

## China Renewable Energy Architecture Development Forecast in the Twelfth Five-year Period

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**Abstract**—Since 2005, China began to construct renewable energy buildings in large-scale manner and extensive application of solar energy and shallow geothermal energy is of great significance for promoting China's energy conservation and response to climate changes. This paper first summarizes the current development of renewable energy buildings in China, analyzes current market situation and development potential, and finally puts forward development scenario of China's renewable energy buildings in the twelfth-five year period by considering the national macro policies.

**Key words:** renewable energy architecture; development forecast; Twelfth Five-year Period

### I. INTRODUCTION

In recent years, renewable energy has been widely used in the world, for example, application of solar photovoltaic power generation and shallow geothermal energy has witnessed over 20% annual increase rate. Since 2005, with continuous strengthening of application of renewable energy and energy conservation and emission reduction in China, a number of laws and regulations have been promulgated and revised, such as "Renewable Energy Law", "Energy Conservation Law", "Medium and Long-term Development Plan of Renewable Energy" and "Civil Buildings Energy Saving Ordinance". In 2006, Ministry of Finance and Ministry of Housing and Urban-Rural Development jointly issued the "Implementation Opinions on Promotion of Application of Renewable Energy in Buildings by Ministry of Housing and Urban-Rural Development", so as to promote large-scale application of renewable energy in building area and carry out nationwide renewable energy buildings pilot work, including utilization of solar energy technologies and shallow geothermal energy technology in the construction fields[1].

As the most important alternative energy to conventional energy sources, renewable energy mainly includes wind, solar, hydro, biomass, geothermal and ocean energy. At present, the main energy used in constructions in China

mainly includes solar energy, shallow geothermal energy and biomass energy used in rural areas. During the "Eleventh Five-Year" period, China has scored remarkable achievements in renewable energy buildings, which played a significant role in the alternative to conventional energy sources. The Twelfth Five-year Period is an important period of strategic opportunity for national energy conservation and response to climate changes and renewable energy buildings will be surely pushed forward as one of the key works.

### II. CURRENT SITUATION ANALYSIS

#### A. Application of solar energy

In the 21st century, solar thermal technology has witnessed rapid development in China. According to data released by industry association, as of the end of 2009, solar water heater industry maintained the total volume of 14500 m<sup>2</sup>, up by over 16% than the previous year, and the production has amounted to 42 million m<sup>2</sup>, increasing by 35.5% than the previous year; the sales reached 63 billion Yuan, among which export sales was 200 million US dollars and increased by 66.6% than previous year; construction market accounted for about 40% of total sales with a total of about 2,800 enterprises. Table 1 shows the 2000-2009 annual production and ownership of water heaters in China and solar water heaters are growing in a very significant pace.

TABLE I. 2000-2009 ANNUAL PRODUCTION AND OWNERSHIP OF WATER HEATERS IN CHINA

Year	2005	2006	2007	2008	2009
Annual production (10000m <sup>2</sup> )	1500	1800	2340	3100	4200
Growth rate of annual production (%)	11	20	30	32	35

Ownership (10000m <sup>2</sup> )	8510	9000	10800	12500	14500
Growth rate of ownership (%)	21%	6%	20%	16%	16%

Solar heating and cooling technology is still in the demonstration phase of construction application in China and operation effect test and design parameters optimization is still underway. The implementation of national standards "Solar Heating Technical Specifications" promoted solar heating project to show a good momentum of development. As the end of 2010, solar heating project has reached 1.5 million square meters[2].

### B. Solar PV power generation

With increasing maturity of photovoltaic technology and rapid expansion of market demand in recent years, the photovoltaic industry has undergone rapid development. Production of solar cells around the world has increased by an average annual rate of 49.5% in last 5 years (from 536.8MWp in 2002 to 6850MWp in 2008); Chinese production of solar cells increased by over 400 times in recent 7 years (from about 10MWp in 2002 to 4300MWp in 2009). Solar photovoltaic industry has surpassed electronic information industry to become the world's fastest-growing high-tech industry. Table 2 shows solar cell production and installed capacity situation of China in last 10 years.

TABLE II. 2002-2009 CHINESE SOLAR CELLS PRODUCTION AND INSTALLED CAPACITY

Year		2005	2006	2007	2008	2009
China	Installed capacity (MW)	5	10	20	40	150
	Cells production (MW)	200	370	1088	2400	4300
	Accumulated installation(MW)	70	80	100	140	290

A photovoltaic construction application is relatively small in China and technology has yet to be developed. In 2009, Ministry of Finance and Ministry of Housing and Urban-Rural Development jointly launched domestic solar roof project and jointly issued Construction Ministry of Finance and the Ministry of Housing and Urban start domestic solar roofs program, having jointly issued the "Implementation Opinions on Promotion of Application of Renewable Energy in Buildings by Ministry of Housing and Urban-Rural Development", "Ministry of Finance Notification on Printing and Distribution of "Solar PV Building Application Financial Subsidy Fund Management Interim Measures" and "Notification on Printing and Distribution of Solar Photovoltaic Buildings Application Demonstration Projects Application Guidelines", and established 111 solar PV buildings demonstration projects with a total installed capacity of 91 megawatts and subsidy amount of about 1.2 billion Yuan. In 2010, the two ministries

again established a demonstration project of 90.2 MW with the total subsidy amount of 1.195 billion Yuan. According to market survey, about 10% of current projects in the market are self-invested with the total installed capacity of about 200 MW. Due to the absence network tariff and other policy support, most of the photovoltaic building projects still need the support of state funds[3].

