a \$300 million project to construct a thin-film silicon PV cell manufacturing base in Shanghai’s Caohejing Pujiang High-Tech Park. The base was planned to have six 50 MW thin-film silicon PV cell production lines. The construction was planned to be completed by the second quarter of 2009 and the first production line was planned to be completed in the second half of 2009 to start commercial production of thin-film PV cells. Timing for further scale up will be fixed basing on market growth.

Marketing

²² See Reference 4, Suntech’s website, its Annual Report 2007, etc.

In 2007, 98.1% of Suntech’s product output sold overseas and, 88.7% of Suntech’s revenues were from the European market. Germany was the largest sales destination for Suntech, accounting for 50.9% (42.5% in 2006) of the firm’s revenues, followed by 34.6% for Spain (20.6% in 2006) (Figure 3).

Due to the 2008 financial crisis, bank loans for power plant construction projects in Europe have stagnated. Furthermore, Spain has lowered tariffs for PV and set FIT quotas. European demand is expected to remain slack in the coming two to three years. Meanwhile, Suntech is likely to pay greater attention to Japanese and U.S. markets in consideration of Japan’s reintroduction of PV subsidies, its planned feed-in tariff system and the U.S. administration’s positive attitude toward clean energy support policies.

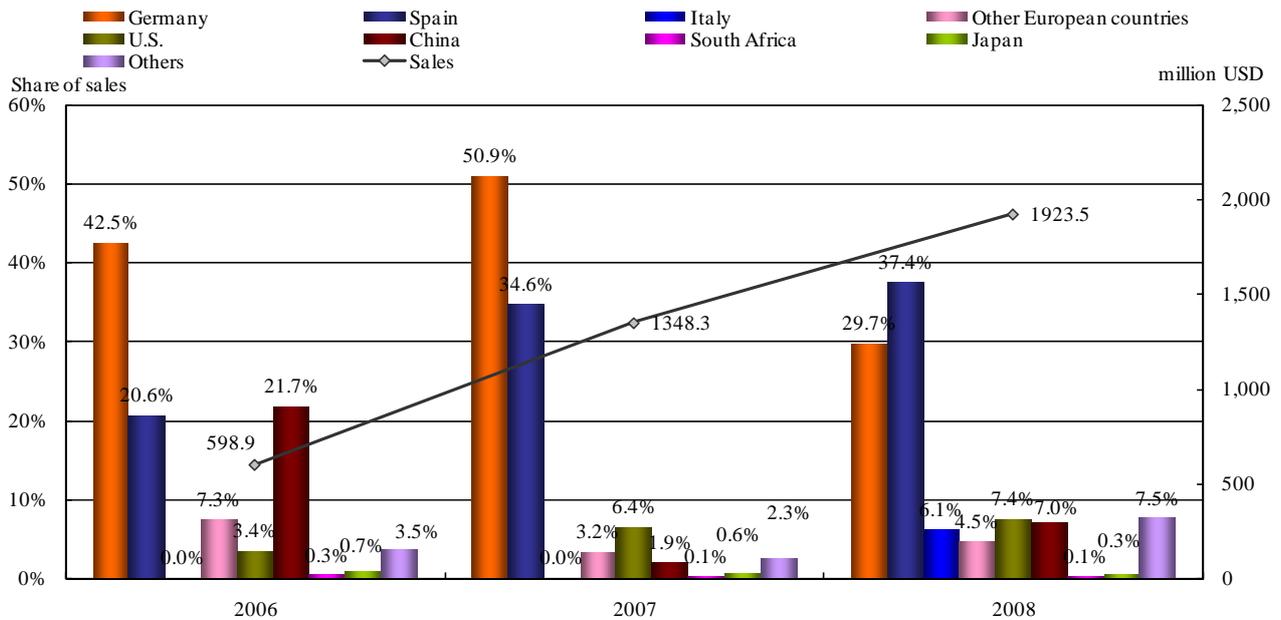


Figure 3 Suntech’s Major Sales Destinations

Source: Suntech Power Annual Report 2008

In August 2006, Suntech clinched a deal to acquire Japanese PV module maker MSK that is advanced in the BIPV (building-integrated photovoltaics) technology. Suntech has taken advantage of MSK’s technology and sales network to expand its BIPV division. Particularly, it plans to expand into Spain and the United States that it views as its major BIPV markets. Suntech has also exploited its MSK acquisition to expand into the Japanese market. Suntech Chairman Shi Zhengrong aimed to expand the firm’s share of the Japanese PV market to 10% within 2009.

In response to slowing overseas demand, Suntech has begun to seriously consider its participation in the power system development as one of its future strategies. In March 2009, Gemini Solar Development Company LLC, a joint venture between Suntech and MMA Renewable Ventures, was reward to build a 30 MW PV power plant in Texas. Gemini plans to operate the plant on its own and has signed a 25-year contract to sell electricity to Austin Energy. Suntech aims to take advantage of the favorable U.S. policy environment to undertake more PV power plant construction projects.

