The Renewable Energy Industrial Development Report 2010

Sino-Danish Renewable Energy Development Programme

Foreword

Significant outputs have been achieved for renewable energy development in China in 2009. By the end of 2009, China's hydropower installed capacity has reached 197 million kilowatts, ranking first in the world; Total installed capacity of wind power doubled for the last four consecutive years, reaching 25.8 million kilowatts; Solar photovoltaic cell production of 4 million kilowatts maintains an absolute advantage in the world; Total solar water heaters usage are over 145 million m^2, representing more than 60% of the world's total solar water heater's usage; Biomass, geothermal and other renewable energy have also developed in some extent. Without considering the traditional use of biomass, China's renewable energy usage is about 258 million tce in 2009, accounting for 8.4% of the total primary energy consumption. The renewable energy supplied electricity has reached 661.674 billion kWh, 17.9% of the total electricity in 2009.

The year 2009 is so historical for renewable energy development. In September, 2009, at the UN Climate Change Conference, President Hu Jintao publicized the serious commitment that the proportion of non-fossil fuel shall reach 15% of the total energy consumption by 2020. In the Climate Change Conference in Copenhagen, Premier Wen Jiabao announced the target that the CO_2 emission reduction per unit GDP shall reduce by 40%～45% by 2020 compared with that of 2005. The amended Renewable Energy Law was passed by the National People's Congress in December, 2009, and clearly identified the important provisions of full power purchase generated by the renewable energy power plants, established the Renewable Energy Development Fund and so forth. In 2009, the strategic position of renewable energy was enhanced. It shall play a more important role in promoting the economic transition and social development, energy mix optimization, securing energy security and combating climate change.

Meanwhile, it is highly recognized that renewable energy development is challenged by the barriers and issue, such as technology innovation, grid

integration, quality control, etc., which shall need more efforts to be addressed in long run and in an orderly way, considering renewable energy's features. Renewable energy grows very rapidly in some scale but more attention shall be paid to its quality and technology innovation.

This Report elaborates the Renewable Energy Law amended in 2009, stating the background for the amendments and lot of issues to be addressed. At the same time, the status quo review is presented in terms of the development trend and issues occurred for wind energy, solar energy, biomass energy, geothermal energy and ocean energy. In addition, the Report provides the international renewable energy development status quo with a global view, and tells the main achievements of renewable energy policy and sector development in main developed and emerging economies. The last chapter analyzes the main tasks to develop renewable energy in China and provide policy recommendations concerned.

This Report is expected to provide reference to renewable energy decision makers, commercial sectors, research institutes, universities, etc.

HAN Wenke

Director General, ERI

Content

1 Introduction of Renewable Energy Development

1.1 Status of Renewable Energy Industrialization

1.1.1 Overall Situation of Renewable Energy Development

Greenhouse gas emission has become a crucial issue in the international realms of politics and economics ever since the Climate Change Conference held in Copenhagen at the end of 2009. New energy also becomes the focal point of the world. To actively response to the global climate change, China made two promises that were closely related to the energy development: a) the percentage of the non-fossil energy will reach 15% of the total energy consumption by 2020; b) the carbon dioxide emissions of unit GDP in 2020 will be reduced by 40% to 45% from that of 2005. To achieve the two goals, the development of the new energy of wind and renewable energy must be vigorously promoted as well as the energy-saving and emission-reduction, nuclear energy and hydropower.

Guided by the Renewable Energy Law and the relevant policies, the development of the renewable energy of China accelerates. By the end of 2009, the nation's installed capacity of hydro reached 0.197 billion kW with the annual output of the electricity generated of 615.6 billion kWh, equivalent to that provided by 0.221 billion tce; the installed capacity of grid-connected wind power was 25.8 million kW with the annual output of the electricity generated of 26.9 billion kWh, equivalent to that provided by 9.119 million tce; the installed capacity of off-grid wind power was 150 thousand kW with the annual output of the electricity generated of 0.274 billion kWh, equivalent to that provided by 94,000 tce; the installed capacity of solar power was 0.3 million kW with the annual output of the electricity generated of 360 million kWh, equivalent to that provided by 0.123 million tce; the installed ca-

pacity of biomass power was 4.44 million kW with the annual output of the electricity generated of 18.4 billion kWh, equivalent to that provided by 5.888 million tce; the installed capacity of geothermal was 25 thousand kW with the annual output of the electricity generated of 0.1 million kWh, equivalent to that provided by 34,000 tce; and the total electricity generated by renewable energy was 661.674 billion kWh, accounting 17.9% of the electricity power consumed that year.

In the field of the bio-energy, the biomass pellet production reached 1.75 million tons, equivalent to that provided by 0.825 million tce; the utilization of the fuel ethanol was 1.72 million tons, equivalent to that provided by 1.763 million tce; and the utilization of the biomass power was 0.5 million tons, equivalent to that provided by 715 thousand tce. Added the non-commercial utilization including heating supply, gas supply and the solar thermal application, the annual utilization of the renewable energy amounted to that provided by 0.259 billion tce, accounting for 8.42% of the primary energy consumption of that year. The utilized quantity of the renewable energy of China 2009 is as follow in Table 1.

Table 1 2009 China Renewable Energy Development and Utilization

	Installation (10 thousand kW)	Annual production (100 million kWh)	Standard coal equivalent (10 thousand ton/year)
1. Power generation	22,718	6,616.74	22,588.6
Hydro Power	19,679	6,156.4	21,054.8
Grid-Connected Wind Power	2,580	269	919.9
Small Off-Grid Wind Power	15(250,000 sets)	2.74	9.4
Solar PV Power	30	3.6	12.3
Biomass Power	444	184	588.8
Geothermal Power	2.5	1	3.4
2. Gas Supply (methane gas)		13 billion m^3	928.2
3. Heat Supply			2,142.9
Solar Water Heater	0.145 billion m^2		1,740
Solar Cooker	3,300,000 sets		75.9
Geothermal Utilization	0.13 billion m^2	75,438 TJ	327
4. Fuel			330.3
Biomass Briquette	1,750 thousand tons		82.5
Ethanol for Vehicle	1,720 thousand tons		176.3
Bio-oil	500 thousand tons		71.5
Total			25,862.8
The Ratio of the Primary Energy Consumption			8.42%

Besides, the installed capacity of nuclear power reached 9,080 thousand kW with the electricity generated of 69.2 billion kWh, equivalent to that provided by 23.7 million tce. In 2009 the non-fossil energy made up 9.2% of the total energy consumption of the nation.

From 2005 to 2009, the utilization of the renewable energy has been expanded constantly and the contribution made by renewable energy to the total consumed energy has increased markedly. However, compared with 2008, the ratio of the renewable energy has decreased and the scale of the renewable energy use decelerated (see in Figure 1, Figure 2), which brought big challenges to the target of achieving the percentage of 15% of the total energy consumption in 2020.

The industry chain of China's renewable energy has formed rapidly regarding to the industrial development and improvement. Wind power has been facilitated the installed capacity at 10 million kW level with the respon-

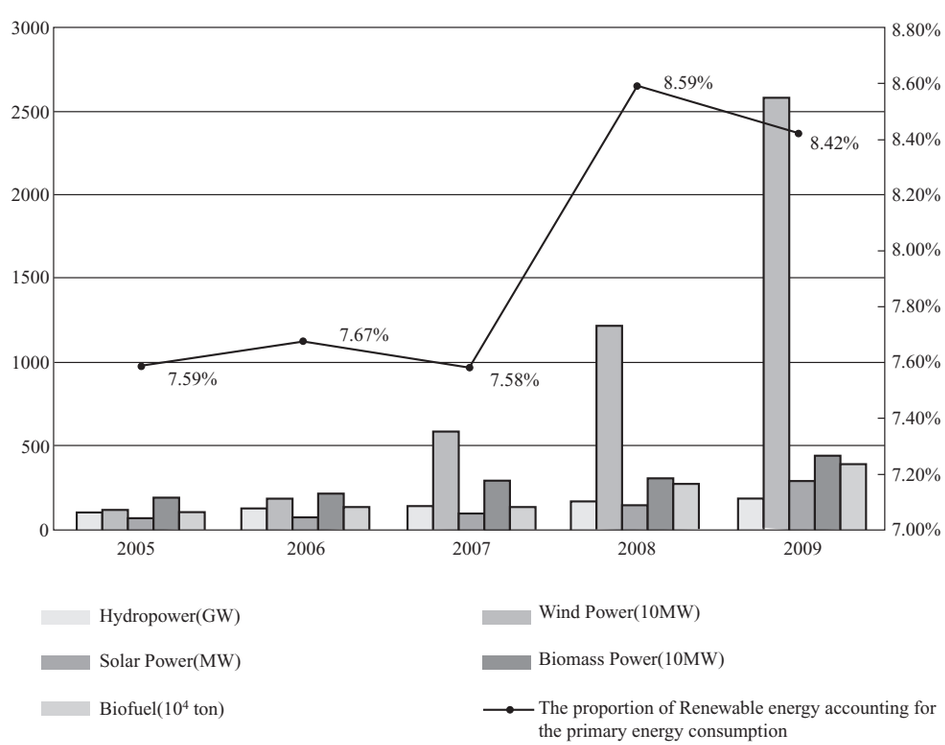


Figure 1 2005～2009 Development Situation of China's Renewable Energy

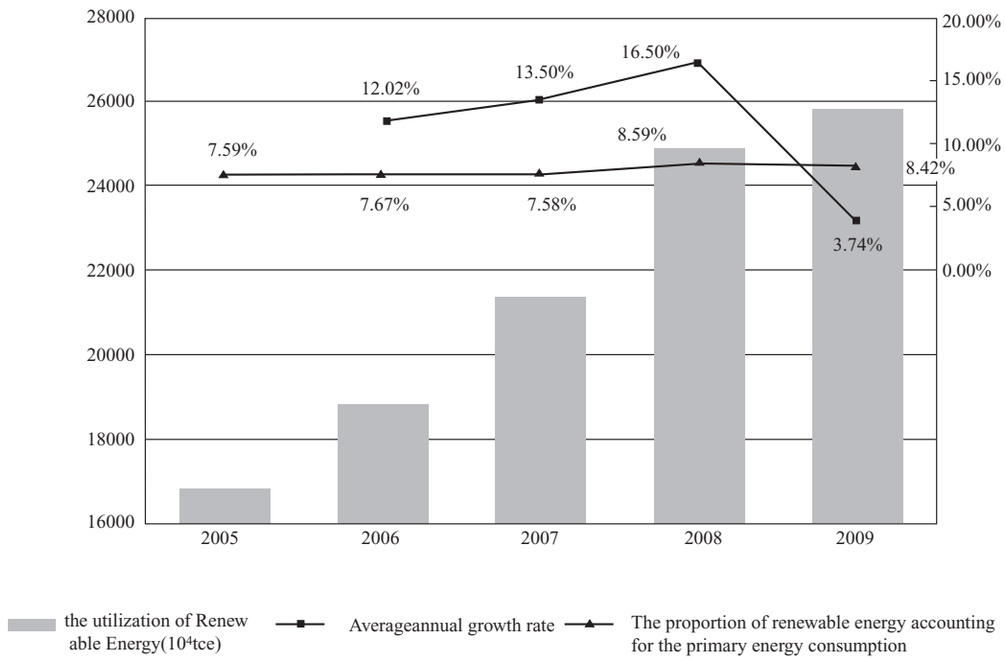


Figure 2 2005～2009 Development Situation of the utilization of Renewable Energy in China

sive manufacturing capacity of accessories; the upstream and downstream of the photovoltaic energy develops in balance; the output of poly silicon multiplies, amounting to 20 thousand tons; the markets of photovoltaic home and abroad develops rapidly; the construction of the offshore wind power has made a big stride forward; the installation of the offshore wind power plant of the East Sea Bridge has finished; meanwhile, the bidding of the construction of the offshore plants with 1 million kW capacity by the coastal area of Jiangsu has been actively promoted. The offshore wind power plants will be one of the key projects of the nation's wind power development in future.

The country is establishing new plans for new energy development based on the development situation of new energy. According to the primary plan made, by 2020, the target of the hydro power will be above 0.3 billion kW with an annual electricity generation of 1,100 billion kWh, equivalent to that provided by 400 million tons of standard coal. If the generation of nuclear energy would reach 70～80 million kW with annual output of electricity generated of 560 billion kWh, equivalent to that provided by 200 million

tce. The wind power installed capacity will reach 0.15 billion kW with an annual output of electricity generated of 300 billion kWh, equivalent to that provided by 10 million tce. The utilization of other new energy is relatively small—solar power will have a capacity of 20 million kW while that of biomass reach 30 million kW. In this situation, the total utilization of the non-fossil energy that can be commercialized will be equivalent to that provided by 70 million tce in 2020 when the ratio of non-fossil energy will be 15.2% if the total consumption by then will be equivalent to that provided by 460 million tce.

1.1.2 Basic Data of Development and Utilization of the Renewable Energies

1.1.2.1 Hydro Energy

According to the review of national water resources in 2003, the total available technical installed capacity of national water resources is 0.542 billion kW and the annual amount of power generation is 2.47×10^{12} kWh; economic available installed capacity is 0.4 billion kW and the annual amount of power generation is 1.75×10^{12} kWh. If the economic available annual amount of power generation can be reused for 100 year, the water resources, accounting for about 40% of national general residual available energy, will be only next to that of coal. By the end of 2009, the total national hydro power installed capacity is 0.197 billion kW with the annual amount of power generation is 615.6 billion kWh, taking charge of the power supply of almost half of country area, one third of counties and a quarter of the nation's population. The investigation, design, construction, installation and production of facilities of our country have already reached an international level and formed an entire industrial system. From now on, the prime problem of hydro power development is disturbance of drainage area's eco-system and related social influences.

1.1.2.2 Wind Power

In 2009, the installed capacity of wind power increased by 12.22 million kW, making the accumulated capacity 25.8 million kW. The number of wind

power plants of the nations also rose from 239 of 2008 to 423. Since the Renewable Energy Law was promulgated in 2006, the wind power stepped into a new stage of accelerated development. During the four years from 2006 to 2009, the increased annual wind power installed capacity constantly exceeded the accumulated capacity of the previous year with the annual accumulated growth rate above 100%. The Figure 3 below shows the trend of the installed capacity of wind power and the electricity generation over the years.

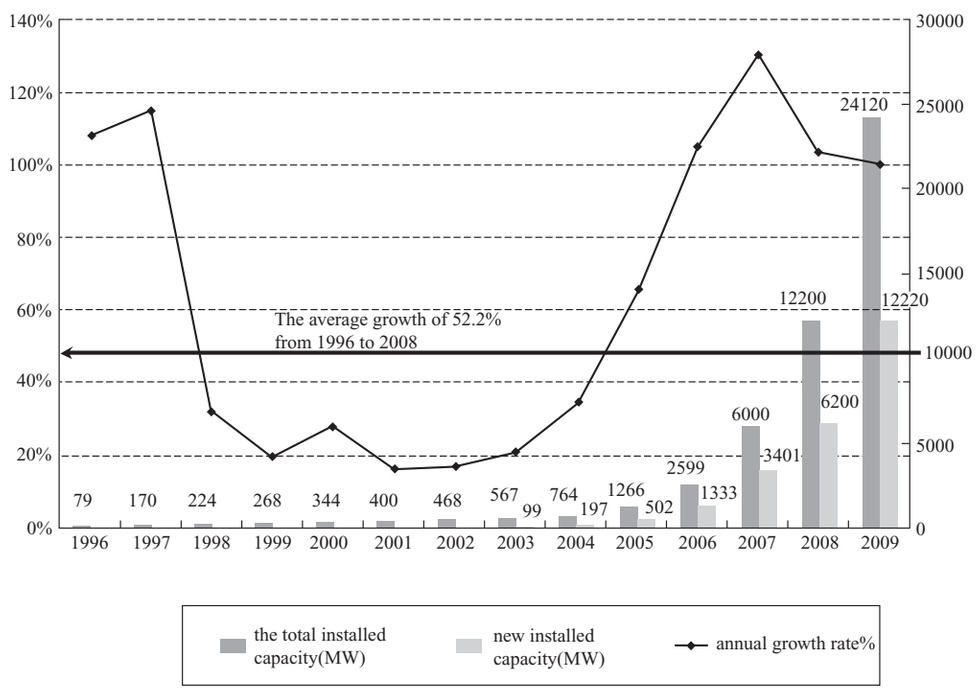


Figure 3 The Installed Capacity of Wind Power and the Electricity Generation from 1996 to 2009

Source: China Wind Power Association, 2010

1.1.2.3 Solar photovoltaic

The solar photovoltaic industry experienced its fastest growth during the 11th "Five-year Plan". Encouraged by the Renewable Energy Law and driven by the international market, China's photovoltaic industry has been growing rapidly for five consecutive years since 2004 with the annual growth rate above 100%. The output of the solar cells ranked first in the world in years of 2007, 2008 and 2009. By the end of 2009, the output of the solar PV cells was 4,000 MW, increasing by 54%, compared with 2008. The newly

increased capacity was 150 MW with the accumulated installed capacity of 300 MW, increasing 103%, compared to 2008. The trend of China's development of photovoltaic is shown in Table 2.

Table 2 2004～2009 Output of Solar PV Cells and Installed Capacity

Year	2004	2005	2006	2007	2008	2009
Output of Solar PV Cell of China(MW)	50	200	400	1,088	2,600	4,000
Annual Growth Rate of the Output of Solar PV Cells of China		300%	100%	172%	139%	54%
Accumulated Installed Capacity of China(MW)	63	68	80	100	145	300
Annual Growth Rate of the Newly Increased Capacity of China		7.9%	17.6%	25%	45%	103%

1.1.2.4 Solar Thermal Utilization.

Solar water heating system is the product of the middle and low temperature utilization of solar power. Today, the solar heating system of China has formed its production scale and has been operated as commercialized products in the market. With years of industrial accumulation, the solar heating system grew rapidly and steadily in 2009 with the annual output of 42 million m^2 and the operating quantity of 145 million m^2. The annual growth rates are respectively 35.5% and 16%. The job opportunities boosted exceeded 2.5 million which was equivalent to the output value of 63 billion Yuan. As an effective product of building energy conservation, the functions of the solar heating system are expanding from the domestic hot water supply to heating supply and the market of different applications is also being enlarged.

1.1.2.5 Biomass Energy

The bagasse power is a grown one among the biomass energy in China. Up to now, the primary sugar factories are all facilitated with bagasse power generation system and the total installed capacity of bagasse of the nation is 1.7 million kW. Agriculture and forestry residuals direct-fired power grows fastest among other biomass power technologies. By the end of 2006 when the first power plant of straw energy was put into operation, more than 50 projects of biomass direct-fired energy have been invested with the total installed capacity of more than 1.1 million kW. Presently all of the bio-

mass energy direct-fired power plants adopt straws as the material of electricity generating except Inner Mongol Shenqi Biomass Power Plant which uses salix cheilophila. By the end of 2009, the installed capacity of biomass gasification generation was around 60 thousand kW of which the primary materials were residuals including rice husks and sawdust.

By the end of 2009, there were only 3 projects on livestock farm's methane grid-connected generation, namely, Mengniu Group in Inner Mongol with the capacity of 1MW, Beijing Deqingyuan Company with the capacity of 2MW and Minhe Group from Shandong with 3MW. The grid-connected electricity generation of these projects had been accomplished by the end of 2008 and there were not any new projects put into operation. Now, apart from the methane power generated from the feces of livestocks on farms, the methane power by industrial castoffs has also come into scale. By the end of 2009, the total installed capacity of methane power by industrial castoffs reached 0.25～0.3 million kW. By the end of 2009, the total installed capacity of power by garbage burned reached 1.2 million kW, concentrating in large cities, central cities and coastal cities in southeast where the economy grow fast.

By the end of 2008, the output of the nation's biomass briquettes was 600 to 800 thousand tons. Particularly, the industry has developed fast ever since the promulgation of the Trial Regulations on the Allowance for Straw of Energy-Oriented Use. By the end of 2009, the output of the nation's biomass briquettes was around 2 million tons. As the scale of application is expanding, the research and development of the equipment of briquettes has been improved. More than 20 enterprises work on the research and development of the equipment while there are more than 10 companies doing the production at certain scales.