### C. Shallow ground source heat pump

In the 21st century, affected by great development of international ground source heat pumps, China began ground source heat pump practice. Shallow ground source heat pumps include soil source heat pumps, water source heat pumps, sea water source heat pumps, and sewage water source heat pumps and other technologies. In 2004, the nationwide ground source heating total area (including cooling) reached 7.67 million square meters and the growth rate has been over 60% by 2009. In 2009, Chinese market capacity of ground source heat pump amounted to about 1.7 billion Yuan, growing by 13% compared with 2008, among which 700 million Yuan was medium and small sized units accounting for 58%.

TABLE III. 2007-2009 SHALLOW GROUND SOURCE HEAT PUMPS SYSTEM APPLICATION AREA IN CHINA

Year	2007	2008	2009
Ownership (10000 square meters)	8000	10500	13450
Growth rate (%)	About 30%	31%	28%

## III. MARKET DEVELOPMENT

### A. Solar heating

There are about over 3000 solar water heaters/heat collectors enterprises in China, among which about 100 enterprises are key enterprises and about 20 are large key enterprises. In 2007, there are about 50 solar heaters / heating collector enterprises with output sales of more than 100 million Yuan, among which 25 enterprises possess output value of more than 100 million Yuan and the market share of large key enterprises has increased from 13% to 31%.

By 2009, solar water heaters ownership of China reached 145 million square meters, an increase of more than 16% than 2008. The ownership per thousand people was 107.4 square meters. The total sale was about 57.85 billion Yuan, up by 34.5% compared to 2008, and exports reached 200 million U.S. dollars, up by 66.6%, showing rapid industry development. China's domestic production capacity can meet the demand new construction installed with solar water heaters[4].

### B. Solar PV power generation

In 2007, China produced 1,088 MWp of solar cells and became the largest solar cells producer and exporter in the world, accounting for 27.2% of the global production with annual output of over 88 billion Yuan, having become a new

growth point of high-tech industries and green economy. PV industry sales reached 88 billion Yuan in 2007 with employment of 82,800 and the sales reached 200 billion Yuan in 2008.

With regard to number of enterprises, a large number of listed companies have come to the fore. In 2007, there are more than 500 PV enterprises and institutions in China. Over 10 overseas listed enterprises represented by Wuxi Shangde, Tianwei Yingli, Jiangsu Linyang, Jiangxi LDK, Changzhou Tianhe, Nanjing Zhongdian and Hebei Jing'ao have attracted great attention of international economic community, energy sector and the business community. The output of star PV enterprise Wuxi Shangde has increased from 10MWp in 2002 to 540MWp in 2007, with production of 336MWp and the sales revenue of over 10 billion Yuan, having become one of top 3 enterprises in world PV. Solar cell production of Tianwei Yingli reached 142MWp in 2007, becoming the world's 9th photovoltaic enterprises. Chinese PV industry has embarked on a path of "specialized, intensive, large-scale" development.

At present, the production and application of solar energy in China are mainly solar cells and the efficiency of monocrystalline silicon and amorphous silicon solar cells which could be put into commercialize the production were 12% -13% and 4% -6% respectively. There is also pilot production of small amount of Polycrystalline silicon solar cells with the efficiency of about 10%. 98% of China's solar cells have been exported, witnessing export of 1.2 billion US dollars in 2006, 3.5 billion US dollars in 2007 and over 9 billion Yuan in 2008. As of the end of 2009, the total installed capacity of solar PV in China is about 180 MW[5].

### C. Ground source heat pump

Since 2006, renewable energy buildings demonstration projects launched by Ministry of Finance and Ministry of Construction contain large number of ground source heat pump demonstration projects. In 2009, renewable energy model cities evaluated by the Ministry of Finance and Ministry of Construction have taken ground source heat pump as an important building energy efficiency means, laying a good foundation to fully promote application of renewable energy in constructions.

By the end of 2007, there are over 280 heat pump manufacturers, system integration and commissioning maintenance and management enterprises in China and application projects are mainly located in Beijing, Hebei, Henan, Shandong, Liaoning and Tianjin and 80% of the projects are concentrated in North China and south part of Northeast China.

According to the trade association predicts, the sales of ground source heat pumps might reach 7.5 billion Yuan and sales of units reach 3 billion Yuan in 2010, among which ground source heat pumps account for 32%, groundwater source heat pumps make up for 42%, sewage water source heat pumps account for 12%, and surface water source heat pumps account for 14%[5].