China’s domestic PV market is still small, dominated by PV systems for large public works projects. On January 25, 2008, Suntech established Xinjiang Suntech Energy Engineering Co., its branch in western China, targeting China’s domestic PV system market. Suntech also participated in the tender for a national PV plant construction project in Dunhuang, Gansu Province, in 2009. Though currently China accounts for only 1-2% of Suntech’s annual revenues Chairman Shi Zhengrong said that the percentage would rise to at least 10% in two years.

On February 1, 2008, Suntech founded Suntech Power (Korea) Co. as its wholly owned subsidiary to expand into the South Korean market on a full-fledged basis. In October 2008, Suntech received the KIER (Korea Institute of

Energy Research) product certification from the Korea New and Renewable Energy Center. In 2008, Suntech clinched a deal with Abu Dhabi's Masdar City to provide PV modules for a 5MW PV power plant.

R&D

Suntech's R&D investment totaled \$3.358 million in 2005, \$8.372 million in 2006 and \$14.984 million in 2007. Suntech has established research cooperation relations with several universities such as the University of New South Wales in Australia, and Sun Yat-sen University and Shanghai Jiao Tong University in China. Among next-generation PV technologies under development by Suntech, the most attention-attracting one is the Pluto technology for PV cell production. According to its annual report for 2007, Suntech used the Pluto technology for pilot production to turn out monosilicon PV cells with an energy conversion efficiency of 18.0-19.0%. In 2008, Suntech began to consider a commercial production line based on the Pluto technology and applied for industrial certifications required for overseas sales of PV modules produced with the Pluto technology. Suntech planned to apply the Pluto technology for producing PV cells with a total capacity of 34 MW in 2008 and those with a total capacity of 300 MW by the end of 2009.

Yingli Green Energy²³

Outline

Mr. Miao Lianshen, now chairman of Yingli Green Energy, founded the company in 1987. Yingli, which was then a trading company, touched on the concept of new energy when Mr. Miao imported a solar neon light production line from Japan in 1993. In August 1998, Mr. Miao Lianshen founded Baoding Yingli New Energy Resources Co. with proceeds from the sale of a 60% stake in Yingli to an investment company controlled by the local government of Gaoxin District in Baoding, Hebei Province. Through changes in shareholdings, state-run Tianwei Baobian and the Yingli group became shareholders of solar energy company Tianwei Yingli. The relationship between Tianwei Baobian and Yingli is illustrated in Figure 4 below. In June 2007, Yingli Green Energy was listed on the New York Stock Exchange.

Yingli International undertakes mainly sales and marketing of PV products, while Tianwei Yingli designs, assembles, sells and installs PV systems.

Yingli's strengths include its vertical organization to produce silicon ingot and wafers as well as PV cells and modules. In January 2009, Yingli acquired silicon producer Cyber Power Group. It then planned to test produce silicon for PV cells around the end of 2009. In 2008, Yingli's production capacity reached 400 MW each for wafers, PV cells and PV modules as earlier planned. The company planned to increase the capacity to 600 MW in 2009.

²³ See the company's website, Annual Report 2007 and Fact Sheet 2008.