In the field of bio-liquid fuel, the output of ethanol by fermenting excess rice maintains 1.02 million tons. The 1.5 generation bio-liquid fuel including ethanol fuel by cassava, sweet sorghum and bio-fuel by jatropha has just experienced a slow start of industrialization. Guangxi established the cassava-based ethanol fuel project with the output of 0.2 million tons in 2007. The in-

dustrialization of the application of ethanol by sweet sorghum is respectively slow with only the pilot project of annual output of 5,000 tons in Heilongjiang province. The three pilot projects of the industrialization of bio-fuel of tung oil tree by the China National Petroleum Corporation, the China Petrochemical Corporation and the China National Offshore Oil Corporation are under construction.

1.1.2.6 Geothermal Energy

The utilization of geothermal energy can be divided into electricity-generating use and direct use. The distribution of national high-temperature geothermal energy is limited, mainly concentrating in Hengduan Mountain Range in Tibet and Yunan. The areas that have already been investigated and exploited concentrate in Yangbajing in Tibet and Tengchong in Yunan. At present, the electricity-generating use develops at a low speed while the direct use of geothermal resources is developing healthily to achieve the scales and the industrialization. Statistics shows that the capacity of geothermal energy remained 25 thousand kW with the annual output of electricity generated of 0.1 billion kWh by the end of 2009. 259 geothermal fields have been exploited and utilized with annual exploited amount of 0.368 billion m^3. The heated areas by regular geothermal resource cover 30.2 million m^2. The areas covered by ground source heating (also refrigerating for some areas) pump have the annual growth rate of more than 30%. In 2009 the areas heated bt ground source heat pump reached 100.7 million m^2 with the power utilization of 5,210MW thermal. The areas heated by regular geothermal water and ground source heat pump reached 130.9 million m^2 with the power utilization of 8,898MW thermal and the total heat generated reached 75,438 TJ which was equivalent to that provided by 3.27 million tce. The annual reductions of carbon dioxide emission and sulfur dioxide emissions were 7.79 million tons and 196 thousand tons. The sustained development of geothermal energy has made great contribution to the energy-saving and emission-reducing cause of China.

1.1.2.7 Ocean Energy

Ocean energy mainly includes tidal energy, wave energy and ocean cur-

rent energy, etc. China's utilization of ocean energy is now at its stage of researching and demonstrating. There are 3 tidal power stations in operation today and another one is in the preparation. The researching and demonstrating projects of the wave energy utilization include two off-shore OWV wave energy devices with the capacities of 100kW and 20kW, and more than 700 1kW (or below) devices. The finished tidal energy devices include the floating vertical axis device with capacity of 70kW and the base-fixed vertical axis device with capacity of 40kW.

1.2 The Framework of Renewable Energy Policy in China

The Renewable Energy Law of People's Republic of China approved on February 28th 2005 made complete regulations for the laws and policies on the promotion of the exploitation and utilization of renewable energy. President Hu Jintao promised at the UN Climate Change Conference on September 22nd 2009 that the ratio of the non-fossil energy of the total primary energy consumed would reach 15% by 2020. Prime Minister Wen Jiabao promised at the Copenhagen Climate Change Conference on December 18th, 2009 that the emission of carbon dioxide of unit GDP in 2020 would reduce by 40% to 45% compared to that of 2005. Under the strategy of the development of renewable energy, a series of laws and policies were carried out during the 10th "Five-year Plan" which vigorously promoted the development of the renewable energy of the nation.

The Renewable Energy Law of People's Republic of China established the basic laws and the policy framework of the renewable energy on February 28th, 2005. On December 26th, 2009 the Standing Committee of the National People's Congress approved the decision of the revision of the Renewable Energy Law of People's Republic of China. Based on the original Renewable Energy Law, the Revision Bill of the Renewable Energy Law firmed the three issues including the plan of the exploitation and utilization of the renewable energy, full price safeguard purchase system of electricity generation and the establishment of renewable energy development fun-

ding. Specifically they are:

First, the regulations for the planning of the utilization of the renewable energy shall be clarified. The competent department of energy and the related departments of the state department compile the exploration and utilization of the renewable energy plan on the medium-long term target of the nation's exploration and utilization of renewable energy, the strategy of energy development and the situation of the renewable energy technologies. The plan will be implemented with the approval of the State Department. Along with the overall plan of the central government, the provincial departments are expected to make their own medium-long development plans.

Second, the renewable energy development funding will be established with the national finance. The sources of the funds include the special funds guided by the national finance and the lawful taking of the additional tax upon the prices of renewable energy power.

Third, China will establish the full price safeguard purchase system of electricity generation. The competent department of energy, regulatory body of the state power and the fiscal department of State Department determined that the goal of the certain ratio of the renewable energy power upon the total electricity generated should be achieved as planned. They set the concrete procedures of the priority scheduling of the power grid enterprises and the full-price purchasing of the renewable energy power. The implementation will be done with the supervision of the competent department of energy, regulatory body of the state power.

The National Development and Reform Commission promulgated The Medium-Long Term Development Planning of the Renewable Energy in September 2007 and The 11*th* "Five-Year Plan" of the Renewable Energy in March 2008. The two plans set the guidelines and principles of the development of the nation's renewable energy, short-medium-long term target of the output and the key areas, vigorously guiding all levels of governments and all fields of societies on the development of the renewable energy.

On the basis of the exploration and development of the renewable energy, bodies including the National Development and Reform Commission con-

secutively established The Regulations on the Renewable Energy Power Generation, The Trial Procedures for the Separate Management of the Power Generating Price and Expense of the Renewable Energy Power and The Supervisory Measures of the Full Price Purchasing of the Renewable Energy Power for the power grid enterprises. These documents, on the one hand form the system of the mandatory adoption of the renewable energy of power grid enterprises, on the other hand, they form the categorized electricity price system of the renewable energy power regarding to the features and the processes industrialization of the different renewable energies, removing the obstacles of the entry and absorbing funding from the societies. The Trial Procedures of the Coordination of the Added Income from the Renewable Energy Electricity Prices established the expense distribution system for the cost of renewable energy power and firmed the of the quota of the prices added, the means of collection and the applications, which greatly promoted the expansion of the renewable energy market. The National Development and Reform Commission dispatched the document which divided China into four wind energy districts and set the responding grid-connected electricity prices of wind power mark-post on July 20th 2009. Later on November 18th it made the amendment towards the price, clearly raising the price to 0. 004 Yuan per kWh, which guaranteed the fiscal support to the renewable energy development.

In terms of the instructions and policies of the industry, documents including The Catalogue for the Guidance of the Renewable Energy Industry Development, The Trial Measures of the Management of the Special Fund for Renewable Energy, The Trial Management of the Special Fund for the Industrialization of the Equipment of the Wind Power Electricity Generation, The Trial Management of the Allowance for the Energy-oriented Utilization of Straws, The Trial Procedures of the Fiscal Allowance for the Application of the Photovoltaic Buildings and the Notice of the Implementation of the Pilot Project of Jintaiyang which were planned to support the uses of the special funds for renewable energies including wind power electricity generation, the biomass application and the photovoltaic buildings were promulga-

ted by the NDRC. These documents established the financial framework for the R&D of the renewable energy technology, the industry development and the market application.

During "the eleventh Five-Year Plan", the taxation system for promoting the renewable energy came into being. The relevant regulations include The Opinions on the Implementation of the Fiscal Allowance for Bio-Energy and Bio-Chemical Industry promulgated by the Ministry of Finance in September 2006, The Notice on Preferential Policy on Income Tax for the Innovation Enterprises by the Ministry of Finance and the State Administration of Taxation in September 2006, The Notice about the Catalogue of the Preferential Policies for the Public Facility Projects Enterprises in 2008, The Notice of the Adjustment of the Taxation on Generating Set with Great Power and the Import of the Accessories and Materials in 2008 and The Notice on the Additional taxation on the Comprehensive Products by Agriculture and Forestry Residuals, the Ministry of Finance and the State Administration of Taxation in December 2009.

Besides, the quota system, as a significant policy is being actively promoted. The relevant safeguard measures to the Medium-Long Term Planning of Renewable Energy promulgated in August 2007 stated clearly about the market quota target of the non-hydro renewable energy generation: by 2010 and 2020, the ratio by non-hydro renewable energy in big power grid-covered area will reach 1% and 3% of the total output generated. The ratios of the non-hydro power rights of installed capacity will reach 3% and 8% to the total power generated for those investors who have the installed capacity over 5 million kW. The rules for the quota system, namely, *The Management of Quota of Renewable Energy Power* (proposal manuscript) and *the Document of the Management Measures of Renewable Energy Quota* are under examination.

In the aspect of the standards making, the *Technical Regulations for Solar Water Heater Building for Civil Use*, *the Technology Regulations of Wind Farm Integration into Power Grid* by the State Grid Corporation, the Vehicle Ethanol and the Diesel Fuel and Bio Fuel have been promulgated since 2004. These regulations and standards on the production, application

and installation of the renewable energy set the direction for the development of the industry.

In April 2009, the State Grid published the *Technology Regulations of Wind Farm Integration into Power Grid by the State Grid* Corporation (in trial) and the *Design Regulations for Wind Farm Integration System* by the State Grid Corporation. These two trial standards were the responsive standards to the ones promulgated in 2006. The State Grid released the *Regulations of the Wind Power Dispatching Operation* in February 2010. The *Technical Regulations for Solar Water Heater Building for Civil Use* was sent to the Standard Commission in May 2010 and it is now under examination.

The certification system of China's renewable energy has also been started. The Certification and Accreditation Administration of China has authorized certification agencies in China to authenticate for the systems and accessories of the wind power, solar power and solar heating sets. Meanwhile, the projects of country level also make the certification essential. Besides, based on legal fact, the related departments carry out the policies including resource estimation, concession bidding and quota setting for the enterprises, which promotes the fast and steady development of the renewable energy industry. Encouraged and led by the policies, the renewable energy market of China expands with improving techniques and increasing investment. The renewable energy industry maintains a sound growth momentum. The efforts made by China in renewable energy were highly appreciated by the international community, which brings positive impact on China's dealing with other international affairs.

Table 3 Renewable Energy Policies, Regulations and Standards Issued in 2009

Renewable Energy Polices, Regulations and Standards Issued in 2009
Documents of the State Council Ministries and Commissions
Renewable Energy Law
2009-12-26
The Standing Committee of the National People's Congress "Decision of the Amendment of the Renewable Law of People's Republic of China"
2009-12-26
"Renewable Energy Law of People's Republic of China (Revision Draft)"

续表

Renewable Energy Polices, Regulations and Standards Issued in 2009
Renewable Energy Policies—Overall
2009-07-06
Ministry of Finance, Ministry of Construction "Circular of the Promotion of the Implementation of Renewable Energy Buildings in Rural Areas"
2009-07-06
Ministry of Finance, Ministry of Housing and Urban-Rural Development, "Circular the Pilot Implementation Planning of Renewable Energy Buildings of City"
2009-09-26
The State Department Forwarded to NDRC "Notice on Several Opinions on Preventing Over-Capacity of Production and Redundant Construction and Leading the Healthy Industrial Development"
2010-01-22
General Office of the State Council "Notice on the Establishment of the National Energy Commission"
2010-05-07
Ministry of Finance "Notice on the Application of the 2010 Renewable Energy Buildings Pilot Projects on City and County Levels"
2010-06-03
Ministry of Finance "Circular of the 'Trial Management of the Fiscal Allowance of Contract Renewable Energy Projects'"
Renewable Energy Policies—Wind Power
2009-07-20
NDRC "Notice on Perfection of the Price Policy of the Grid-Connected Wind Power Generation"
2009-12-25
NDRC "Notice on the Elimination of the Localization Rate of the Purchasing Facilities of the Wind Power Projects"
Renewable Energy Policies—Biomass Power
2009-02-09
NDRC, Ministry of Agriculture, "Notice on the Instruction on the Compiling of the Comprehensive Use of the Straws Planning
2009-06-15
The State Department, "Notice on the Policies of Promotion of the Biomass Industry"
2009-12-07
The State Administration of Taxation, "Notice on Additional tax Policy of the Products with the Materials of Agriculture and Forestry Residuals"
Renewable Energy Policies—Solar Power
2009-03-23
Ministry of Finance "Suggestions on the Implementation of the Promotion of the Application of the Solar Power Buildings"
2009-03-23
"Circular of the Trial Management of the Allowance of the Pilot Projects of Photovoltaic Buildings"
2009-04-16
"Notice of the Publishing of the Guidance of Application of the Pilot Photovoltaic Projects"
2009-07-16
"Notice on the Implementation of the Jintaiyang Pilot Projects"

续表

Renewable Energy Polices, Regulations and Standards Issued in 2009
2009-11-08
"Notice on the Hard Work and New Progress of the Jintaiyang Pilot Projects"
2009-11-09
"Catalogue of the Jintaiyang Pilot Projects"
Renewable Energy Policies—Small-size Hydropower
2009-07-23
NDRC, Ministry of Water Resources "Notice on the Promotion of the Small-size Hydropower Fuel and the Electrification of Rural Areas"
Renewable Energy Powers—Others
2009-01-23
Ministry of Finance, Ministry of Science and Technology "Trial Procedures of the Pilot Promotion of the Fiscal Allowance for Energy-saving and New-Energy Cars"
2009-01-23
Ministry of Finance "Notice of the Launching of the Experimental Pilot Projects of the Energy-saving and New-Energy"
Renewable Energy Power Prices
2009-06-17
NDRC, SER "Notice on Allowance and Quota Trade Planning for Renewable Energy Prices During July to December 2008"
2009-11-18
NDRC "Notice on the Adjustment of the Price of the Electricity of Northeast China" NDRC Price No. [2009]2920
2009-11-18
NDRC "Notice on the Adjustment of the Price of the Electricity of North China" NDRC Price No. [2009]2919
2009-11-18
NDRC "Notice on the Adjustment of the Price of the Electricity of East China" NDRC Price No. [2009]2924
2009-11-18
NDRC "Notice on the Adjustment of the Price of the Electricity of Central China" NDRC Price No. [2009]2925
2009-11-18
NDRC "Notice on the Adjustment of the Price of the Electricity of South China" NDRC Price No. [2009]2926
2009-11-18
NDRC "Notice on the Adjustment of the Price of the Electricity of Northwest China" NDRC Price No. [2009]2921
2009-12-25
"Notice on Allowance and Quota Trade Planning" NDRC No. [2009]3217
Renewable Energy Technology Standards
2009-04-14
"The Technology Regulations of Wind Farm Integration into Power Grid by the State Grid Corporation (in trial) "and the "Notices on The Specification of Wind Farm Integration into Power Grid by the State Grid Corporation (in trial)"

续表

Renewable Energy Polices, Regulations and Standards Issued in 2009
2009-04-14
"The Technology Regulations of Wind Farm Integration into Power Grid by the State Grid Corporation (in trial)"
2009-04-14
The Specification of Wind Farm Integration into Power Grid by the State Grid Corporation (in trial)
Local Administration Documents
2009-02-27
"Promotion and Utilization Planning of Solar Energy Industry of Qinghai Province"
2009-05-07
"Opinions on the Promotion of the Utilization and Industry Development of the Solar Power of Zhejiang People's Government General Office"
2009-05-15
"Outlines of the New Energy Industry Restructuring and Rejuvenation of Jiangsu Province"
2009-05-27
Shanghai Municipal Commission of Economy and Information, "Circular of 'Action Plan of Promotion of the Industrialization of the High-tech of New Energy (2009-2012)'"
2009-06-02
Hainan Development and Reform Commission's Reply on "Suggestions on Building Solar Power Plant to Promote the Photovoltaic Island"
2009-06-19
"Opinions of the Promotion of the Photovoltaic Industry of Jiangsu Province"
2009-06-19
"Development Concepts and the Goals Planning of the Photovoltaic Industry of Shizuishan City, Ningxia Province"
2009-07-22
"Circular of the New Energy and Renewable Energy Development Planning of Guangzhou"
2009-11-26
Chengdu People's Government General Office, "Circular of Chengdu New Energy Industry Development Planning (2009-2012)"
2009-11
"The Comprehensive Utilization Planning of the Straws of Jiangsu Province"
2009-12-15
Shandong People's Government, "Circular of the Policies of the Promotion of the New Energy Development"
Leaders Addresses
2009-09-22
Hu Jintao's Remark on the Opening of the UN Climate Change Summit
2009-12-18
Wen Jaibao's Remark on Copenhagen Climate Change Conference
2009-12-27
Zhang Guobao: General Requirement and Tasks of Energy 2010

From the present status of associated regulations and rules established, the implement framework of national Renewable Energy Law has already been set up. Whereas aspects such as price setting of renewable energy products, allowance mechanism, approving projects system and so on need further improvement.

1.3 The Management Framework of Renewable Energy in China

Considering the overall implementations of laws of China and that of Renewable Energy Law, China facilitates itself with an enforcement and supervision system formed by the supervisions of the state power, the administrative departments and the society.

The national authority could follow up the implementation status of the law and push the related administrative departments for its effective implementation through legal examination, listening to reports of governmental departments, special research and other methods that are conducted by the Standing Committee of NPC at all levels. Currently the Environment and Resources Committee of the NPC and the corresponding committees in charge of environment and resources as well as finance and economy at local levels take the responsibility of examination and supervision work.

With regards to the administrative implementation and supervision, the national and local Development and Reform Commissions dominate the implementation of the RE Law and at the same time the departments in charge of finance, science and technology, technical supervision, etc. exert specific legal functions according to the law and their administrative obligations. Within the State Council, it involves over ten ministries and departments (see in Table 4).

The implementation and supervision experiences show that civil organizations have become an important force in supervision of the law's implementation in recent years. Some of the environmental protection and energy organizations including industry association and environment civil organiza

Table 4 The Institutional Arrangements of State Council for Implementation and Supervision of Renewable Energy Law

1. Overall Administration
National Energy Administration
National Development and Reform Commission
Ministry of Finance
Ministry of Science and Technology
2. Administrations by Sectors
Ministry of Agriculture
Ministry of Housing and Urban-Rural Development
Ministry of Environmental Protection
General Administration of Quality Supervision, Inspection and Quarantine
State Forestry Administration
China Meteorological Administration
3. Independent Supervision
State Electricity Regulatory Commission

tions are greatly concerned about RE development and utilization. On the one hand, they give active support for the utilization of wind power, solar power and biomass, and on the other hand, they worry about the biological damages that are brought by the rapid development of hydro power. These organizations that pay attention to RE can be divided into three categories: those on behalf of the RE industry association and groups including All-China Federation of Industry & Commerce, Chinese Renewable Energy Industries Association, etc; the RE academy groups and organization including the Academy of Renewable Energy, Chinese Society for Environmental Sciences, etc; and civil environmental protection organizations that conduct special activities in RE area. In addition, the international environmental protection organizations have also exerted important influence in the RE development in China (see in Table 5).

Table 5 Societies and Associations Concerned in China

All-China Federation of Industry & Commerce
Chinese Renewable Energy Society
Solar Thermal Utilization Association
Solar Photovoltaic Association
Solar Photochemistry Association
Solar Building Association

续表

Wind Energy Association(China Wind Energy Association)
Biomass Energy Association
China Rural Energy Industry Association
Small Power Source Association
Bio-gas Association
Biomass Energy Conversion Technology Association
China Energy Enterprise Management Association
China Agriculture Environmental Protection Association
China Energy Research Society
Chinese Renewable Energy Industry Association
China Society for Hydro Power Engineering
China Energy Conservation Association
China Resource Recycling Association
Chinese Hydraulic Engineering Society (CHES)
Chinese Society for Environmental Sciences
China Association of Environmental Protection Industry

This shows that the public participation and social supervision have played a positive role in RE development in China. Some associations have even been actively involved in the research and drafting of the RE Law, associated rules and regulations, technical norms and standards as well as in the RE planning. They have also participated in education activities as well as implementation of some projects that make considerable contributions to the establishment and implementation of the related laws, policies and planning.