## IV. DEVELOPMENT PREDICTION

### A. Solar heat

In terms of solar energy application area, according to China's renewable energy medium and long-term development strategy developed by National Development and Reform Commission, solar hot water will be calculated according to the installation area of heat collectors, which will be expected to reach 300 million square meters by 2020. "China's Renewable Energy Strategy" proposed that the installation area of solar collectors will amount to 5 million square meters by 2020. Considering current development trend of solar heaters, the installation area of solar heaters will far exceed the goals set by the National Development and Reform Commission by 2020, reaching medium development goals put forward in the strategic research.

According to the data from Table 1, the annual growth rate of China's solar heat application is over 15% in recent three years. With the expansion of demonstration areas imposing compulsory application of solar heat, the growth rate will remain high. During the "Twelfth Five-year Period", the expected usage area of solar heating collectors is as shown in Table 4.

TABLE IV. OWNERSHIP OF SOLAR HEAT COLLECTORS DURING THE TWELFTH FIVE-YEAR PERIOD (UNIT: 100 MILLION SQUARE METERS)

2011	2012	2013	2014	2015
1.92	2.21	2.54	2.92	3.35

During the planned period, it is expected that new solar heat collection area will reach 168 million square meters to form the total annual replacement capacity of 20.16 million tons of standard coal.

### B. Solar PV

On the basis of current situation analysis, China's solar PV building applications stay only in the initial stage and the market driving effect of demonstration projects have also shown initially, however, the lack of supporting policies leave the market for further development. According to the calculation of the goals of "establishment of 20000 roof PV projects in entire country with the total capacity of 100 kilowatts" put forward in the current state "Medium and Long-term Development Plan for Renewable Energy", China needs to achieve goals shown in Table 5 in the Twelfth Five-year Period.

TABLE V. CHINA'S SOLAR PV BUILDINGS TOTAL INSTALLED CAPACITY VOLUME PREDICTION DURING THE TWELFTH FIVE-YEAR PERIOD (UNIT: MW)

Year	2011	2012	2013	2014	2015
Total installed capacity	117.5	191.13	223	266	324

Driven by the annual demonstration projects, about 10% PV building projects have been built by the full investment of developers. By the end of 2010, the national revenue will support 180 MW and the nationwide PV building installed capacity will reach about 200 MW. If demonstration projects construction of the same scales will remain undergoing

during the Twelfth Five-year Plan, the planned goals will be achieved in advance.

### C. Ground source heat pumps

According to the Medium and Long-term Development Strategy for Renewable Energy formulated by the National Development and Reform Commission, the annual use of geothermal energy will reach 12 million tons of standard coal, namely establishment of 1 billion square meters of geothermal energy application. Calculated by annual use of 4 million tons of standard coal of geothermal energy by the end of 2010, the building application will reach 150 million square meters accounting for about 50%, namely, annually increasing by 12.8%. During the Twelfth Five-year Period, the building application area of geothermal energy is as shown in Table 6.

TABLE VI. TABLE 6 PREDICTED NEW GEOTHERMAL ENERGY APPLICATION AREA DURING TWELFTH FIVE-YEAR PERIOD IN CHINA

Year	2011	2012	2013	2014	2015
Total area ( 100 million square meters)	1.69	1.91	2.43	2.74	3.09

During the planned period, the new geothermal energy building application will reach 159 million square meters to form the annual alternative capacity of 1.91 million tons of standard coal.

## V. CONCLUSION

During the Twelfth Five-year Period, new solar energy heat collector area will be expected as 168 million square meters with solar PV buildings application total capacity of 500 MW and geothermal energy application area is expected to reach 159 million square meters with the investment of about 380 billion Yuan. The development prediction is shown as in Figure 1 and Figure 2.

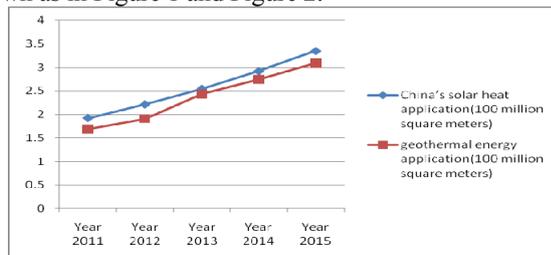


Figure 1. Solar energy building application area

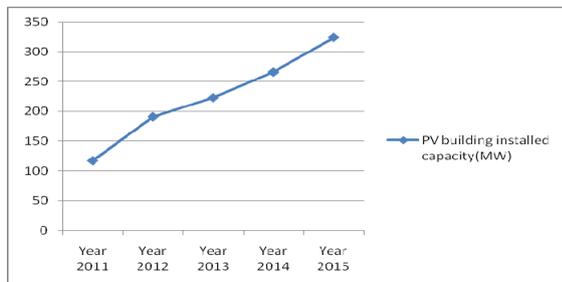


Figure 2. Geothermal energy building application area

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