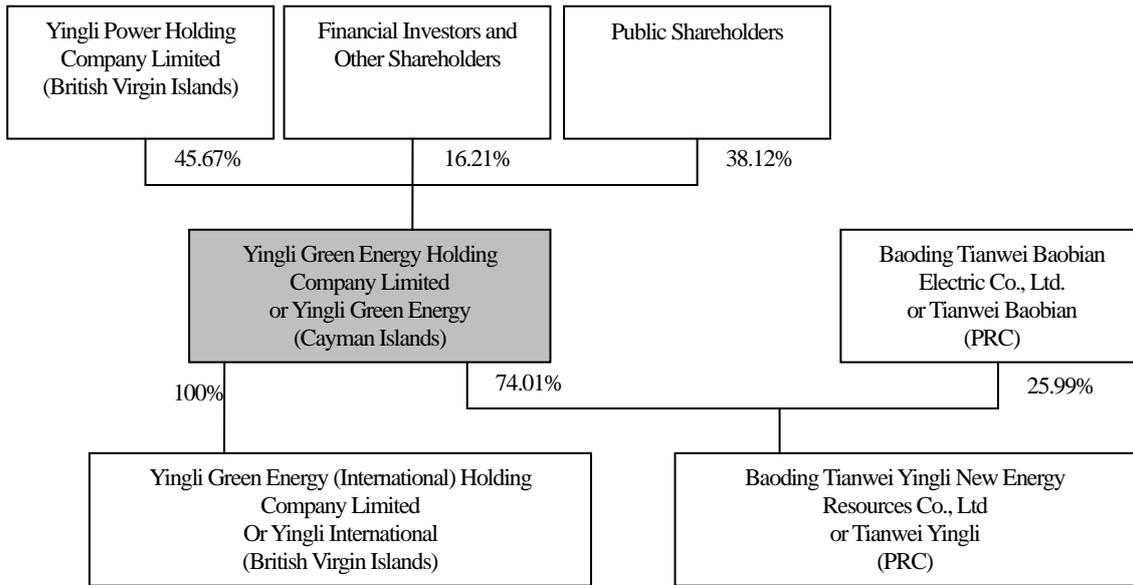


Figure 4 Yingli Organization

Source: Yingli Green Energy Holding Company Limited Annual Report 2007

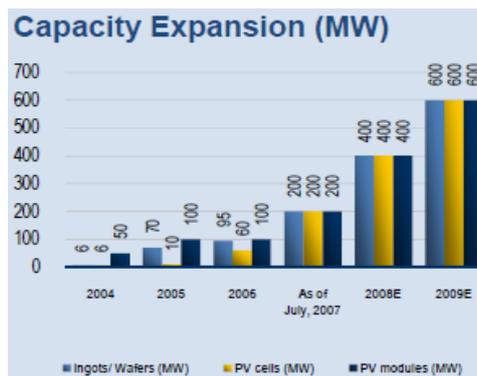


Figure 5 Production Capacity Expansion from 2004 to 2009

Source: Yingli Solar Investor Fact Sheet 2008

Marketing

Yingli’s sales had been limited to the domestic market until 2003. The company began to expand overseas market in 2004. Between 2004 and 2006, Yingli’s sales in Germany accounted for the largest share, followed by the domestic sales (2004 and 2005) and Spain (2006). However, in 2007 Spain surpassed Germany becoming the largest market for Yingli. Yingli’s main products for overseas sales are PV modules for grid-connected PV systems (Figure 6). For the Chinese market, Yingli handles not only PV modules for grid-connected PV systems but also those for telecommunications and public lighting equipments. Germany, Spain, the United States and China are major markets for Yingli. In April 2008, Yingli cut a deal to provide PV modules with a total capacity of 3.3 MW for two South Korean companies, expanding into the South Korean market.

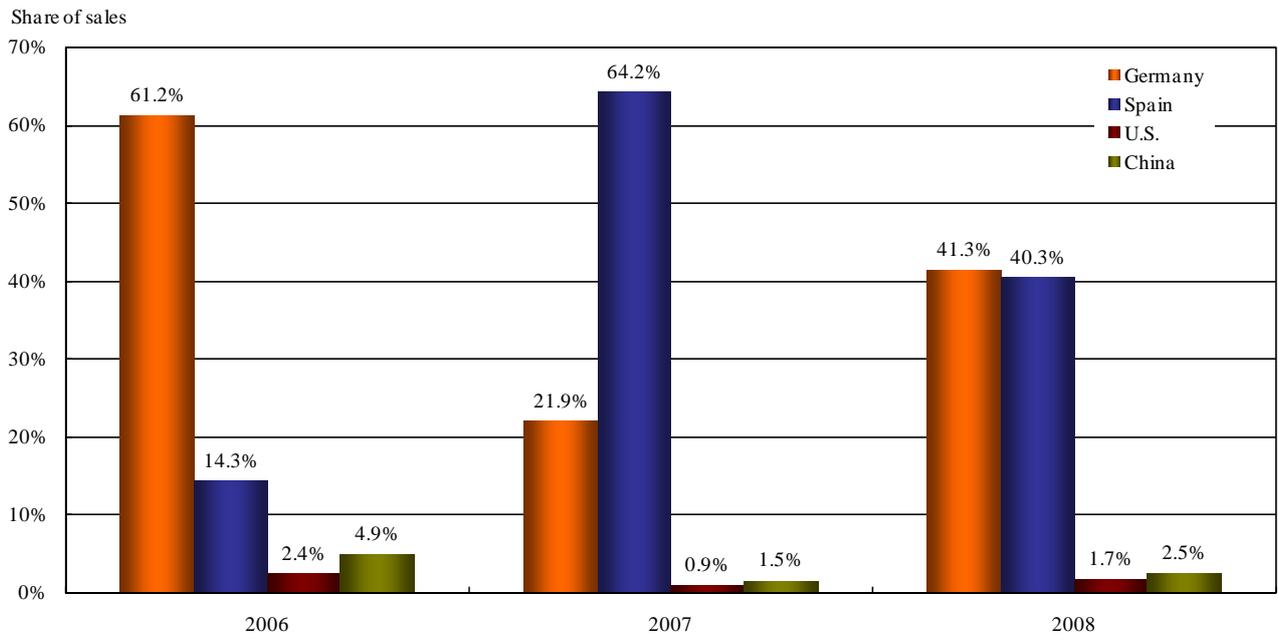


Figure 6 Yingli's Major Sales Destinations from 2006 to 2008

Source: Yingli Green Energy Holding Company Limited Annual Report 2008

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