On the whole, there is a lack of general coordination mechanism in the development of the renewable energy industry. Departments of the NDRC including the Energy Bureau, the Economic Operation Bureau, the Price Department, the Industry Department, and the High-tech Industry Department are in charge of RE planning, project approval, energy allocation, prices and industry development respectively. Ministry of Finance undertakes the related budget and the arrangement of the RE Special Fund; the Ministry of Science and Technology is in charge of project demonstration of important technologies and the State Power Supervision Committee is playing the role of market supervising of RE power. There is no department that is able to overall manage the administrative functions, the related resources investigation

and planning, scientific and technological researches, technical demonstration and promotion, the supporting of industry development, project approval or pricing.

1.4 Rural Electrification in China

The electrification of rural areas and solving the electricity problems in rural and non-electrification areas is an important part of the building of a harmonious society and the construction of a comfortably-off society. It is endowed with great significance of livelihood as well as political importance.

Currently, the government attached great importance to the electrification of the rural and remote areas with constant efforts and measures. The 10th "Five-year Plan" and the "National Medium and Long Term Development Planning" clearly define that the renewable energy power shall be vigorously promoted in rural areas and the supply to non-electrified area and the improvement of the energy uses shall be one of the major tasks during the next 15 years.

By the end of the 2005, there were around 2.7 million households and 12 million populations that had no access to electricity. Generally they concentrate in rural and remote areas of Yun'nan, Sichuan, Tibet, Inner Mongol and Guangxi (See Table 6).

Table 6 Non-electrification Households and Population

No.	Province /Autonomous Regions	Non-electrification Household and Population		No.	Province /Autonomous Regions	Non-electrification Household and Population	
		Household	Population			Household	Population
1	Yun'nan	503,003	2,189,361	13	Shanxi	12,744	50,976
2	Sichuan	476,707	1,939,150	14	Ningxia	12,664	49,650
3	Tibet	212,431	1,200,668	15	Liaoning	10,854	33,403
4	Inner Mongol	186,658	746,632	16	Dalian(city)	9,821	44,670
5	Guangxi	163,302	727,892	17	Fujian	4,797	20,901
6	Chongqing	153,699	18	18	Hebei	2,800	11,909
7	Gansu	123,936	523,394	19	Hunan	31,074	124,595
8	He'nan	134,472	505,372	20	Hainan	8,700	35,000
9	Qinghai	89,488	495,372	21	Shaanxi	126,838	477,831
10	Hubei	72,947	243,482	22	Xinjiang	95,300	415,700

续表

No.	Province /Autonomous Regions	Non-electrification Household and Population		No.	Province /Autonomous Regions	Non-electrification Household and Population	
		Household	Population			Household	Population
11	Guizhou	111,830	466,350	23	Xinjiang Production and Construction Corps of CPLA	23,234	78,106
12	Guangdong	47,938	238,417		Total	2,695,681	11,467,438

In non-electrification area in China, there are still 70% households whose energy supply is generated from traditional straw, fuel wood, etc. and such energy utilization pattern is featured with low efficiency. Most of the people in such area have to depend on lighting with kerosene lamp and candle without sufficient energy and electricity supply for the agricultural and poultry product processing. The lack of the accesses to the broadcast and television isolates them from the progressing society. Only a few people can adopt diesel-powered generators for life electricity supply, but the situation is less satisfied due to the low supply, high price and bad quality.

1.4.1 Solving Models of the Electrification

The electrification of rural areas is a comprehensive project that involves aspects of power, finance, engineering and logistic service. The successful implementation demands great support from the governments, the relevant regulations, advanced technologies, modern management and diversified channels of investing and fund raising.

Presently, China adopts the model of "led by the central government, implemented by locals and enterprises, supported by international communities and financed by multi societies" to promote the electrification of rural and remote areas and to solve the power supply problem for the non-electrification areas.

(1) Led by the Central Government, Promoted Jointly by Departments

and Committees

The electrification of China's rural areas is mainly guided by the central government. As early as in 1980s, the government has organized the committees to promote the electrification of rural areas. Since 21st century, the electrification of rural areas has been developing fast with the promotion of the central government. Projects include "Tibet Non-electrification County Construction", "China Light Project", "Tibet Aliguang Power Plan", "Sending Power to the Counties Project" and "Electrification in non-electrification Areas" have been carried out and departments including the NDRC at all levels, the State Energy Administration, Department of Finance, the Department of Science and Technology, Department of Agriculture, Provincial Bureau of Agriculture, National Meteorological Bureau and the National Environmental Protection Agency were involved.

Besides, the NDRC required that the provincial committees should work out their construction planning for the non-electrification areas to solve the power supply problem of the non-electricity population in an economical and sustainable approach so as to remove the poverty, raise the living standards of the people and develop the remote areas.

(2) Implemented by Locals and Enterprises through Various Methods

The electrification of the rural areas is implemented by people's government at all levels and the relevant enterprises. The cause is undertaken within the framework of the "Electrical Codes of the People's Republic of China" and the "Renewable Energy Law of People's Republic of China" . Bodies involving include state-owned companies such as the State Grid, China Water Resources Consultancy Group and China Energy Conservation Investment Company as well as civil societies including China Association of Resources Comprehensive Utilization, Special Committee of Renewable Energy and China Methane Association.

Most of the projects obey the basic principle of "Overall organizing, scientific planning, locality adapting and results focusing" . As the power supply is guaranteed, the government greatly concerns the sustainable development of the environment. The forms of the project vary from moving to fa-

vorable areas, expanding grids to the uses of small hydropower, solar power as well as wind power.

(3) International Cooperation

The electrification of rural areas in China wins tremendous supports from international agencies and governments. The major international bodies, such as World Bank, Global Environment Funding, European Union and the governments of the United States, Germany, Japan and China establish all-around cooperation in the fields of the electrification cause.

In recent years, the World Bank has carried out a series of projects to promot the renewable energy among which there were China Renewable Energy Scale Project (CRESP) and China Renewable Energy Development Project (REDP). Since 2002, Germany has been supplying independent power system for farmers and herdsmen in remote non-electrification areas. Meanwhile, the project of "China-Germany Utilization of Renewable Energy to Promote the Development of Rural Areas" was initiated in June 2002. It was implemented at both state and local (Yun'nan, Gansu and Qinghai) levels.

(4) Raising Funds from Various Sources

The sources of the funds for rural electrification include three aspects, namely, the fiscal funds from the government, the donations from enterprises and societies, and the grant and loans from international community. The project of "Sending Electricity to the Rural Areas" is the biggest project in non-electrification and remote areas of China and even of the world with the total investment of 4.7 billion Yuan. Involving 268 small-hydropower plants and 721 solar power plants and hybrid solar and wind power plants in seven provinces (Tibet, Xinjiang, Qinghai, Gansu, Inner Mongol, Shaanxi and Sichuan) in the west of China, the state-financed project supplies power for 0.3 million households and 1.3 million populations.

1.4.2 Achievements of the Electrification of Rural Areas in China

The Chinese government is pushing the construction of primary electrification of rural areas and the electrification of towns through a set of policies and encouraging measures. Up till now, the electricity is available to all of

the towns in the power supply areas covered by the state grid. 100% of the towns, 99.9% of the counties and 99.8% of the villages are supplied with electricity with the annual per capita household electricity consumption of more than 1,000 kWh, which satisfies the demand of electricity in the new rural construction.

Besides, with the basic principle of expanding power grid, promoting small-hydropower, solar power, wind power and hybrid power, China has built up the rural energy structure of "big power grid supply as the primary, and small-hydropower, wind power, biomass power, solar power and geothermal power as secondary." Benefited from the expansion and the development of small-hydropower, more than 1.2 million households and 4.5 million populations have gained the accesses to the electricity. The technologies of solar and wind powers provide the farmers and herdsmen with lighting and media accesses in rural areas.

2 The Interpretation of Amendment to China Renewable Energy Law

2.1 The Context for the China's RE Law

In spite of rich renewable energy resources in China, the exploration and utilization of RE faced with issues and problems and developed very slowly before 2005, which cannot met the national economic development. At that time, among the issues and problem, the first critical issue for RE development was recognized as lack of policy and legislation system, including identifying development objectives, strategic policy, law and regulations, technical codes, etc. with such policy and legislations system, it is deemed that RE technologies and industry can obtain an enabling political and market environment, therefore effectively attracting more investment at home and abroad to ensure RE sector sustainable development.

According to the national and international experiences, it is very necessary for a legislation system setting up at early stage of the renewable energy sector development. Such as the RE grid integration, especially for wind power, the issues of grid integration shall be addressed by effective policy and regulations of mandatory grid integration and cost sharing. Many of the government sectors promulgated policies (for instance, wind power grid integration, low-interest loan, tax exemption, etc.), to some extent, which may be not systematic and even conflict for each other. RE power is not able to compete with conventional energy, for instance, with coal power currently without taking environmental cost into consideration, which is unfair because they are not treated as the same. Therefore, it is very hard for RE power integrating into power grids at larger and commercialized scale while lingering at the present small scale and pilot project stage.

Government commits the RE development targets, and policy, law and regulations related with investment, tariff, pricing, financial shall material-

ize the target achievements. Even in terms of the RE market development, policy, law and regulations shall identify and regulate the role of government, possible measures to be taken, the rights and obligations of market players, etc.. With such concrete provisions established in the RE Law, the responsibilities of all the players, government and market players can be contributing to RE sector development. With such background, the RE Law was generated.

2.2 About the Legislation of the RE Law

2.2.1 The Rationale of the RE Law Legislation

Based on the analysis of international experiences and Chinese RE sector development situations, setting the RE target is very critical for RE market development. Therefore, the rationale of the RE Law is to define the national target, which can expand the RE market share, reduce cost and improve technology, enhance the RE economy and competitiveness, and result in the scale-up and commercialization of RE technologies. The effective working mechanism as well as the enabling market to encourage fair and orderly competition shall be established to implement the RE Law for RE scale-up rapidly with substantial cost reduction.

2.2.2 The Factors for the RE Law Legislation

Several factors regarding to RE Law legislation are considered according to international best practice and domestic situations:

(1) Defining the strategic position of RE in China

It was not very clear for RE's position within energy strategy, which could not raise sufficient awareness of related stakeholders. Therefore, the legislation can contribute to clearly define the position and provide a legal foundation for involvements of all the related stakeholders, government sectors and industry. For instance, the incentive policy and effective measures to be undertaken by government, the power regime reform, investment and fi-

nancing reform, environmental regulations, etc. can be comprehensively considered for RE technology application and commercialization.

(2) Eliminating market barriers of RE development

RE market is a pre-condition to large scale RE commercialization and development, and within this market, the political and economic interests of all stakeholders shall be well balanced and coordinated. For instance, the feed-in tariff can clearly identify the relationship between RE power enterprises and grid enterprises, which mitigates the barriers to RE power grid connection; cost-sharing can reduce the loss of grid enterprises and attract their active participation; etc. therefore, the legislation shall play a role of establishing game rules and eliminating barriers.

(3) Establishing the financing system to RE development

Due to the high construction cost, it is very critical to solve the RE power cost sharing. The cost sharing regime established shall provide financing sources and contribute to market barrier removal and improve the involvements of players in RE rich resource area, esp. the rural energy development and non-electrified regional energy development. Such regime also can find a solution to financing for RE R& D, resource assessment, standard and code development, etc.

Expand RE market. As mentioned, the legislation can ensure RE a market to develop and grow. It has been proved by international experiences. Therefore, the potential investors can be guaranteed with good return.

(4) Setting up a full-scale industrial system

The industrial system, esp. the manufacturing industry is core to RE technology commercialization. Among the high-tech and important technology and equipment R& D projects, the RE sector shall be paid more emphasis and attracts more commercial involvements. The capacity building for RE technology improvement and innovation shall be enhanced based on such R& D projects and be finally transferred to industrial development and market competitiveness improvement.

(5) Raising public RE awareness

It is one of the important tools for public awareness rise in order to cre-

ate an enabling environment, including promotion activities of environmental protection, saving resources and energy shortage, etc.. Through the legislation, government shall set the good example to the public by RE utilization in priority, large enterprise shall be encouraged to utilize RE, and some pilot projects can be set up to orient the investment to RE technology R&D, equipment manufacturing and production. Also, promotion activities to raise public awareness may include the volunteer program to consume green energy and orient the new energy consumption concept.

2.2.3 The Principle for the RE Law Legislation

RE development is a long term mission, considering its natures of low market competitiveness and at early stage of technology development. Government support and market adjustment shall be well integrated to facilitate the RE development. Therefore, the legislations considered the following principles:

(1) The principle combines the obligations of government and the people

It is now a common practice that RE is a strategic energy solution to address the current energy demand and future energy option in the world. Most of the countries define such strategic considerations are closely related with not only obligations of government setting up the RE position by national policy, but implementations by cost sharing the additional cost of RE among all the consumers in China. Efforts by all society, RE can be developed in a large scale. For China, it can mitigate the environmental pollution caused by over-consuming fossil energy and improve the life standard of the people through developing RE, which meet the demand for social and economic sustainability. Therefore, the international experiences for obligation requirements of government and the people are learned for RE Law legislation, of which the provisions identify clearly the government obligations and emphasize the obligation of the people to consume RE. The principle is the basic to all the other regulations.

(2) The principle combines the government promotion and the market orientation

Currently, government plays a leading role in the promotion of the RE

development, for the purpose of accelerating the commercialization and scale-up of RE in China at the early stage of RE development. Therefore, the responsibility of government mainly focus on creating enabling environment, such as developing the game rules and regulating the market, while at last RE development shall be market-oriented and the market players shall be motivated with their respective interests well coordinated. The legislation shall identify the obligations of government for resource assessment, national target development, key national project investment, sector development, technology R& D, economic incentive tool, etc. At the same time, it shall define how government play a role for market regulated and competitiveness of market players motivated.

(3) The principle combines the short-term demand and long-term development

RE development can well contribute to harmonization of the demand for current energy supply and the future energy supply. Such contribution can be identified by legislation, considering commercial RE technology application, and future technology R& D. To address the current energy demand, the RE technologies of solar power, micro hydro power, efficient utilization of biomass energy, biogas, MSW combustion, LFG recovery, etc. may help to solve the issues of the rural and urban power supply. With such technology application in rural area and urban area, the life standard, environment quality and the employment and revenue are improved. Also, the measures undertaken to improve the technologies with rather market competitiveness such as small hydropower and solar water heater shall contribute much to share increase of RE power accounting for the total energy consumption and optimization and diversification of energy structure. The commercialization process for new RE technologies shall play a role in promoting the RE technologies with rich resources, market potential and contribution to energy structure optimization, such as wind power, biomass power, solar power and liquid bio-fuel. Therefore, incentives shall be adopted to create market for such technologies.

(4) The principle combines the national situations and international ex-

periences

The international best practices have proved the success of RE deployment based on effective legislation. China will learn the experiences. Therefore, during preparing the draft of the RE Law in terms of the detailed provisions, the applicable international experiences as well as national special situations shall be well integrated and consistent. For instance, the setting of National RE Target defines the RE share accounting for the total energy production and for the total energy consumption, the Cost Share regime, etc. As well, the obligations of government and all the people are identified based on experiences learned from national legislation for environmental protection and international similar experiences.

2.3 Analysis of the Key Regulations of the RE Law

The RE Law was enforced on Jan. 1st, 2006, including the five regulations to support RE technology, market and sector development.

2.3.1 The Regulation for RE National Target

It is the core content for the regulation of RE National Target that government sectors in charge shall propose the RE development objectives in a fixed period according to the legislation, based on the factors of RE resources, GDP, energy demand, etc.. Therefore, the RE deployment scale can be identified and the market to orient investment and technology improvement can be created. Other guarantees regulations, such as RE planning, FIT, tariff, etc. shall be developed to ensure the enforcement of the regulations for RE National Target. In the RE Law, the provision 4 defines the strategic position of RE; and the provision 7 identifies that the state energy authority shall develop the national target for the medium and long term RE deployment according to the energy demand and RE resources. Such target shall be reviewed and approved by the State Council and put into enforcement. The state energy authority shall work together and help regional gov-

ernment energy sectors in charge of developing and enforcing the regional RE deployment targets in medium and long term, according to the national target approved, the regional GDP and the regional RE resources.

2.3.2 Feed-in Tariff (FIT)

There are two key points about FIT. One is full purchase of the RE power, and the other is facilitating the RE power connection into grid. The two points require that grid enterprises shall not only receive all the RE power generated, but ensure the infrastructure construction for the RE power connecting the grids. Therefore, the responsibilities of grid enterprises are clearly defined.

As well, similar to the RE power grid integration, the RE Law clearly identifies the market entrance for biogas, heat by biomass and liquid bio-fuel. For the qualified biogas and heat in accordance with the gas and heat grid connection, the enterprises operating gas grids and heat grids shall approve the connection; for the qualified liquid bio-fuel in line with the national liquid bio-fuel standards, the oil sales enterprises shall accept the liquid bio-fuel within their sales network. So the responsibilities of the gas, heat and oil sales enterprises are clearly defined.

2.3.3 The Regulation of Categorized Pricing

The definition is that government identifies the price of some RE technology in a fixed period according to the National Target and different technology development. The purpose is to reduce the bureaucratic procedures to approve similar projects, to clearly signal the investment return, to reduce the project development cost and to regulate the unfair competition. The pricing mechanism defines different fixed prices according to different RE technologies within a period, as well as the methodology to adjust the prices. The principle to define the fixed prices is to improve RE deployment technology at a cost-effective way based on different RE power technologies in different regions, and flexible adjustments shall be given according to technology im-

provement; and the grid-connection price shall be publicized. As well the principle to follow the bidding price shall be reserved for concession projects but no exceeding the grid-connection price of the similar RE power projects.

2.3.4 The Regulation of Cost Sharing

The additional cost of RE power shall be appropriately addressed for RE development. As is known that RE resources is much distributed and shall be mitigate the regional impact caused by the high cost of RE deployment. Therefore, the additional cost shall be shared at national level. For instance, wind power technology is more competitive than other RE technologies. But during large-scale development, the severe facts are the wind energy resources are mainly distributed in northwest, north, north east and south east coastal areas, esp. very rich in Xinjiang and Inner Mongolia. It may be unfair to put the additional cost burden on local people, which will make them reluctant to develop RE. Also, financing support to RE development is a key issue. So fundamentally, there are two options to address the financing issues. One is to establish the RE development fund through the tariff surplus added on the final electricity price, which will be collected by utilities and grid enterprises and submitted to national finance authorities to establish the fund, but the procedure may be too complex and less practical. The other option is the setting-up cost sharing.

The regulation of cost sharing can well combine the obligations of the people and the state. It requires all the regions evenly share the additional cost, proving the legal and political fair principles. The calculation is based on provincial grid annually. Every provincial grid prepays the RE power, and at the end of the financial year, the cost are shared within all the provincial grids. Finally the additional costs are shared among all the electricity consumers.

It is defined in the provision 20 and 21 that grid enterprises shall add the additional cost caused by RE power higher than conventional energy power connected to power grids to the sales power price. The cost for constructing additional grid infrastructure shall be calculated within the transmission cost

and returned through sales power price.

2.3.5 The Regulation of Special Fund

The cost sharing should be the important support to solve excess cost for renewable energy power generation, while more financing sources are in great need for relieve the bottlenecks of other renewable energy development issues. The Renewable Energy Special Fund are established to support the fields the cost sharing mechanism cannot cover, such as bonus, subsidy, etc to be adopted to support renewable energy development. For instance, the areas cover:

- RE technology R&D, standard and pilot projects
- RE projects in rural areas
- RE distributed power system for remote areas and island
- RE resource investigation, assessment, and database
- RE equipment localization

But, the RE Law is a framework law and needs more supporting and implementation regulations. To ensure the effective, substantial and practical implementation of the Renewable Energy Law, since 2005, National Development and Reform Commission, Ministry of Finance, State Regulatory for Electric Power, the Ministry of Construction, the Standardization Administration Committee, etc. issued more than 20 implementation regulations, including:

a. The Medium and Long term RE Development Planning and the 11th Five Year RE Development Plan. The national RE targets were identified and provided overall guidance to provincial government and society for RE development.

b. The technical regulations for renewable electricity grid connection, the cost sharing for grid connected renewable electricity, the guide to RE Industries and the regulating measure for full purchase of RE power by the grid enterprises were issued to further address the barriers to RE development and attracted large investment to RE sector.

c. The trial measures to regulate RE tariff surplus was issued for the

cost sharing among all the power consumers and identifying the amount, as well as how it is collected and what it is for.

d. The trial management measure for the special fund of RE development and the trial management measures for wind power equipment localization were issued to support the development of wind power, biomass utilization and solar power combined with buildings. The financial incentive framework was established to support RE technology R&D, sector development and application.

e. The technical codes for solar water heater application in civil buildings, the technical codes for wind farm integrated into power systems, etc. were publicized. And such codes and standards of renewable energy product, technology application and building integration well regulated the sector development.

f. The tax system to renewable energy improvement is established. In the last few year, there already issued the added-value tax exemption for biogas power generation enforced in 2001, the added-value tax for wind power generation deducted with 50% and the preferential tariff for the key component imported for wind turbines developed in 2008. Besides, the tax regulations also included the preferential tax catalogue for commercial sector with a comprehensive resource utilization, the enterprises who constructed the public infrastructure, the high-tech enterprises for sector development in national priority, RE project development in terms of biomass energy efficient utilization, wind power, solar power and RE equipment manufacturing, etc. For the time being, the added-value tax is at transitional stage. Because there is no fuel cost during the RE project development and the added-value tax can be deducted for equipment purchase. Therefore, the tax burden can be greatly mitigated for such enterprises. In conclusion, both the existed tax system and the new tax regulations special for RE project development significantly improved RE sector development in priority.

According to the RE Law, the activities were undertaken such as resource assessment, concession projects, quota, etc. With the policy and regulation support, the RE market is expanded, technology improved, and in-

vestment increased. The RE sector development obtained a good reputation in the international community.

2.4 The Context for the RE Law Amendments

The RE Law was drafted in August, 2003 and passed by the National People's Congress in February 2005. In 2003, the primary energy consumption reached 1.678 billion tce, topped the 2nd in the world. While with the rapid growth of GDP, the demand for energy increases greatly. It was projected by many institutions that the primary energy consumption would be 2.8 billion to 3.3 billion tce by 2020, twice as that in 2000. The assumptions included:

a. The RE power installations would reach 121 million kW by 2020, 12% of the total power installations, with 300 million tce newly-added RE power. To achieve such targets, the small hydropower, solar thermal utilization and geothermal energy shall be taken into considerations, i.e. utilizing the available resources in proper way. Therefore, the RE energy will be efficiently utilized by 2020, including wind power, biomass energy utilization, solar power, etc.. The targets for different technologies were set as: by 2010, the total power installations would be 60 million kW, including 50 million kW small hydropower, 4 million kW wind power, 6 million kW biomass power, 450,000 kW solar power, and other RE power such as geothermal power, 10% of the total power installations. By 2020, the total power installations would be 121 million kW, including 80 million kW small hydropower, 20 million kW wind power, 20 million kW biomass power, 1 million kW solar power, and other RE resource utilization such as RE heat supply and liquid bio-fuel, about newly-added 300 million tce RE supply capacity.

b. The share of RE accounting for the total energy would be increased greatly. Referring to the international experiences, the RE may meet the 30% to 40% of the total energy demand by 2050. To obtain the targets, it needs wind power to contribute more than nuclear power, top 3 power sources in China by 2040; more than hydropower, with about 400 million to

500 million kW capacities by 2050. During 2020 to 2030, the small hydropower will be fully explored with about 100 million capacities. By 2050, solar water heater will reach above 500 million m^2, as alternative capability to 300 billion kWh electricity, or 200 million peak power. By 2050, solar power installations will reach 20 million kW. In the same time, other RE resources shall be exploited such as biomass energy, ocean energy, geothermal energy, etc.

The year of 2009 was the 6th year after the amendments of the RE Law since 2003, and 3 years since the enforcement of the RE Law. The situations changed a lot at home and abroad. The energy consumption soared since 2003, with 2.85 billion tce in 2008, even higher than the estimation for energy consumption for 2020, 12 years earlier than the expected. The global issues of climate change, environmental protection and economic development became more and more severe. In the Climate Change Conference in Copenhagen, the arguments between the developed countries and the developing countries are growing. The issues are so complicated, combining politics, economy, national defense, energy security and environmental protection, and so critical for more future development spaces of the developing countries and for new economic development opportunities and global control of the developed countries.

To make a conclusion based on all the estimations of energy demand, the energy demand by 2020 may reach about 4.6 billion tce, based on the annual 8% economic growth rate, annual 0.54% population growth rate, annual 0.9% urbanization growth rate and annual 3.5% energy conservation rate.

The estimation is not always able to meet the changing situations. In the last four years, the RE Law played an important role in promoting RE sector development. But most of the RE technologies were at the early development stage, R&D or the transitional stage to commercialization. The issues and barriers to large scale RE development became more and more serious in terms of resource assessment, technology R&D, proper pricing, grid integration and load management, market regulating, etc.. To summarize them in the following.

2.4.1 Insufficient Scientific Decision-making Process

The RE Medium and Long Term Development Planning was issued by NDRC in September 2007. The RE power targets were set as show in Table 7 below:

Table 7 Targets for RE Power Installations (GW)

Year	2005	2010	2020
Hydropower	117	190	300
Biomass power	2	5.5	30
Wind power	1.26	10	30
Solar PV power	0.07	0.3	1.8

Other RE development targets:

By 2010, non-food liquid bio-fuel, such as ethanol would reach 2 million tons, bio-diesel would reach 200,000 tons; by 2020, ethanol would reach 10 million tons, bio-diesel would reach 2 million tons.

For solar thermal use, by 2010, the heat collection area by solar water heater in China would reach 150 million m^2, plus other solar thermal utilization patterns, annual alternative to 30 million tce conventional energy; by 2020, the heat collection area by solar water heater in China would reach 300 million m^2, plus other solar thermal utilization patterns, annual alternative to 60 million tce conventional energy.

Compared with the targets identified and the actual RE sector development, the analysis shall be the national targets shall be more identified at more scientific basis.

According to the RE Law in 2005, the RE Medium and Long Term Development Planning proposed RE consumption accounting for 15% of the total primary energy consumption by 2020. Also, in the climate change summit in 2010 publicized by Chairman Hu Jintao, the non-fossil energy shall account for 15% of the total primary energy by 2020. However, the target in the Planning was identified based on the estimation of the total energy demand at 2.8 to 3.3 billion tce by 2020, so 15% of the total energy demands coming from RE means 500 million tce. Now the estimation for the energy

demand by 2020 increased to 4.6 billion tce, 15% of the total energy demands coming from RE means 700 million tce, 200 million tce more than the estimated 500 million tce.

To meet the target of 700 million tce, by 2020, the installations of grid connected wind turbines shall reach 150 million kW from the original estimated 30 million kW; solar power installations shall reach 20 million kW from the original 2 million kW; biomass power installations shall reach 40 million kW from the original 30 million kW (the technology mix may change greatly, the straw power generation shall decline); and the solar water heater installation area shall increase 300 million m^2. Also it shall include the liquid bio-fuel, which is much uncertain even for achieving the original target set. The analysis concludes it will be a big challenge to obtain the 15% target based on the increasing total energy demand by 2020.

There are two factors for definition of RE development targets.

First, it is hard to justify an accurate scale due to the RE low level basic R&D, non-commercialized technology and high cost. Compared with fossil fuel energy, the RE deployment cost is not competitive. For instance, wind power is one kind intermittent power with high cost, and need government support during the scale-up development process. For biomass energy, it is not certain where the technology trend leads to. For instance, cellulosic ethanol has a large potential but underdeveloped technology. The common issues and barriers to RE development to a large scale are technologies and high cost.

Second, the insufficient resource assessment cannot meet the demand for project development. Generally with a large resource potential but the micro-citing is far less than the demand for concrete project development. For instance, wind and solar energy resource assessment are not available to identify and prove the so-called largest potential among the RE resources. The established biomass energy projects are challenged by raw material supply due to the resource assessment much lagging behind. None of the land resources are clear for defining the available and non-food supply land for energy plants. None of the water resources are clear for such availa-

ble land resources. None of the assessment provides economic and natural feature analysis for available biomass species. Not to mention the much weaker ecological environmental resources without any assessment in depth. For the geothermal and ocean energy resources, even there was no actual assessment at all.

2.4.2 No Proper RE Pricing Mechanism

There was no proper RE power pricing mechanism. For wind power price, there were many pricing pattern adopted, even the prices for the project with the similar wind energy resource may be very different. And the competition was fierce and the projects may won the bid with the lower price than its real cost. Such improper market competition impacts the sector development.

In the RE Law, the Article 19 identifies that Grid power price of renewable energy power generation projects shall be determined by the price authorities of the State Council in the principle of being beneficial to the development and utilization of renewable energy and being economic and reasonable, where timely adjustment shall be made on the basis of the development of technology for the development and utilization of renewable energy. The price for grid-connected power shall be publicized. But in practice, the implementation cannot make it clear what is so-called "the principle of being beneficial to the development and utilization of renewable energy and being economic and reasonable". There is so far no precise definition how can justify the "being economic and reasonable".

2.4.3 The Largest Barrier—Power Grids to RE development

There are six local power grids, north China, east China, northeast, middle China, northwest and south power grids. But the six power grids are rather independently operated. Additional local power grids, such as Xinjiang power grid, within the northwest area but independently operated, Mengxi power grid, within the north China power grid, but independently opera-

ted. The national power grid cannot play its role like the European continental or US power grids or even Russian power grids, which is much synchronized. It is expected the existed strong thermal power installations, which accounts for 80% of the total power installations (800 million kW by the end of 2008), shall be capable to support the load management of the intermittent RE power, mainly to wind power and solar PV power. However, the fact is that China has not a strong synchronized power grids but segmented local power grids. Such segmented power grids are not able for effective load management.

The RE resources are mostly distributed in west, north and northeast of China, but the power load are concentrated in middle, east and south of China. It means that the RE power shall be transmission from resource-rich areas to the load centers. During the process, the disadvantages of RE power, the intermittence cannot be well dealt within any of the local segmented power grids, esp. the GW-level and even larger scale RE power in future. It will be the largest barrier to RE development to a large scale if the overall power grid synchronization cannot be addressed.

2.4.4 Lack of Talent Education and Training Mechanism

The RE technology is less developed than the sector development demand. For instance, the enterprises are not able to master the key know-how and there is lack of rolling investment, esp. from the government. Most of the RE enterprises are new and even involvements of venture investment but lack of involvements of strategic investors. There is no well-organized personnel education mechanism to support the sector sustainable development, including:

a. product, technology standard, testing and certification system are not fully established. The productivity is much increased but no complete standard system for equipment, product and key components and no national standards or codes for power grid integration, liquid and solid fuel. The shortage of standards impacts on testing and certification as well.

b. effective and third-party regulating capacity and law enforcement im-

pact assessment mechanism are not fully established. The capacity, mainly for the institutional capacity of NDRC and local DRC are much understaffed, which cannot meet its missions, including planning development, sector guidance, investment review and approval, price regulating, etc.. The existed capacity cannot fully fulfill the sector regulating and supervision (information collection, administration, supervision and penalty); the State Electric Power Regulatory Commission is limited to power market regulating and cannot supervise the whole chain of RE resource exploration, processing and power conversion, and market sales and consumption. Without a well-coordinated supervision, the issues cannot be properly and timely addressed, such as the improper competition of wind power concession projects, the perfectness rate of the wind power equipment, the restriction to connect RE power to power grids, the over-development of some sectors in some areas, etc.

c. the public RE awareness and capacity building is low. There are still two contrary altitudes for RE development: one is negative and thinks RE is not worthwhile and the other is positive and thinks RE is of great importance and shall be rapidly and greatly developed. The two altitudes are argued a lot and will impact the policy support. Actually, for conventional energy development, there already set up the national energy technology research institutions and service organizations for sector development, for instance, the scientific research institutes and planning institutes for coal, the scientific research institutes and planning institutes for power, the scientific research institutes and engineering planning institutes for oil, the scientific research institutes and planning institutes for hydropower, nuclear technology research institutes, etc. As well, power, cola and oil industry has many of the professional design institutes and national research institutes to support the industry development. Even in universities, the faculty capacity is very strong. Such capacity were established when the new republic of China was established. And it provided strong support to technology improvement, sector development and engineering construction. However, there is no professional research institutions and engineering management institutions for RE, and mostly depend on conventional energy management institutions. The RE

capacity is much distributed even if there are a few professional institutions and not able to support the rapid RE development as a well-organized system. Such shortage leads to ineffective national policy making process and RE key national project management and planning. The low technology localization and innovation capacity are key barriers to the sector development. If with the disadvantages in long term, the national target cannot be well planned and achieved.

In the recent years, China government puts great emphasis on RE development, and takes it as the strategic option to adjust energy mix, guarantee energy security and combat climate change. With sector expansion, esp. the soaring development of wind power and solar energy sectors, the barriers to RE sector development become more and more obvious. The RE Law in 2005 is not able to match the RE sector development. Therefore, it generates the demand to revise the RE Law. For Germany, the RE Law shall be revised every four years and has been revised twice so far.

2.5 The Issues to be Considered for the RE Law Amendments

2.5.1 Develop the Planning and Targets at Scientific Basis

It is necessary to identify appropriate and practical targets based on proper data and analysis. There shall be the fundamental work in place to identify the targets, including the national budgets in priority allocated to the wind resource assessment, solar resource assessment and biomass resource assessment and the technology roadmap development for RE technologies.

2.5.2 Develop the Pricing Mechanism at Resource Basis

The cost sharing mechanism shall be improved to reflect all the cost of RE power, esp. according to different RE technologies, commercialization level, various resources, etc.. To ensure the RE targets, healthy sector development and technology improvement and cost reduction, the pricing and

cost sharing mechanism shall be improved. For instance, wind power price shall be based on different resources, and solar PV power price shall be based on FIT identified by concession projects and reduced every year.

2.5.3 Establish the RE Development Fund

RE is one kind of new emerging energy. RE technologies are high-tech and need government policy support and national investment to infrastructure. It shall be very efficient and practical to establish the RE development Fund to support RE sector development. First, it is featured by "vertical management", which means less bureaucratic procedures and low administration cost; second, the Fund is based on the rules of "uniform collection and distribution" and the investment for RE investors can be returned with sound benefit during a reasonable period, therefore, the RE stakeholders are much motivated esp. for developing RE in the rich RE resource areas; third, the fund grows due to the strong policy support and the RE power market scale expands, and it is estimated that the fund shall be even tens of billion RMB instead of the current 6 billion RMB. Therefore, it needs better fund management patterns to avoid resource waste.

2.5.4 Develop the Synchronized Power Grids at National Level

China is rich on solar and wind energy resources, but such resource-rich area is mostly located in west and north of China, where the power load is much low and the power grid network is very weak. So the RE power shall be transmitted to the high power load area, east of China. Currently, the issue of power grids is the key barrier to RE power sector development. Duet to the intermittence of wind power, it is not as easy as the transmission of thermal power through point-to-point transmission pattern by a high-voltage transmission line. The transmission of RE power, esp. from large RE power generation bases shall be based on the synchronized power grids.

Crossing large power grids shall be the development trend in the world. And the international experiences prove that the synchronized power

grids develop from small scale to large scale. Thanks to the synchronized power grids, wind power developed rapidly in US and Europe. The highest instant wind power load in Demark is permitted 60% of the total power loads, for it is synchronized with Norwegian, French and German power grids. To develop the synchronized power grids, it also require improving energy infrastructure to facilitate the RE sector development. For instance, in order to encourage the research and application of smart grid technology, energy storage technology and consolidation of power grids to integrate more distributed power including RE power, power grids shall improve and expand the load management and control systems. The power grid capacity and control shall be expanded to a large extent, esp. the synchronized connection among large regional power grids and smart control within one regional power grid.

To accelerate the power grid reform, the RE quota system shall be improved. The quota system will allocate the mandatory task—some amount of RE power to power grids. Currently, there is a need for reviewing the RE market and the overall power market and analyzing the possible impact of overheating bidding, excessive competition and explosive market expansion if quota system is enforced for large power enterprises. In the same time, it shall be also taking an analysis on the social obligations of large power enterprises to invest RE sector, as well as the obligation of power grid enterprises when identifying the quota—RE power amount. The matching regulations such as RE power certificates, trading, supervision and bonus-penalty shall be established for guaranteeing the "full purchase of RE power integrated into power grids". When enforcing the obligations of power grids, the additional cost to integrate the intermittent RE power shall be compensated and the issues in terms of technology, operation and management shall be fully realized and appropriately addressed with support.

2.5.5 Establish the National RE Center

In a long run, it shall be a full system construction in terms of infrastructure, public technology R&D, talent education and training for RE sec-

tor development. The sustainability of RE sector development specially depends on high technology and talent, which is very critical for the competitiveness of the overall RE sector.

So far, there is no professional RE research and engineering institutions in China. Only a few capacities still belong to conventional energy institutions and much distributed. Compared with conventional energy research and technology institutions, RE sector is far short of capacities to support technology innovation and sound management. For instance, government needs stronger management and more effective enforcement capacities for the RE policy, planning and national key project. Also the current policy environment shall be improved to facilitate the technology innovation and industry system development. Therefore, a national RE center shall be established to ensure the sustainable development of RE sector, the missions of such a center shall cover the management of technology and sector, and provide service to industry in terms of technology R&D, policy research and national key project implementation. Concretely, it covers:

a. To organize and coordinate research and development (R& D) institutions in matters related to renewable energy;

b. To review renewable-energy policy, strategies, and plans; To support to formulation of policies, the preparation of plans and projects, and the drafting of legislation for the renewable-energy sector;

c. To organize and monitor implementation sub-sector strategies ("national projects") for renewable-energy development;

d. To support industrial development in renewable energy through the promotion of standards, testing, and certification;

e. To promote international cooperation, management, and harmonisation within the renewable-energy sector;

f. To promote information exchange and dissemination through events and publications; and

g. To provide outreach services to national and local government institutions, industry associations, etc.

2.5.6 Establish and Improve the Sector Regulating, Information Access and the Reporting Mechanism about the RE Law and Regulation Implementation

RE sector development also need supervision by the regulatory authorities. The government information access mechanism shall be established, including regulating rules, planning and strategy development, project review, approval and management, pricing development, etc. Based on the mechanism, the public can easily understand and participate the decision-making process information. As well, the information mechanism shall also cover the evaluation and reporting on the RE Law and related regulation implementation. It needs the regular reporting by the State Council and provincial energy authorities to the NPC or provincial people's congress, as well as the promulgation to the public.

2.6 The Amendments to the RE Law

The Amendments to the RE Law solved the key issues but not all the issues. The amendments are related with the Article 8,9, 14,20,24 and 29.

2.6.1 The Amendments to Article 8 and 9

The purpose of the amendments to Article 8 and 9 is to enhance the RE planning well matched with the overall energy planning, and to define the local government responsibilities to develop the local RE planning according to the national RE planning. For instance, the amendments to Article 9 stated "In preparing the implementation plan for the development and utilization of renewable energy, it is necessary to make comprehensive arrangements for the development and utilization of renewable energy such as wind energy, solar energy, water energy, biomass energy, geothermal energy, and ocean energy by following the principles of developing a plan in line with local conditions, making an overall plan taking all factors into consideration, promoting reasonable distribution, and systematic development. The plan shall in-

clude development targets, major tasks, a plan for regional distribution, key projects, time schedule, power grid construction, a service system, and measures to guarantee implementation. " It specially emphasize that the power grid construction.

2.6.2 The Amendments to Article 14

The purpose of the amendments to Article 14 is to enhance the obligations of the power grid enterprises. The RE Law regulated the full purchase of RE power, but the enforcement mainly depended on the negotiation between power plants and the regional power grid enterprises. But with the increasing RE power generated in the local, the regional power grid was not capable to accommodate all the RE power.

It is very complex system for RE power grid connection. For instance, wind power grid integration is challenged with the situations that "additional RE power not accommodated in the local is not well transmitted to the other regional grids where power supply cannot meet demand" . The technical issues in terms of wind turbines such as the power curve forecasting, low voltage ride through, etc. are easier addressed compared with the grid integration issues. It is not appropriate to emphasize the wind turbine grid connection codes and the reliability impact by wind farm grid integration on power grids. It shall be realized that the key issue shall be: first, the strong power grids conflicting with low wind power integration; and second, the weak regional power grid limiting wind power development. To address the key issues or barriers one by one according to their different priorities, first, it is necessary to establish the synchronized power grid at the national level to address the most prioritized issue, which is the strong power grids conflicting with low wind power integration. And then the second prioritized issue which is the technical consistency of wind turbine and wind farm with the power grids shall be addressed later. For the time being, European power grids are at the second stage, when appropriately addressing the second prioritized issue. There are only 20 million wind turbine installations in China, a tiny part within the nearly 900 million kW power installations in total. Compared with

the situations between China and Europe, China is far from the development stage to address the second prioritized issue. Therefore, to address the first issue, the rule of "full purchase of RE power" makes big sense to RE sector development. It will effectively materialize the national target to power grid enterprises, which will be motivated to solve the first issue with the obligations.

2.6.3 The Amendments to Article 20 and 24

The Amendments to RE Law was enforced on April, 1 2010. The Amendments stated that the RE Development Fund will be established based on national budget.

The RE Development Fund is public funding for public benefits. The purpose is to provide support for the RE sector development with less competitiveness.

The public benefits which the Fund shall cover, a) RE technology improvement, b) RE deployment capacity building and improvement, c) RE efficiency improvement, d) RE production cost reduction, e) Public energy expenditure conservation, and f) Public economic and environmental benefit increase.

The funding sources fundamentally come from the energy consumers, esp. the power consumers. Conventional thermal power consumes non-renewable energy resources and the power generated is consumed by the public. Therefore, it is reasonable for the consumers to pay the environmental loss. The additional fees shall be paid for RE deployment and benefit to the public in turn.

The Fund sources and usage are much related with the overall energy development. The Amendments states that "The sources of the fund include the special fund annually arranged by the government budget and the income of the renewable energy surcharge which is levied in accordance with law."

The renewable energy development fund is used to compensate the excess cost as stipulated in article 20 and article 22 of this law and is used to support the following:

a. Scientific and technological research, standard establishment and pilot project for the development and utilization of renewable energy;

b. Construction of renewable energy projects in rural and pasturing areas;

c. Construction of independent renewable power systems in remote areas and islands;

d. Surveys, assessments of renewable energy resources, and the construction of relevant information systems;

e. Localized production of the equipment for the development and utilization of renewable energy.

Regarding the Fund collection and management, the Amendments stated clearly that the financial department of the State Council shall work together with the departments of the State Council in charge of energy and price to formulate specific methods for the collection, use, and management of the renewable energy development fund. It means that the management shall involve the NDRC (price department), NEA and MOF. During implementation, more the other players such as SEPRC, power grid enterprises and power enterprises will be much involve in the process. Therefore, the common understanding shall be agreed on the Fund management issues, in terms of coordination, task allocation, etc. to avoid any new conflicts.

3 Wind Energy

3.1 Wind Energy Resource in China

The wind resource assessment can be categorized by macro, middle and micro level and such levels are functioning to different purposes of strategy and planning, wind farm layout, project design, etc. CMA conducted the first wind resource assessment in late 1970's at macro level, followed by several assessments at national level later. While to meet increasing data demand, it is necessary for more detailed wind assessment. With the perfection study on the meteorological knowledge, observation techniques and calculation model compared to the previous study are higher precision, wider and specific on wind resource assessment.

3.1.1 Onshore Wind Energy Resources

The main onshore wind energy resource results are summarized as follows:

In late 1980's, CMA utilized the data (data compiled before 1980's) collected by more than 900 field stations all over China and conducted the second wind resource assessment. It was concluded that the theoretical wind resource storage at 10 m hight was 32.26×10^8 kW and the technical availability was 2.53×10^8 kW. The concept of "technical availability area" was defined as the wind resource area with wind power density of more than $150W/m^2$ at 10m high.

During 2004 to 2005, CMA conducted the third wind resource assessment as well as to reedit and recalculate the data from 2400 weather stations with nearly 30 years observation data resources. It was concluded that the theoretical wind resource storage at 10 m high was 43.5×10^8 kW and the technical availability was 2.97×10^8 kW.

During 2003 to 2005, UNEP organized the wind resource assessment. The simulation model was utilized to analyze the wind resource for 3 million km^2, east of China and coastal area. The 10 met masts at 70m height funded by UNEP and data from 170 weather stations and more than 60 existed met masts verified the simulation. The result provided the technical availability of wind resources at 50 m height. It was concluded that the onshore (excluding provinces/autonomous regions of Xinjiang, Qinghai, Tibet and Taiwan) theoretical wind resource storage at 50 m high was 0.284 million km^2 and 14.2×10^8 kW. The technical availability was 14.2×10^8 kW. The concept "for technical availability area" was defined as the wind resource area with wind power density of more than $400W/m^2$ at 50m height.

CMA conducted the wind resource assessment by adopting the simulation during 2006 to 2007. It was concluded that the theoretical wind resource storage at 50 m height was 26.8×10^8 kW, 0.284 million km^2 without concerning on the Qinghai-tibet plateau. The concept of technical availability was defined as wind resource availability at 50m height with more than 400 W/m^2 wind power density.

CMA made use of the wind resources observation network and its weather service network to unify the national wind resources observation and evaluation at 2009. More than 2,400 ground meteorological offices and stations of the wind observation resources by using the wind resources evaluation model System of (Wind Energy Assessment System, referred to as WERAS) to get the data in detailed. It was concluded: China land 50 meters high from the ground, Wind power density is greater than or equal to $300W/m^2$ and the potential development was about 2.38 billion kW, mainly distributed in the northeast, north and northwest and coastal areas.

These data model calculation was more than the third national wind resource observation.

Although there are several wind resource assessments to conclude different amounts, the distribution of rich wind resource is similar. The factors which differentiate the assessment result include methodologies, data sources, height levels, etc. The second and third wind assessments adopted

the data at 10m height, while the last two wind assessment utilized simulation at 50 m height. Simplifying the estimation by wind shear at 10m height, the technical availability at 50 m height and 70m height shall be 6×10^8 kW and 7×10^8 kW respectively.

In conclusion, there are 0.2 million km^2 wind resources with more than 150 W/m^2 wind power density at 10m height onshore, 4 billion kW in equivalent, among which it is 0.6 billion to 1 billion kW technical availability.

Such conclusion is established at macro level, and can only provide the general reference to the overall layout of wind resources by analysis of technical availability. The wind farm sitting shall depend on the middle and micro level wind resources, and more factors shall be considered, including data of terrain, ground cover, power grid, etc.

Therefore, China has the best wind resources in the world although without unified conclusion, and it is enough for the future potential development.

Table 8 Onshore Wind Resources Measuring and Evaluation Results in Different Agencies

Measuring institutions	Exploitation area (10 thousand km^2)	Height apart from the ground(m)	Technical availability* (100 billion kW)	Evaluation method
CMA				
2nd Observation (1990s)		10	2.53	Based on meteorological data, calculating by 10% of wind theoretical value at 10 meters height
3rd Observation (2007)	20	10	2.97	Based on meteorological data, calculating by the area with over 150W/m^2 wind density at 10 meters height
CMA (2007)	54	50	26.8	Adopting the numerical simulation technology, for the area with wind power density greater than or equal to 400 W/m^2 at 50m height (not including Xinjiang, Qinghai, Tibet and Taiwan), calculating by the wind generator layout of 5MW/km^2

续表

Measuring institutions	Exploitation area (10 thousand km^2)	Height apart from the ground(m)	Technical availability* (100 billion kW)	Evaluation method
CMA				
UNEP (2004)	28.4	50	14.2	Assessing regions not including Xinjiang, Qinghai, Tibet and Taiwan; In China's eastern coastal and Inner Mongolia and other areas by numerical simulation, and other regions based on meteorological data. For the area with wind power density greater than or equal to w/m^2 at 50m height, calculating by the wind generator layout of $5MW/km^2$
ERI(2007)	20		6～10	Comprehensive parties data suggest using data, the available land area of 20 million km^2, calculating by the wind generator layout with low limit of $3MW/km^2$ and high limit of $5MW/km^2$
Wind and solar energy resources evaluation center of CMA(2009)		50	23.8	Wind power density greater than or equal to $300W/m^2$, using the energy resources professional network and combined with the measuring wind material of 2,400 multiple ground meteorological offices and stations under the CMA's basic meteorological observation network, through Chinese wind resources evaluation of refinement numerical model system

* Means: in accordance with the state regulations, the developed area with above the third level wind resources, divided by the wind power density index, the wind resources area with over $150W/m^2$ at 10 meters height, over $400W/m^2$ at 50 meters height.

3.1.2 Offshore Wind Energy Resource

The offshore wind resource assessments were conducted by CMA, NCC, CAS, UNEP, respectively. The assessment methodologies they adopted cover statistic, simulation based on atmospheric circulation combined with remote-sensing satellite. The most recent data collected by NCC told that the technical availability of offshore wind resources (with wind power density $\geqslant 400 W/m^2$) was 7.5×10^8 kW. The data collection and analysis adopted simulation methodologies by simulating the offshore wind resources 50km away from coast. It is the middle level wind resource assessment. And also the analysis deducted the wind resources in the area with more than three times of typhoon annually according to statistic. Although many of the research were conducted, the results cannot be finalized for the offshore wind resources in China (Table 9).

Table 9 The Offshore Wind Resources Measuring and Evaluation Results in Different Agencies

Forecasting institutions	Exploitation area (10 million km^2)	Technical availability * (100 billion kW)	Height apart from the ground(m)	Evaluation method
The China Meteorological administration (90's)		7.5	10	According to the second continental wind resources survey results, by the offshore resources 3 times of the land wind resources
The United Nations Environment Program, (2004)	12.2	6	50	Using the numerical simulation technology, calculating the area with wind power density greater than or equal to 400 W/m^2
Chinese Academy of Sciences Geography Institute (2006)	—	20	10	Using remote sensing satellite data for numerical simulation, 2km distance coastline where wind resources for 0.4 billion kW, with the distance of 10km, about 2 billion kW
The China Meteorological Administration (2007)	3.7	1.8	50	Calculating the area with wind power density greater than or equal to 400 W/m^2, by the numerical simulation technology

续表

Forecasting institutions	Exploitation area (10 million km^2)	Technical availability * (100 billion kW)	Height apart from the ground(m)	Evaluation method
The National Climate Data Center (2009)		7.58	50	Using the numerical simulation calculation, consider the area within 50km offshore, and with the wind power density greater than or equal to 400 W/m^2 area, the regions suffered violent typhoon III and above level deducted
Energy Research Institute estimates (2007)	3	1.5	—	According to the exploitation and utilization ocean area planned by State Oceanic Administration, calculating by the wind generator layout with 5MW/km^2

* Means: in accordance with the state regulations, the developed area with above the third level wind resources, divided by the wind power density index, the wind resources area with over 150W/m^2 at 10 meters height, over 400W/m^2 at 50 meters height.

All the research implies the rich offshore resources, but it is the actual available area decides the technical availability. The larger of the wind turbines power, the larger distance shall be between wind turbines to avoid interaction and impact of the tail waves, and vice versa. Therefore, the number of wind turbines is definite for some fixed area. According to the existed technical condition, one square kilometer can hold 3 to 5 MW wind turbines. Therefore, the number of wind turbines is definite for some fixed area. According to the existed technical condition, 1m^2 can hold 3 to 5 MW wind turbines.

Based on the Research Report of National Coastal Zone and Shoal Resources, there are 157,000 km^2 sea areas from 0～20m isobaths of shallow sea. In 2002, the National Marine Functional Zone Planning was issued and provided a detailed description of functional zones for shipping, fishery, tourism and engineer, etc. and planned 60 zones for ocean energy utilization. Simplifying the technical availability and deducting the functional zones,

there shall be 10%～20% ocean area to be utilized, and equivalent to (1～2)×10^8 kW wind turbine installations. But it shall be further detailed by the national planning.

3.1.3 The Wind Reserves on MW Level Wind Power Bases

The NEA organized the planning tasks of 1,000 MW level wind power bases based on the wind resources observations and previous work of wind power construction. Gansu, Xinjiang, Hebei, Mengdong, Mengxi, Jilin and Jiangsu have successively completed the planning. The seven 100 MW wind power bases are rich in resources which are at MengDong and MengXi of Inner Mongolia, Xinjiang Hami, Gansu Jiuquan, Hebei Bashang, Jilin west and the coastal Jiangsu. The potential wind resources at 50 meters height and with 3 level wind resources are about 1.85 billion kW. The total installed capacity of the seven 100 MW wind power bases can be 570 GW. The wind resources situations are:

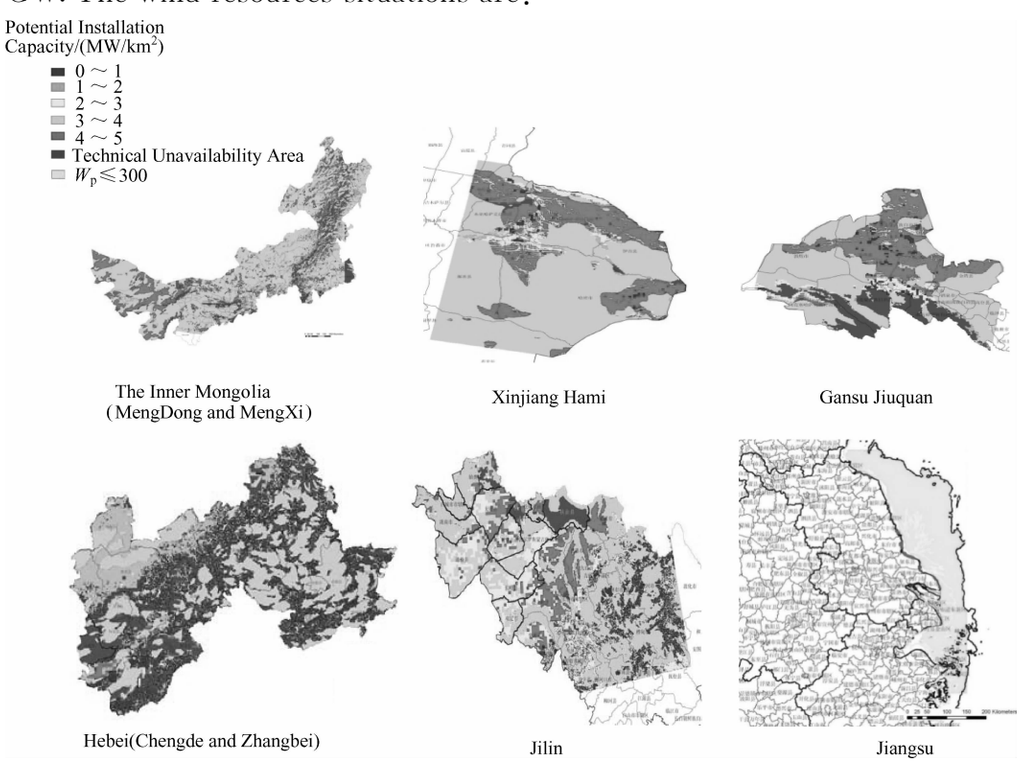


Figure 4 The Wind Resource Distribution of Seven 100 MW Wind Power Bases

3.2 Grid Connected Wind Power

3.2.1 Wind Farm Development Situation

3.2.1.1 Wind Farm Construction

In 2009 China installed more than 10,129 wind turbine units, with the installed capacity of 13800 MW, compared with the 6150 MW installed capacity in 2008, the new installed capacity growth rate is 124%. The cumulative installed wind turbine in 2009 is more than 21,581 units with an installed capacity of 25,805 MW. The total installed capacities of wind power by prov-

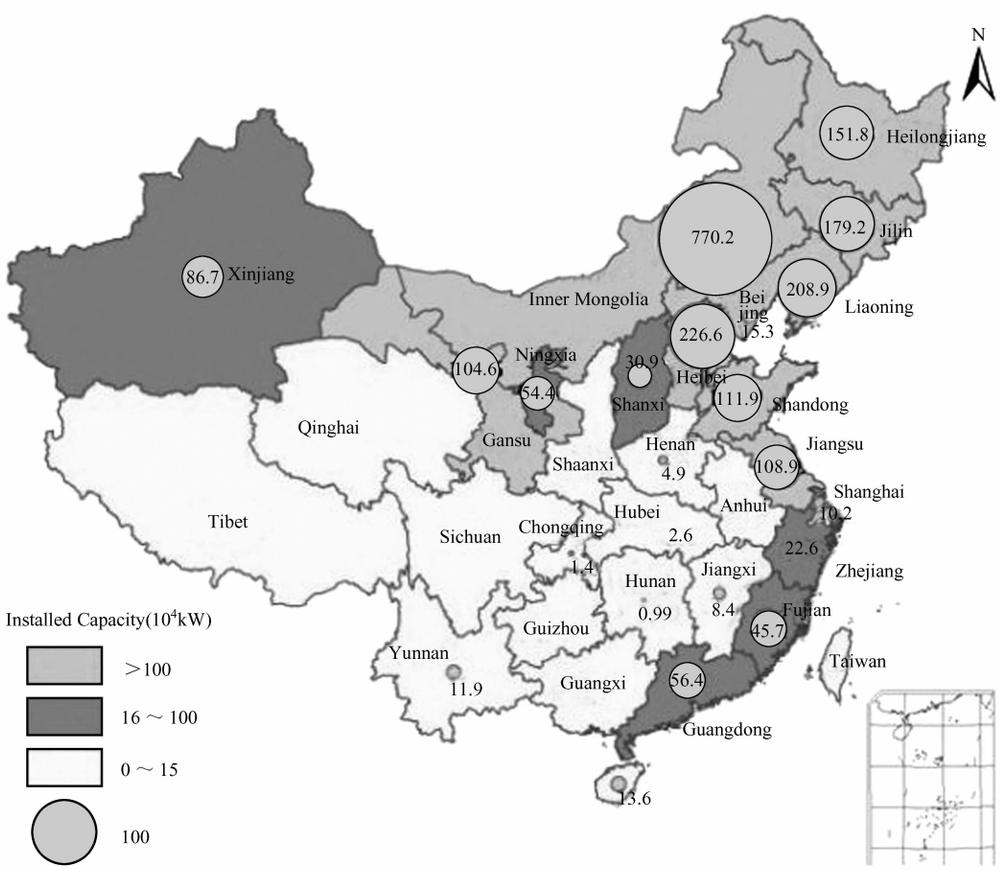


Figure 5 China Wind Turbine Distribution

ince in 2009 are shown in Table 10. Compared with the 12,150 MW cumulative installed capacities of 2008, the growth rate of cumulative installed capacity in 2009 is 114%.

By the end of 2009, more than nine provinces have the total installed capacity of more than 1 GW, and 4 provinces with the capacity of more than 2 GW which respectively are Inner Mongolia, Hebei, Liaoning province and Jilin. Figure 5 shows the total installed capacity in different provinces.

Table 10 Over MW-Scale Installed provinces Lists

Regions	2008 Cumulative Installed Capacity(MW)	2009 New Installed Capacity (MW)	2009 Cumulative Installed Capacity(MW)
Inner Mongolia	3,650.99	545.17	9,196.16
Hebei	107.7	1,680.4	2,788.1
Liaoning	224.26	1,201.05	2,425.31
Jilin	1,066.46	997.4	2,063.86
Heilongjiang	836.3	823.45	1,659.75
Shandong	562.25	656.85	1219.1
Gansu	639.95	548	1,187.95
Jiangsu	645.25	451.5	1,096.75
Xinjiang	576.81	443.25	1,020.06

During 2009, major domestic investment and developer of wind farms are the central and local state-owned power generation enterprises and energy-invested enterprises. The wind power developers with installed capacity of more than 1MW are Guodian, Datang, Hua'neng and Huadian. These four groups accounted for 37.6% of market share. The Guodian (including Longyuan) have new installed capacity of 2.6 million kW which the market share was 18.8% at the first grade. The share of new installed capacity in 2008 is shown in Table 11.

3.2.1.2 Offshore wind power construction

At present, offshore wind power development is still at the initial stage. The constructed offshore wind farms are mainly in beaches and intertidal zone. The wind farm development is mainly using the cofferdam concept, only few demonstration projects for the offshore wind farm construction. The more important offshore wind power projects are shown in Table 12.

Table 11 The New Installed capacity of China Wind Power Developers (2009)

Installed Capacity	Enterprise	Capacity(10 MW)	Share(%)
1 Billion kW	Guodian	260	18.8%
	Datang	174	12.6%
	Hua'neng	164.5	11.9%
	Huadian	123	8.9%
100～500 million kW	China Guangdong Nuclear Power	85.4	6.2%
	Jinneng	79.8	5.8%
	Guohua	59	4.3%
100～500 million kW	The Energy-saving	40	2.9%
	China Power Investment Corporation	32	2.3%
	Huarun	31	2.2%
	Tianrun	31	2.2%
	China wind power	29.6	2.1%
	Hebei Construction Investment	16	1.2%
	China investment electricity	15.2	1.1%
	CWE	14.9	1.1%
	Ningxia electricity	14.4	1.0%
	China Min	13	0.9%
	Shenneng Noth	12.9	0.9%
	Luneng	10.2	0.7%
	Hongteng new energy	10	0.7%
Others		164.6	11.9%
Total		1,380.3	100%

Note: by Chinese wind energy association statistics, data from the wind generator manufacturing enterprises.

Table 12 List of China offshore wind power projects

Regions	Location	Developer	Item	Set	Capability (MW)
Jiangsu	Dafeng	China Power Investment Corporation	Beaches/intertidal	1	2
Jiangsu	Xiangshui	Sanxia/Changjiang New Energy	Beaches/intertidal	1	2
Jiangsu	Rudong	Longyuan	Beaches/intertidal	1	2
Jiangsu	Rudong	Longyuan	Beaches/intertidal	2	3
Jiangsu	Rudong	Longyuan	Beaches/intertidal	2	3
Jiangsu	Guanyun yanwei	China Energy Cooperation	Beaches/intertidal	4	8
Jiangsu	Yancheng chengjia	Sanxia/Changjiang New Energy	Beaches/intertidal	41	61.5
Shandong	Rongcheng	Huneng	Beaches/intertidal	2	6
Shanghai	Donghai bridge		Demonstration	21	63
Total				**75**	**89**

The constructed offshore wind power demonstration projects are introduced as follows:

(1) CNOOC Offshore Wind Power Demonstration Project

During 2007, the first offshore wind power plant was constructed at Bohai Sea approximately 46 kilometers from the coast by CNOOC. The wind generator is the 1.5 MW from Goldwind, and it connects to their offshore oilfield electricity net with an approximately 5 kilometers long submarine cables, and forms the complementary system with four dual fuel hyaline turbine units.

This project provides experience and data for the basic design and operation of offshore wind generators. It also took study on the wind generator environment adaptability, fuel/wind complementary power system.

Figure 6 CNOOC Offshore Wind Power Demonstration

(2) Shanghai Donghai Bridge Offshore Wind Power Demonstration

Donghai bridge offshore wind project was the first Chinese offshore wind project, the total investment was 3 billion RMB. It was planned to install 34 units' Sinovel wind generators of 3MW and the total installed capacity was 102 thousand kW. The expected electricity can reach to 260 million kWh for more than 200 thousand households in Shanghai. Until 2009, Donghai Bridge wind farm has installed 21wind turbines and all connect to grid.

Figure 7 Donghai Bridge Offshore Wind Power Demonstration

3.2.2 The Status of Grid-Connected Wind Power Equipment Industry Development

3.2.2.1 Wind Turbine Manufacturers

(1) Marketing Structure

By the end of 2009, the number of wind turbine manufacturers is about 80, including foreign-owned enterprise, joint venture enterprises and domestic enterprises. The total new capability of wind turbine manufacturers is 13.8 GW, with total capability of 25.81 GW. SINOVEL, Goldwind and Dongfang Turbine continue to market "top three" position. The new capability of SINOVEL was 3.495million kW, Goldwind was 2.722million kW and Dongfang was 2.035million kW. The total amount of the three enterprises was 8.252million kW. It accounted for 59.7% of the total new market. Figure 8 shows the market share of the top ten in new installed capability.

Domestic enterprises are developing rapidly and the market share is increasing during recent years. In 2007, domestic enterprises products firstly exceeded oversea products and the market share accounted for 55.9% of new market; In 2009, the market share of domestic enterprises has rapidly added, which accounted for 87% of new market, and the accumulative market share has exceed over 50%. Besides, the national products exports and have

entered to the international market with displaying our strength. By 2009, the total exported capacity of wind turbines of domestic enterprises was 28MW.

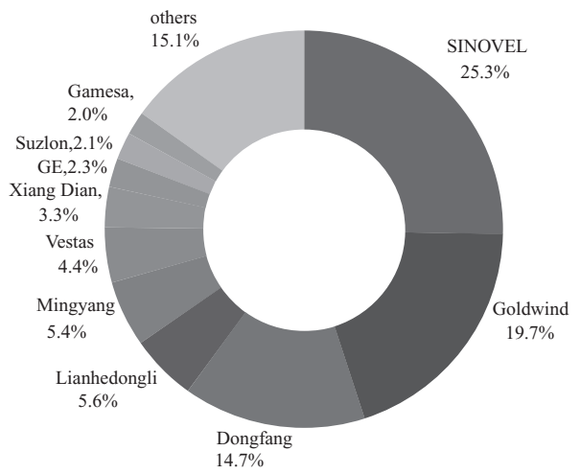


Figure 8 China's New Market Share Capability in 2009

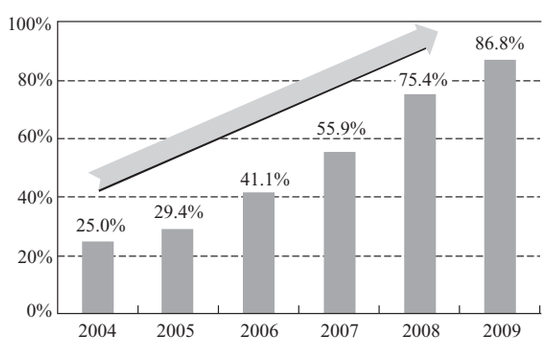


Figure 9 The Share of Domestic Enterprises Products Accounting for New Market from 2004 to 2009

(2) Main Wind Turbine Manufacturing Supplier and the Industries Distribution

Since 2005, the megawatts market share of wind turbine has increased unceasingly, especially the wind generator with single set power of 1.5 MW has gradually become the mainstream product. Otherwise, the number of installed wind turbine of 2MW has increased. According to CWEA statistical information, at present our country are focusing on the wind turbine with single set power between 1～2 MW, which still in testing level. In 2009, we also achieved a lot in researching 2 MW (≥2) wind power turbine. For example, Goldwind has

put efforts in researching 2.5MW and 3 MW wind turbine and already started trial operation in wind farm; The 3 MW offshore wind turbine researched by SINOVEL are generating and connects to the grid in Shanghai Donghai Bridge wind farm; Shengyang Industry University has researched the 3 MW wind turbine successfully. Besides, SINOVEL, Goldwind, Dongfang, Haizhuang and Xiangdian have started to research 5 MW wind turbine. It means China stared to research the wind turbine with more megawatt capacity.

Table 13 National Wind Turbine Manufacturing Situation

Company Property	Name	Turbine Type	Rating Power	Industrialization schedule
Domestic enterprises	SINOVEL	variable propeller, variable speed	1,500kW	batch production
		variable propeller, variable speed	3,000kW	small batch production
	Goldwind	fixed propeller, fixed speed	750(800)kW	batch production
		variable propeller, variable speed(direct driving)	1,500kW	batch production
		variable propeller, variable speed(direct driving)	2,500 kW	sample testing
		variable propeller, variable speed(half-direct driving)	3,000kW	sample testing
	Dongfang	variable propeller, variable speed	1,500kW	batch production
	Zhejiang Windey Wind Power Engineering	fixed propeller, fixed speed	750kW	batch production
		variable propeller, variable speed	1,500kW	batch production
	Shanghai Electric	variable propeller, variable speed	1,250kW	batch production
		variable propeller, variable speed	2,000kW	batch production
	Guangdong Mingyang	variable propeller, variable speed	1,500kW	batch production
	Xiangdian Wind Energy	variable propeller, variable speed(direct driving)	2,000kW	batch production
	Guodian Unted Power Technology Company	variable propeller, variable speed	1,500kW	batch production

续表

Company Property	Name	Turbine Type	Rating Power	Industrialization schedule
Joint venture enterprises and foreign-owned enterprise	Yuanjing New Energy	variable propeller, variable speed	1,500kW	batch production
	Side	variable propeller, variable speed	1,500kW	batch production
	GE Electric	variable propeller, variable speed	1,500kW	batch production
	Gamesa	variable propeller, variable speed	850kW	batch production
		variable propeller, variable speed	2,000kW	plan production
	Vestas	variable propeller, variable speed	2,000kW	batch production
		variable propeller, variable speed	850kW	batch production
	Suzlon Energy	variable propeller, fixed speed/initiative break speed	1,250kW 1,500kW	batch production
		variable propeller, variable speed	2,100kW	plan production

Recently, along with the national planning of 100 MW wind power base has gradually come out, domestic machine manufacturing firms accelerated industrial layout. Some large wind turbine manufacturing enterprises have planned the wind power base in neighbor countries. These layouts close to the market that can effectively reduce the transportation cost and ensure the delivery date, as well as the service after sale, which positivity support the local wind power firm development. Because the policies of VAT transformation issued, the tax income of local governments which have wind firms decreased. To increase the local tax, some local governments have established incentive policies to attract enterprises. Such administrative intervention is likely to lead blind investment in some areas, and bring some resources waste to the enterprise.

(3) Domestic enterprises equipments export

With the rapidly development of globe wind power market, it bring the opportunity to the national wind manufacturing. Since the beginning of 2007, the national wind manufacturing has started to explore the overseas market.

Table 14 Part of National Wind Turbine Manufacturing Distribution

Enterprises	Location
SINOVEL	Dalian, Yancheng, Jiuquan, Baotou, Dongying, Baicheng
Goldwind	Urumchi, Baotou, Yinchuan, Jiuquan, Chengde, Beijing, Xi'an, Dafeng
Guodian Unted Power Technology Company	Baoding, Lianyungang, Chefeng, Jiuquan
Dongfang	Deyang, Tianjing
Xiangdian Wind Energy	Xiantan, Zhangzhou, Laizhou
Zhejiang Windey Wind Power Engineering	Hangzhou, Zhang Jiakou
Guangdong Mingyang	Tianjing, Jilin, Zhongshan, Xi'an, Nantong
Vestas	Tianjing, Huhehaote

By the end of 2009, Baoding Huide, Zhejiang Huayi, Goldwind, Shanghai Electric, SIONVEL and Jiangsu Xinyu, etc. realized the wind turbine exports. At present, the total expert amounts are 39 units (see Table 15), it's a small number, but this is an important base for the domestic enterprises to explore the overseas market.

Table 15 National Enterprises Equipments Exports

Manufacturer	Distribution	Units	Single set capacity(MW)	Total capacity (MW)
Baoding Huide	US	10	1	10
Zhejiang Huayi	Chile	3	0.78	2.34
Goldwind	Cuba, US	9	0.75, 1.5	9
SIONVEL	India	10	1.5	15
Shanghai Electri	Thailand, UK	5	1.25	6.25
Xin Yu	Thailand, US	2	1.5	3
Total		39		45.59

(4) Employment and Production

Chinese Wind Energy Association (CWEA) investigated 39 national wind turbine manufacturers, the total employment up to 51.5 thousand people, of which the technical employee account for 17.58% (see Figure 10). But based on the data collection from the different enterprises, because some enterprise may relate to other industries, the data may involve the employee from other manufacturing industry. In order to clarify the real employment, this study has surveyed on the top 5 wind power manufactur-

ers. The total amounts are 16,600 people. Annual sales amount of wind turbine is 9,788 MW, and the average employment per MW wind turbine is 1.7. The sales of the top 5 wind manufacturers account for over 70% of our national market, with great representation. If calculating with 1.7 person / MW, the employment of wind turbine manufacture are up to 23,500 (including foreign companies) in 2009.

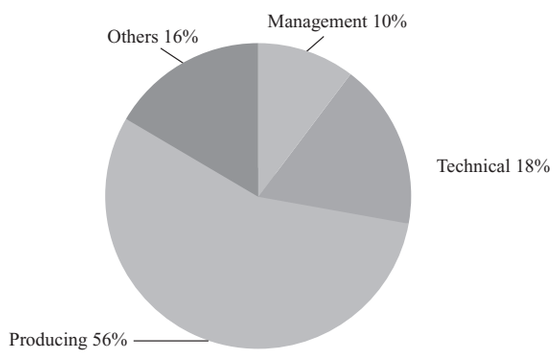


Figure 10 The Employment Structure of National Wind Turbine Manufacturers

The present statistical information of domestic wind power industry hasn't involved in wind industry production. Thus, the forecasting statistics of wind industry production value is based on the actual sales volume and the average sales price. From 2008, the domestic wind generator price has declined; especially since 2009 it has rapidly declined. Until the end of 2009, the price has declined from 6,200 RMB/kW to 5,000RMB/kW. The following figure shows the market price trend.

If the average market price is 5,000 RMB/kW, in 2009 the production value of national wind turbine industry is 6.9 billion RMB.

3.2.2.2 Wind turbine component manufacturing

The mainly components of a wind turbine unit generally include blade, generators, gear box, electric control system and tower etc., and others are cabin base, the engine cover, many kinds of bearings and metal structure parts such as flanges, spindle and so on. Different from the foreign countries, China's wind power equipment manufacturing has clear division

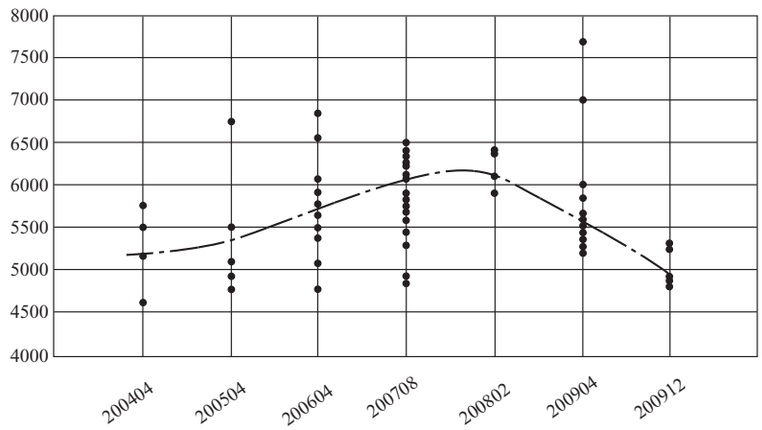


Figure 11 2004～2009 National Wind Generator Price Trend

of labor, the wind turbine manufacture enterprises just produce one or two parts (mainly blade), other components provided by the professional components production enterprises.

At present, the key components manufacturers quantity are increasing significantly in China, the total of 52 blade manufacturing enterprises, 10 gearbox manufacturing enterprise, 16 bearing enterprises and 12 converter manufacturing enterprise. The blades production and supply capacity can meet our wind turbine manufacturing market demand.

(1) Blade

Our country has 52 blade manufacturing enterprise, including the wind turbine enterprises serving themselves and independent blade enterprise. In the separate blade production enterprise, at present the main market suppliers are Zhonghang HuiTeng wind power equipment Co., LTD, Zhongfu Lianzhong composite materials group Co., LTD. and YiErM fiberglass products (Tianjin) Co., LTD. The total productivity of the three companies is about 5,000 sets/year. Some other blade production enterprises also have certain production capacity. Foreign capital and joint venture such as: Gamesa, Vestas, Suzlon, Norex have their own blade production. China's blade production and supply capability have been able to meet the market demand.

(2) Gear box

The foreign-capital enterprise of domestic wind gearbox currently are

Winergy Companies of Siemens Group and Hansen Wind Power Transmission Equipment Company, mainly supply Vestas, Suzlon machine and other foreign wind turbine enterprises. Domestic gearbox enterprises are mainly Nanjing High Accurate Drive Equipment Manufacturing Group Co., Ltd. (NGC) and Chongqing Gear box Company, both companies' market share account for over 50%. Daliang Zhonggong Group produces the gearbox for Sinovel as a supporting.

(3) Generator

There are many generator manufacturing enterprises supporting the wind turbine enterprises, such as Lanzhou motor, Yongji motor, Shanghai motor, Xiangtan motor, Dalian Tianyuan, Dongfeng motor, Nanyang motor, Zhuzhou, Shenyang Yuanda, Jiamusi motor, Guangzhou, Xi' an Dun'an electrical, Winergy etc.. Besides there are also some wind turbine manufacture enterprise producing generator themselves, such as Suzlon, Gamesa, Vestas, Jiangsu Xinyu and Beijing BeiChong etc. In accordance with the current WTG technical requirements, China's generator production and supply ability can meet the market demand.

(4) Converter

In our country, the wind generator converter supply still depend on imports and purchase from foreign-capital enterprise products, the main suppliers are ABB, Converteam, Ingeteam etc, the domestic converter producers are Beijing Kenuo Weiye, Hefei sunshine, Xuji electrical, Qingneng HuaFu, Jingxin electrical and Emerson network energy (foreign), mostly are small batch production or in the testing phase.

(5) Bearing

Wind power bearing generally includes the yaw bearing, variable OARS bearing, generator bearing, gear box bearings and spindle bearing. China has achieved batch production of yaw bearing in big size, variable OARS bearing and spindle bearing, and has a strong supply capacity, the main enterprise have Luoyang LYC company, Wafangdian bearing group, Xuzhou ROM, Ed, Tianma group, etc. Gearbox bearing and generator bearing

used in wind field currently are using imported products. The bottleneck restricting the current wind power equipment manufacturing industry fast development is the lack of precision bearing supply for the gear box. Because these bearing need high quality requirements, with technical difficulties, only individual domestic enterprises are in the trial production, it have not formed a batch supply capacity.

(6) Metal structure parts

Including base, tower, flange, the wheel hub, spindle, gear box body, generator case etc. Because these components technical requirements and processing difficulty are relatively low, many domestic enterprises has started to provide supporting production, there is no obvious problems in market supply.

3.2.3 The policy and main problems of wind power industry

3.2.3.1 Policy

(1) The policy summary

China has already established mature policy framework system to support wind power market development and manufacturing development. In 2005 before Renewable Energy Law enacted, our country has formulated and implemented several supporting policy related to wind power, and launched a batch of national construction projects to promote the establishment of wind power market and to support the development of the manufacturing industry. The policy covers wind power price, on-grid policy, technology R&D, economic incentives, industrialization promotion, market scale, etc.. Although some policies especially that related to investment, credit and loan aren't stable and no long-term continuity, these policies and their implementation provide a good foundation for supporting system establishment relevant wind power in Renewable Energy Law. They together with Renewable Energy Law and subsequent supporting measures formed the policies framework to support wind power development. The main wind power policies are summarized as follows:

Table 16 Current Wind Power Incentive Policy

Incentive policies for wind power equipment manufacturing	Localization needed, and motivation	1. Wind power concession projects require the localization rate of wind power equipment more than 70%. (cancelled in 2009) 2. *Interim Measures for the Administration of Special Funds for Wind Power Generation Equipment Industrialization*, providing subsidies to the eligible domestic wind power equipment
	Tariff preference	Drawback for the imported key components and raw materials of the wind turbines more than 1.2MW
	Tax incentive	High and new technology enterprise income tax levied 15%
	Technical specifications	Relevant wind power equipment standards and wind power grid standards
	R&D input	Science and technology support plan; "863" plan; "973" plan, etc.
Incentive policy for ensuring the steady development of wind power market	Tariff system	China executes wind power grid tariff policy, four different categories resource areas pricing. Wind power cost-sharing
	Planning objectives	*The Renewable Energy Medium and Long-Term Development Planning*, *The Renewable Energy Development Planning During the 11th Five Year Plan*
	Resource concessions/bid	1. wind power concession project tendering, 2. wind power base project tendering
	Tax incentive	Wind power value added tax halved
	Mandatory access to grid	1. Wind power must access to grid, 2. The part over the grid price will be shared by the users

(2) 2009 wind power policy

In July 2009, in order to regulate the wind power price management and to promote the healthy and sustainable development of wind power industry, the price department of National Development Reform Commission issued "Notice on perfecting the wind generating power tariff policy", wind power pricing by bidding changed to implementing grid power tariff policies. Notification regulates wind resource area are divided into four categories of pricing, in accordance with the wind resources situation and construction condition. The grid price in four categories resource areas are respectively 0.51 Yuan/kWh, 0.54 Yuan/kWh, 0.58 Yuan/kWh and 0.61 Yuan/kWh. The new onshore wind power projects uniformly execute the wind

power grid tariff. Offshore wind power tariff will be decided separately according to construction process. At the same time, it will continue to implement the wind cost-sharing system. Wind power tariff above local coal generation grid price will be shared by the national renewable electricity price additional part.

By the end of 2009, the National Development Reform Commission issued the Notice on cancelling the requirement of the localization rate of wind power equipment purchasing. The Notice cancelled the requirement of "Wind power concession projects require the localization rate of wind power equipment more than 70%, the non-eligible wind farm doesn't allow to be constructed" in the Notice on the wind construction management relevant requirements. In the future, the implement organization must do the open, fair and public bidding in accordance with the "Bidding Law" and the relevant national standards and technical requirements.

3.2.3.2 Main problems

(1) Has Not Yet Fully Formed the Design Capabilities of Core Technology

Although the current wind firms have passed the initial phase of "technology introducing", and stepped into the mainstream of the "joint design", it is still not fully into the key stage of "innovation" . The so-called second innovation is limited in material selection, partly process improvement to meet the special requirements of climate and environment, which shows that China's enterprises haven't got rid of the dependence on foreign technology, and haven't formed their own design capabilities.

There are many reasons to promote enterprise relying on foreign design, such as the rich experience, the higher reliability of technique. But another important reason is that self-developed model is too slow, which can't meet the needs of the rapidly growing market. If you do not keep up with the mainstream, the opponents will over you in the market. For instance, Yunda Company has the strong R&D team, but they still chose the integrated design pattern for produce new models soon.

The commercial mode of integrated design can not only guarantee gaining the core technology, also can improve the level of self development. But

it increased the costs of product, for example, Shangdian spent 0.12 billion Yuan on design software and personnel training during the joint design process when corporate with German company. The more important is that the enterprise will completely obey to foreign technical team in the future development. And the foreign design company always corporate with several Chinese enterprises at the same time to obtains excess profit. If it continues, it will seriously affect the innovation ability of China's enterprises and its formation of international competitiveness.

(2) The Key Components Still Dependence on Imported

Although most components of the wind turbine are domestic production, spindle bearing, frequency conversion and control system are still mainly rely on the import, especially the key components of new megawatts level turbine are mostly imported, which undoubtedly increase the overall cost, and become the is the weakest link of the wind power industry development currently.

The large-scale development of wind power industry in China only lasts five years, so it's common that some key components can't realize localization. The bottleneck of bearing is the domestic steel materials can't satisfy the actual demand; bearing processing technology level also behind the abroad; the frequency conversion and control system technology are closely to the design of whole turbine. Such dependence on import reflects we are weak in basic research and core technology.

(3) The Technical Level and Product Quality Lags Behind the International Advanced Level

Compared with foreign advanced technology, China's technical level of wind product is relatively backward. For example, the current mainstream commercial turbine doesn't have the function of power control and low voltage across, but these grid friendly advanced technologies are universally implemented in foreign products. In addition, the wind farm operators also express that domestic wind turbine have the issues of high failure rate and weak reliability.

In the initial development period, the government formulated the pro-

tective policies with "the localization rate of 70%" . But with the rapid expansion of wind power market, the state has cancelled such policy. Although national product has the obvious advantage of prices, without the improvement in performance, quality and service, the adaptive capacity of national product market won't increase, and the national product won't have the competitive power.

(4) Enterprise Focusing on the Expansion of Production that Brings Overcapacity

Currently, China's wind power industry grows rapidly, and there are more than 80 wind turbine manufacture enterprises. The production capacity of the top five wind turbine enterprise around 2010 will be more than 12 million kW, plus the production capacity of other enterprise, the producing capacity of domestic wind turbine will exceeded domestic market needs in short-term. The domestic overcapacity contradiction will gradually outstand in the next or two years later.

More importantly, the domestic mainstream wind firms all show the trend that they take the production capacity expansion as the important means for market competition ability enhancement, not the self R&D capability improvement. The advantage is they can quickly capture the market; on the one hand, the scale expansion can reduce the production cost. Under the background of shrinking in demand of other industries, lots of capacity in manufacturing, plenty of funds, such thinking made the rapid expansion in such emerging industry.

(5) Weak in Product Certification and Testing

At present domestic wind turbine design uses the IEC61400-1 standards, and it's not suitable for Chinese wind and climatic characteristics without considering China's national conditions. In the northwest, the wind turbine designed according to the IEC61400-1 standard is not economic and with high cost; meanwhile in the southeast coastal area, the wind turbine designed with the same standard is not strong enough and weak in service time. It will reduce the wind turbines economy that the standard does not adapt to China's real wind condition.

China's testing capabilities in wind power needs improving. First, the Chinese wind power equipment testing just starts along with the wind power industry development this year. Many of the third-party testing institutions are weak in the knowledge and experience, and need to improve in the further developing process, especially in the mechanical load and power quality, power characteristics testing capability. Second, at present many component enterprises establish their own testing center and testing platform, but the enterprise only test their own production, it's limited for the technical data and experience accumulation. It also wastes the resource to establish so many testing platforms, and the testing ability and the detection range are very limited. In addition, the enterprise test results is difficult to get owners approval without the certification from the third-party certification body.

At present, China doesn't have the unified wind power certification model and certification ability to unify the criteria on wind power product. Some enterprises claim they got the certification by using test certificates, letters of certification, product inspection certificate and authentication certificate with special conditions of foreign authentication institutions, which caused wind farm developers and investors to misunderstand, and also influence the validity and seriousness of certification.

3.2.4 Recommendations on the Future Industry Development

Recent China's main task is to promote the large-scale development of wind energy, based on which, the supporting policy on stable price and continuing to expand the market demand are the essential policy means.

Therefore, the three key issues restricting China's wind power development need to be solved, which are wind resources investigation and assessment, wind power grid technology and planning, the wind generator design and manufacturing technology with the independent innovation, to achieve the breakthrough of development bottleneck and improvement in wind power economy during the 10th "Five Year Plan".

(1) To support and gradually establish the wind power industry system with independent intellectual property rights, and to form the completed in-

dustry chain with components and wind turbine manufacturing. Through price policies to promote large-scale wind power development and construction, to promote technological progress and industrial development of wind power, to achieve the localization of wind power equipment manufacturing, reducing the cost of wind power greatly to make wind power competitive.

(2) The development of wind power gives priority to onshore wind, the key development inland is northwest, North China and northeast of the "three norths", together with eastern coastal areas, including Hebei, Inner Mongolia, Jilin, Gansu, Xinjiang, and Jiangsu, Zhejiang, and Shandong provinces, which are adaptable to develop large-scale wind farm. For the region limited by topography and restricted by grid condition, small and medium-sized distributed wind farm can be developed.

(3) For the offshore wind power, previous study on offshore wind farm should be made. Based on the testing experience of Shanghai Donghai bridge wind farm, try to establish several offshore wind farms in Jiangsu, Shanghai, Zhejiang, and Shandong and coastal regions before 2015. Put effort on the research and exploration of core technology of offshore wind power, mainly on solving the overall optimization design of wind turbine, foundation construction, the transportation, installation and anticorrosion technology etc, make a good base of the large-scale development of offshore wind farm after 2020.

3.3 Small Wind Power

3.3.1 Current Situation of Industry

At present China's off-grid wind turbine production have 19 types, the single set capacity are respectively: 100W, 150W, 200W, 300W, 400W, 500W, 600W, 1kW, 2kW, 3kW, 4kW, 5kW, 10kW, 15kW, 20kW, 25kW, 30kW, 50kW, 100kW. The annual production capacity is 100,000 sets. In 2008, 34 production units produced 78,411 off-grid wind turbines with the capacity below 100kW, with the total installed capacity of 72,825

kW, the total production up to 51.8901 million Yuan, the tax value of 9.948,1 million Yuan. The enterprises with the annual production over 1,000 sets are: Yangzhou Shenzhou, Hunan Zhongke HengYuan, Ningbo Fengshen, Guangzhou Hongying, Beijing Yuandong Boli, Nanjing east dragon, Inner Mongolia lung XinBo, BoYang, Shandong huhhot NingJin China and Asia, Shanghai centre, Shanghai Yuefeng, Jiangsu Nangtong Zilang, Qingdao AnHua New energy development, Baotou Tianlong, Ningxia Fengshuang, Qingdao AnHua New energy.

According to the annual statistics by the secretariat of CWEEA, from 1983 to the end of 2008, the total production of various off-grid small size wind turbine by Chinese manufacturers are 509,085 sets. Annual production, total production, production capacity, exports all list in the top of the world. From 2002 to 2008, small wind turbine production, output value, capacity, profit, and exports all rapidly developed (see Table 17).

Table 17 National Small Wind Power Development Situation

Year	2002	2003	2004	2005	2006	2007	2008	Total (2002～2008)
Output (Set)	29,658	19,920	24,756	33,253	50,052	54,843	78,411	290,893
Capability(kW)	8,873.2	6,083.7	11,300.2	12,020	51,740.8	35,014.6	72,825	197,857.7
Value (10,000 RMB)	7,059.6	4,740.5	6,653.7	8,472	17,090.8	31,794.37	51,890.1	127,701.1
Tax Profit (10,000 RMB)	984.5	660.6	775.9	992.9	1,415.99	3,749.03	9,948.59	18,527.46
Export(Set)	1,484	2,484	4,189	5,884	16,165	19,520	39,387	89,113

Our traditional users, clients of small wind power equipment are still farmers, herdsman and fisherman in the no-electricity and lack of electricity area. Inner Mongolia is the earliest, best and most region of China's popularization and application small WTG.

See from the specific models, the most popular type is 300W, total sales of 22,279 sets, accounting for 28.5%, and the Second is 200W type with the sales of 11,171 sets, accounting for 14.4%. The sales of these two types in total ac-

count for 42.9% of all. This shows that the main market of small WTG is in rural no electricity areas. And see from nationwide, 44% users are farmers.

It is worth noting, in the past years, the type of 200W and 300W accounted almost two-thirds in the small WTG production sales. In recent years, it has declined. This shows that the user's demand for small WTG capacity is gradually increasing. The total number of sales of small wind turbine generators in 2006 accounts for 51% of the total sales, but in 2008 it fell to 43%. The market of small WTG still give priority to the rural market, so the types of 200W and 300W still occupy the half market.

In recent years, two points appeared in small wind power equipment sales: one is independent power supply of wind and wind/solar lamps for the domestic urban and rural highway fast development, which need 100 watts level wind turbine generators; the other is the application of distributed power generation, which need kilowatt wind turbine generators. The 2008 statistics show that China's small WTG production is 78,411 sets, with the installed capacity of 72,825 kW, including 39,387 sets export, installed capacity of 51.5 MW, accounting for 70.7% of the total installed capacity, the average single set power of 1.31 kW.

According to other statistics, among China's total sales (sets) in 2008, the off-grid type occupied about 67%, distributed type occupied approximately 33% (mainly exports, while small WTG isn't allowed to access to grid in China). In the domestic market of small wind turbine generators, the off-grid type accounts for 97%, and distributed type (on-grid) only 3%; in the export of small wind turbine generators, the off-grid type accounts for 52% (sets), while the distributed type (on-grid) accounts for 48%. Foreign popularization of the application of the distributed power generation promote the kilowatt and above level WTG development.

According to the statistics of 19 major export production enterprises, we exported 39,387 sets small wind turbine generators with the capacity below 100kW in 2008, one time increased than 2007. The total value is 44.6656 million dollars, 20.1% increased than 2007. The total export amount of the nearly 10 years is 92,145 sets.

In 2008 we exported to 46 countries and regions, including DPR Korea, India, Korea, Mongolia, Thailand, Philippines, Indonesia, Taiwan, Singapore, Vietnam, Kazakhstan, Japan, Turkey, Israel and Lebanon, Hong Kong, Malaysia, Syria, France, Britain, Russia, the Netherlands, Ireland, Denmark, Spain, Belgium, Sweden, Germany, Italy, Poland, Scotland, Greece, Finland, Croatia, the United States, Canada, Chile, Ecuador, Mexico, Dominican republic, Brazil, Australia, New Zealand, Nigeria, Kenya, Guinea.

The main export enterprises are: Yangzhou Shenzhou, Guangzhou Hongying, Hunan Zhongke Hengyuan, Ningbo Fengshen, Beijing Yuandong Boli, Qingdao Anhua wind power equipment, Zhejiang, Shandong HuaYing NingJin China and Asia, Shanghai Zhiyuan, ShanghaiYuefeng and Ruian Haili.

3.3.2 Manufacturing Situation

According to the incomplete statistics, by the end of 2008, China has 102 small WTG production enterprises, among which 74 enterprises engage in the development, research and production of off-grid wind turbine (mainly 36 WTG factories), 28supporting enterprises, and the scientific research institutes, colleges and universities of 10.

Main producers are: YangZhou shenzhou WTG Co., LTD, Hunan Zhongke HengYuan energy technology Co., ltd., Guangzhou Hongying energy technology Co., LTD, Ningbo Fengshen Co., ltd., and Beijing Yuandong Boli wind power equipment Co., LTD, Inner Mongolia Huhhot BoYang renewable energy company, Qingdao wind WangFengLi generator Co., LTD., Jiangsu Nangtong purple lakefront WTG manufacturing Co., LTD, Shandong NingJin China and Asia industry Co., LTD, Qingdao AnHuaXin source wind power equipment Co., LTD, Nanjing east dragon electronic technology center, permanent magnet motor, Ningxia Baotou Tianlong wind bully machinery Co., LTD, Shanghai vision of green energy Co., LTD, Zhejiang HuaYing wind power equipment Co., LTD., Zhejiang Ruian HaiLi special WTG factory, Shanghai Yuefeng new energy tech-

nology Co. , LTD. Etc.

Main research institutes are: Shenyang Harbin industrial university, China academy of sciences electrician wind energy research institute, institute of Shantou university, university of north China electric power renewable energy institute, Hefei sunshine, Shandong ShangyifuaoWind energy research institute, Jiangsu Nangtong purple lakefront of vocational and technical college, the ministry of water resources conservancy scientific research institute, pastoral He'nan Hebi city science and technology innovation research institute, China NongJiYuan Hohhot sorting energy research institute, etc. However, most of these research institutes are engaged in the research of large-scale wind power, rarely concerned small wind power.

Around the turn of the century, the main producers of small WTG are distributed in Inner Mongolia such northern regions. According to the statistics by the wind machinery branch of CWEEA, in 2001, China has 20 small WTG production enterprises, and its distribution see the Figure 5. 12. If the Yangtze River as the dividing line between north and south, 12 enterprises are from the north, accounting for 60%. Especially Inner Mongolia, 5 enterprises of 20 are from Inner Mongolia, occupied 25%. At that time, major markets of China's small WTG are in Inner Mongolia.

In recent years, due to various reasons, especially the change of market demand, China's small WTG production enterprise distribution pattern gradually by north toward the south metastasis. The original part of northern small wind power equipment manufacturing enterprises closed, or stopped, or transferred. The enterprises no longer exist or no longer produce small wind turbine generators. The main production enterprise concentrate in the south, near the emerging markets, such as mobile communications, or near the capital market, because the south area have plenty of free funds. According to the incomplete statistics of CWEEA, by the end of 2008 China has 80 southern small wind power production enterprises.

3. 3. 3 Market Application

(1) Electric Power Construction in Farming and Pastoral Area

Our country's wind resources are rich, but available region for the development and utilization only 76% of the total national land, which mainly distributed in the northwest, north China, northeast, Qinghai-Tibet plateau and coastal areas. China's no power areas are also distributed in the above regions. According to the foregoing statistics, by the end of 2006, there are about 3 million no electricity households in China, with 11.47 million residents without electricity, among which 1.5 million households, about 7 million people will use the electricity by grid extension, the small hydropower and migration, the rest 1.5 million no electricity households will use the off-grid wind power generation and wind/solar system to resolve the problems.

Along with the economic reform, the national economy is developing healthy and steady, the farmer and herdsman's living standards are improving, household appliances has become the necessity of life. Therefore, the wind turbines with larger power such as 300W, 500W and1kW, also the wind/solar generating system are needed. Some other township (village) and town need high-power centralized power supply system to solve their daily living power and small agricultural products processing electricity needs.

(2) Troops, Border Posts

In the remote regions frontier army, outposts, island garrison, fishermen, microwave station located in the wild mountains, TV station, weather stations, highway, no power station of railway, observation post and tidal breeding (China has the total length of 32,000 km coastline, the mainland coastline of 18,000 kilometers, the island coastline of 14,000 km) such places, diesel or gasoline is needed to generate power. The cost of power supply is quite expensive, in some places more than 3 Yuan/kWh. Meanwhile most of these places are rich in wind resources. Using "wind/oil power generation systems" can ensure the power supply for 24 hours, and save the fuel and capital, but also reduce the pollution.

(3) Power Construction in Inland Lake

Our country has broad coastlines and inland lake. In recent years, due

to the development of aquaculture, fishermen use more and more small WTGs. Due to the higher income of fishermen; the public causes like shipboard school, shipboard clinics and village government require using high-power wind turbine generator. In 2006, the Dutch governments provide a 5kW wind turbine generators, installed in a school of Honghu village to solve electricity problems.

(4) Mobile communication

Global mobile (GSMA) development fund held the global mobile communication meeting in September 2008 in Kenya capital. The meeting issued a combination of "green energy initiative" and "mobile telecommunication green energy project", promoting the green energy in the future mobile base construction. Initiative thinks that future mobile communications users increase mainly depend on the population in no electricity area (in the next five years, estimating that each year 50,000～100,000 off-grid bases will be built). The congress proposal the operators use the solar arrays and the wind turbine generators in the site planning. In November of 2008 Asian mobile communications conference and exhibition in Macau also designed a green energy feature.

China mobile and China Unicom started to the wind, solar, wind/solar power supply at the beginning of this century. China mobile proposed the "green energy plan" in 2007, in 2009 it announced the target that 20% of the energy for communication station will come from renewable energy until 2012. At present, the power of mobile base away from the grid are transforming from diesel generator to wind and wind/solar power generator to get the highest output-to-input ratio and environmental benefits.

(5) Traffic Monitoring and Forests, Oceans Data Monitoring

Along with improvement and enhancing of the environmental awareness, people protect natural resources in various channels. For instance the State Forestry Administration issued the "converting cropland to forest", the State Oceanic Administration issued "sustainable development strategy", etc. People need more information faster to achieve effective protection and use of the resources. The most basic method is to establish monitoring net-

work in forests, oceans, railway, highway, and to achieve real-time information transmission. However, most places such as marine and forests are far from conventional power grid, the monitoring equipment cannot be used without electricity supply. People cannot get accurate effective information at the first time, and cannot make correct judgment of forest fire danger, tsunamis, traffic accidents to make timely corresponding decision and measures.

Renewable energy independent powers generation become the main way to solve the power supply in these areas. Small wind power is easy to provide electricity for the normal work of monitoring network. For example, our country's Antarctic sails installed a 10kW wind turbine generators for melting ice, which has already work for five years and is now considering expansion.

(6) Scientific Research and Teaching

Application and theoretical research of renewable energy attract more and more attention from different aspects, many universities have set the renewable energy development and utilization as a teaching content, introduce the basic knowledge to the student, such as: wind power, PV power, hydropower, straws power, geothermal energy, biomass energy, and cultivate their interest in renewable energy to reserve all kinds of talents in renewable energy. Many universities have opened the wind power course, and bought wind power experiment and demonstration equipment, such as Inner Mongolia polytechnic university's wind test center, logistic engineering college teaching demonstration system, Qinhuangdao army institute, Zhejiang university teaching demonstration projects, Shandong construction engineering college teaching demonstration project, Shanghai second industrial university teaching demonstration projects, etc.

(7) Export

Because the lower prices of domestic small WTG and larger profit margins for middlemen, the international demand of Chinese small-sized WTG is increasing year after year. According to the statistics from CWEEA, Chinese export of small and medium WTG were over 30,000 sets in 2008. These products are exported to 46 countries and regions, of which

more than 60% belong to on-grid distributed wind power generation equipments.

3.3.4 Auxiliary Products

The off-grid wind energy and wind/solar complementary system are normally formed by energy acquisition (wind generators), energy control (charging controller, inverter, central control module, ac/dc power distribution) and energy storage (battery). The on-grid distributed wind power systems is formed by energy acquisition (wind generators) and energy control (grid inverter) two parts.

(1) Charging Controller

Charge controller is very important component of the system. Many system faults are caused by the problems of controller. Because different enterprise has different WTG structure, power curve, over-speed and over-power protection principle, generally charging controller cannot be universally used. Professional production enterprises of wind controller are Hefei sunshine, Beijing Hengdian, etc.

However, many WTG production enterprises and users choose charging controller freely, which caused the wind turbine generator or the controller burned, and after the accident, the responsibility is difficult to distinguish, which makes some professional wind charge controller manufacturers gradually lost enthusiasm in supporting the production of controller.

(2) Inverter

Whatever the off-grid DC/AC inverter, or on-grid inverter, they have the professional producer. The inverter enterprises are mainly Hefei sunshine, Beijing Hengdian and Nanjing Guanya etc. The single set capacity is from hundreds watt to dozens kW, can output modulation sine wave and standard sine wave. The off-grid DC/AC inverter R&D and design have developed with the support of the "send electricity to town" project implementation, the quality and reliability enhanced unceasingly.

Because China has not yet allowed small renewable power generation equipment to the grid, the small WTG industry has not fully developed.

(3) The battery

Battery is the main storage ways for the off-grid wind energy system. At present China does not have the specific battery for renewable power generation systems, most commonly used is lead-acid battery, then the alkaline batteries. "Send electricity to town" project implementation promotes the research and production of battery for off-grid power generation systems. Product quality improved while price declines. But because the battery needs to be replaced once every 3～5 years, battery is still one of the main reasons that small wind generating power station construction with high cost and unsustainable.

The main battery manufacturers are: Jiangsu Shuangdeng, Shandong Shengyang and Chongqing Wanli, etc. Some companies are developing all vanadium fluid flow battery, phosphoric acid lithium iron batteries, but the cost is higher, it is impossible to apply in small wind power field.

4 Solar Energy

4.1 Solar Resources in China

Solar radiation resources are rich in China. According to China's solar energy resource distribution, as well in order to facilitate the development and utilization of solar energy resources, the solar energy resources in China can be divided into four regions, as shown in Figure 12.

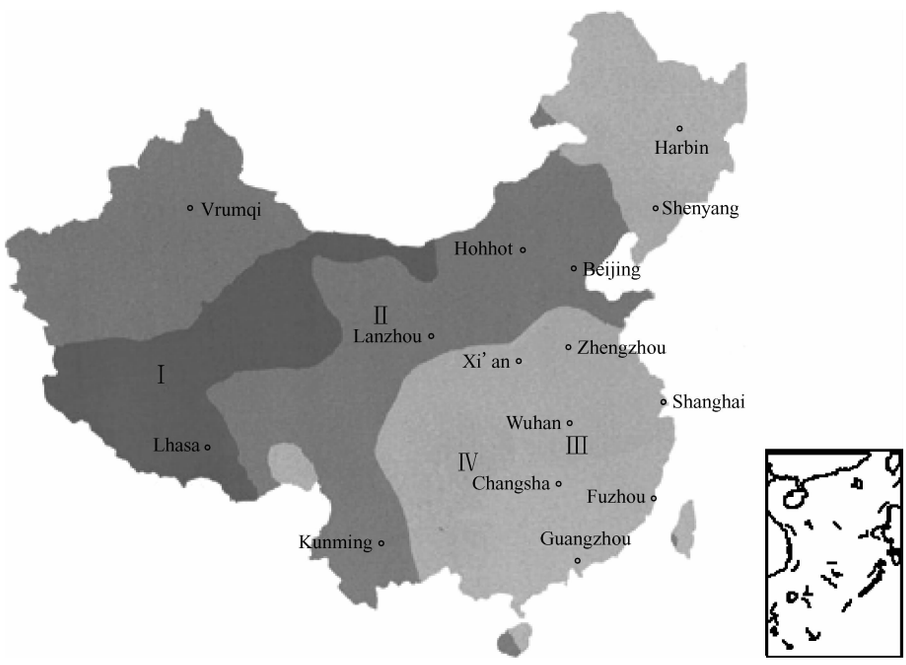


Figure 12 Solar Radiation Resources Distribution of China

(Ignored Dongsha, Nansha, Xisha Islands)

Source: China Meteorological Administration

The 30-year average data in 1971～2000 show that China's rich solar energy resource regions account for about 96% national land area [total annual solar radiation around 1,050～2,450 kWh/(m^2 · a)], as shown in Table 18.

Table 18 Solar Resources Region Distribution of China

Title	Sign	Index /[kW·h/(m²·a)]	Percent of national territory	Region
Abundant	Ⅰ	≥1,750	17.4%	Main parts of Tibet, south parts of Xinjiang, Qinghai, Gansu and west parts of Inner Mongolia
Very rich	Ⅲ	1,400～1,750	42.7%	Main parts of Xinjiang, Qinghai, east parts of Gansu, Ningxia, Shanxi, Shanxi, Hebei, northeast parts of Shandong, east parts of Inner Mongolia, southwest parts of the Northeast, Yun'nan, and west parts of Sichuan
Rich	Ⅲ	1,050～1,400	36.3%	Heilongjiang, Jilin, Liaoning, Anhui, Jiangxi, south parts of Shanxi, northeast parts of Inner Mongolia, He'nan, Shandong, Jiangsu, Zhejiang, Hubei, Hunan, Fujian, Guangdong, Guangxi, east part of Hainan, Sichuan, Guizhou, southeast parts of Tibet, Taiwan
Average	Ⅳ	<1,050	3.6%	Middle part of Sichuan, north part of Guizhou, northwest part of Hunan

Source: China Meteorological Administration

4.2 Solar PV Generation

Solar PV generation is the power generation technology of generating electricity from solar energy directly by the photoelectric conversion effect of semiconductor, an important form of solar energy utilization. This chapter introduces China's solar PV industry developments in 2009.

4.2.1 Solar PV Market Current Station in China

Into the 21st century, China's PV market began to develop relatively fast driven by the government, and a lot of national plans have been implemented, such as the "Power Supply Project for Un-electrified Counties in Tibet", "China Brightness Program", "Brightness Program in Ali District, Tibet", "Township Electrification Program" and "non-electric power construction in the region", and etc. During the period from 9th "Five-Year Plan" to 11th "Five-Year Plan", several demonstration projects have been

carried out, such as urban grid-connected photovoltaic power generation and large-scale desert plant grid integration.

In 2009, China has launched many projects such as "photovoltaic building", "Golden Sun demonstration projects" and large-scale desert solar power plant tender in Dunhuang, led by these projects, the installed capacity reached to 160MW, over the total installed capacity of past years, the cumulative installed capacity up to 300MW. Specific data are shown in Figure 13.

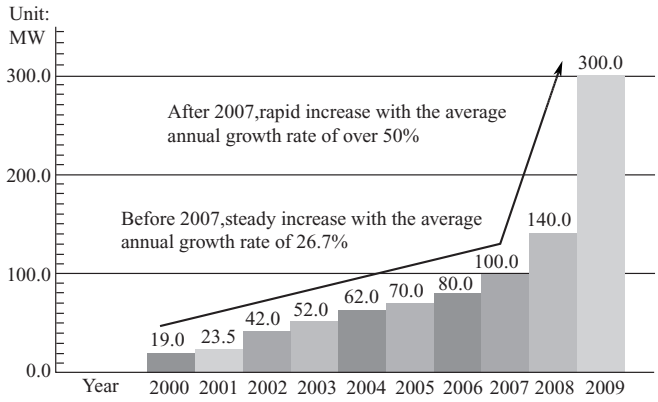


Figure 13 China's Total Installed Capacity of Solar PV Power Generation over the Years

Building Integration Photovoltaic (BIPV) power generation has developed rapidly since 2007. By the end of 2009, total installed capacity is approximately 34.2MW, representing a 240% growth compared to that in 2008, 17 times of that in 2007. Specific data and trends are shown in Figure 14.

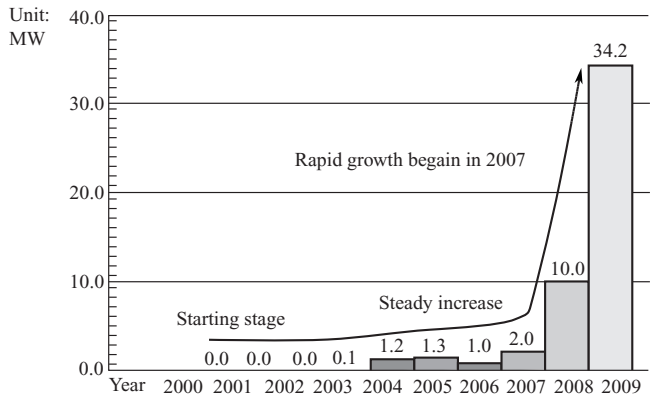


Figure 14 China's BIPV Market Development

In 2009, China launched the concession tender project of 10-MW solar PV power plant in Dunhuang. As the first large-scale PV power plant by concession tender, the construction of the project started the market of China's large-scale solar power stations, specific effects shown in Figure 15.

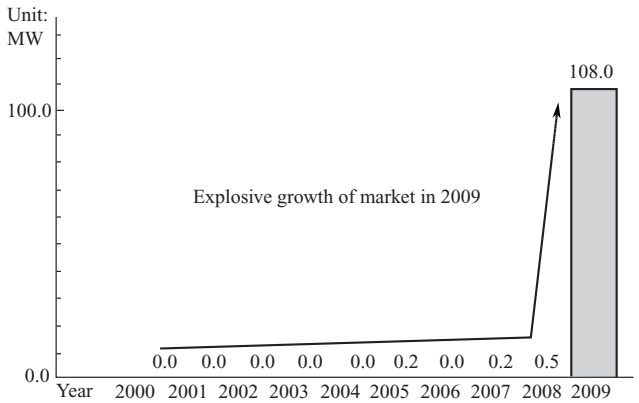


Figure 15 China's LS-PV Power Station Market

In addition, each province or autonomous region in China has the large-scale solar PV power plant under construction, the specific projects listed in Table 19.

Table 19 Solar PV Power Plants Under Construction in 2009

Province	City	Investor	Scale(kW)	Completion Date
Jiangsu	Tantu of Dongtai	Huadian Group	10,000	Under construction
	Xuzhou	Jiangsu Zhongneng Guiye Technical Development Ltd. Co	20,000	2009. 12. 30
Ningxia	Shizuishan	CECIC	10,000	2009. 9. 30
	Shizuishan	Zhejiang Zhengtai	10,000	Under construction
	Shizuishan	SDIC power Co	10,000	Not started
	Pingluo County of Shizuishan	Ningxia Guodian ATS New Energy Development Co. , Ltd.	10,000	Under construction
	Taiyangshan	Ningxia Power Investment Co	10,000	Under construction
	Taiyangshan	Ningxia Electric Power Group	10,000	2010. 01. 16
	Taiyangshan	CECIC	10,000	2010. 01. 16
	Ningdong	Huadian International Ningxia Branch	10,000	Under construction
	Gaoshawo of Ningdong	Ningxia Electric Power Group	20,000	Under construction
Gansu	Dunhuang	CGNPC	10,000	Under construction
	Dunhuang	SDIC power Co	10,000	The end of 2009
Yun'nan	Shilin	Huaneng Lancangjiang Hydropower	10,000	Under construction
	Shilin	Yun'nan Power Investment Co	10,000	Under construction
Shanxi	Shiyu	Shanxi International Electricity Group	10,000	Not started

Overall, China's PV market maintained a steady development trend. Compared to international development, it shows low base, slow growth and small amount, especially asymmetry with the pace of PV manufacturing development. While the domestic market is starting, but the "market out" the situation has not changed, the domestic installations in 2009 accounted for only 4% of solar cell production, there are still 96% for exports. China's photovoltaic industry totally depends on the international market, the domestic market needs to be further expanded.

4.2.2 Solar PV Industry Current Station in China

Encouraged by the "Renewable Energy Law", also benefited from the international market pulling, China's photovoltaic cell manufacturing industry develops rapidly after 2004, with the annual growth rate of more than 100% for 4 consecutive years, and exported in large quantities, production capacity and yield both increased significantly. By end of 2009, China's output of solar photovoltaic cells is 4011MW, an increase of 54%. The data are shown in Table 20.

Table 20 The Domestic Solar PV Cell Production and Growth Rate in 2009

Year	2004	2005	2006	2007	2008	2009
Domestic production of solar PV cells (MW)	50	200	400	1,088	2,600	4,011
Annual growth rate of the domestic production of solar PV cells		300%	100%	172%	139%	54%

China's PV cell production capacity increased rapidly, especially after 2006. China became the world's largest producer of PV cell after 2007, and its production ranks the number one in the world for three consecutive years from 2007 to 2009. The proportion accounting for the world's production of photovoltaic cells has increased from 17% in 2006 to 38% in 2009. Seen from the current situation, China's photovoltaic industry has formed leading production capacity, also has the same level technology. The specific data are shown in Figure 16.

From the view of Chinese manufacturer of solar PV cells, by the end of

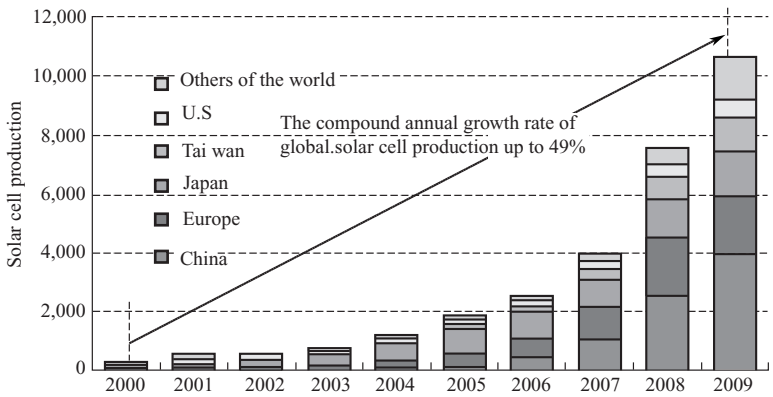


Figure 16 The Proportion of China's Solar PV Cell Production Accounting for the World's Production in 2009

Source: China PV Industry Research Report (2006～2007), GTM Research (2010)

2009, the first five manufacturers of photovoltaic cells are Suntech in Wuxi of Jiangsu Province, Baoding Yingli in Hebei Province, Hebei Jingao Company, Changzhou Trina solar Company in Jiangsu, and Jiangsu Linyang solarfun Company, the production respectively is705MW, 527MW, 504MW, 426MW and 316MW. China's top ten companies of solar photovoltaic cells are shown in Table 21.

Table 21 China Solar PV Companies Ranking in 2009

Ranking	Company Name	Yield(MWp)
1	Wuxi Suntech power Co. ,Ltd	705
2	Baoding Yingli	527
3	Hebei Jingao	504
4	Changzhou Trina solar Co. ,Ltd	426
5	Jiangsu Linyang solarfun Co. ,Ltd	316
6	Suzhou ATS	315
7	Changzhong Yijing	200
8	CEEG	180
9	Ningbo Solar electric Co. ,Ltd	150
10	Zhejiang Sunowe Photovoltaic	120
	Total	3,443
	National	4,011

Source: PHOTON, GTM Research.

View from the upstream solar polysilicon production, the global polysilicon production capacity in 2009 was between 120,000 and 150,000 tons, of

which the United States, Europe, China and Japan rank the top four, the proportion was respectively 39%, 18%, 18% and 12%. Table 22 shows the actual polysilicon production in 2009.

Table 22 China's Actual Production of Polysilicon in 2009

Province	Company Name	Yield in 2009(tons)
Sichuan	Sichuan Xinguang	951
Sichuan	Sichuan Yongxiang	700
Sichuan	Emei Semi.	655
Sichuan	Ya'an Yongwang	620
Sichuan	Rene Sola	190
Sichuan	LeSi Tianwei	50
Jiangsu	Jiangsu Zhongneng	7,450
Jiangsu	Yangzhou Shunda	1,070
Jiangsu	Wuxi Zhongcai	440
He'nan	Luoyang Zhonggui	2,204
Shanxi	Shanxi Tianhong	200
Chongqing	Chongqing Daquan	1,523
Hubei	CSG	515
Total		16,568
National Total		20,000

China's rapid development of PV manufacturing promotes the progress of the whole industry chain. We develop some polysilicon technologies in the upstream area, gradual localization of production equipment, industry scale has expanded rapidly and the cost of production continued to decline. The situation that polysilicon materials, critical manufacturing equipment and photovoltaic cells dependent on foreign market, has improved, the whole industry situation is shown in Table 23.

4.2.3 Economic Analysis of China's Photovoltaic Power Generation

4.2.3.1 Downward Trend of the Cost of Solar PV Power Generation

First, reduce raw material costs and improve cell efficiency. From a technical point of view, as the new technology advancing, there is still a substantial decline space for the solar polysilicon price, and the power generation efficiency of solar photovoltaic cells will steadily improve.

Table 23 The Output Value Statistics of China's Solar PV Industry in 2009

	Yield (Output)	Average price	Estimated value (10^8 Yuan)	Estimated employment (10^4)
Ⅰ. Domestic solar polysilicon	20,000 tons		94	1
Imported solar polysilicon	20,000 tons	70 US dollar/kg (470Yuan/kg)	94	
Ⅱ. Crystalline silicon ingots/wafers	40,000 tons	4 US dollar/piece (27 Yuan/piece)	350	4
Silicon export	4,000 tons			
Ⅲ. Solar PV cell			444.6	11
Crystalline silicon solar cells	4,000MW	1.6 US dollar/W (11 Yuan/W)	440	
Thin-film solar photovoltaic cells	46MW	1.5 US dollar/W (10 Yuan/W)	4.6	
Ⅳ. Solar PV cell modules	4,100MW	2.2 US dollar/W (15 Yuan/W)	615	10
Ⅴ. Solar PV power generation market	160MW	20,000 Yuan/kW	32	1
PV cell Modules of which		1.1US dollar/W	17.6	
Ⅵ. Equipment manufacturing (estimated)			65	5
Solar crystalline silicon equipment manufacturing			20	
Solar ingot/slicing industry equipment manufacturing			10	
Solar cell equipment manufacturing			20	
Solar modules equipment manufacturing			10	
Other equipment manufacturing			5	
Ⅶ. Auxiliary materials			20	3
Ⅷ. Others			10	1

At present, due to the domestic polysilicon plants capacity increasing and import polysilicon prices decline, polysilicon prices have reached 50 U. S. dollars/kg. With the silicon material of the upstream firms reducing and the cells efficiency of the downstream cell manufacturers increasing, the proportion of the polysilicon costs accounting for the cost of crystalline silicon cells had decreased from 70% in 2008 to 30%, approximately equivalent to 0.4 U. S. dollars/W.

The second is to reduce the cost of cells and module manufacturing sector. By the end of 2009, China's crystalline silicon solar cell module price is about $ 1.8/Wp (equivalent to 12 Yuan/Wp) . Compared to rapid decline in the cost of solar polysilicon, the manufacturing cost of "silicon-solar cells-module" part has not changed greatly, the proportion increased from less than 30% to 70%.

Third, improve equipment localization rate and reduce the cost of production equipment. Our low price of solar photovoltaic cells is closely related in addition to the efforts from the firms to reduce costs, also benefited from the localization of the production equipment. The same solar photovoltaic cell production line, a 25MW production line needs about 50 to 60 million Yuan, while a domestic equipment production line only needs 20 to 30 million Yuan, 40%～60% lower than the imported production line. It's similar to the key production equipment, an 8 inch of single crystal furnace, the imported one needs 0.8 million Yuan, while the price of domestic equipment is the half of the imported one; for a 270 kg of polycrystalline silicon ingot furnace, the imported price is about 1.3 million U.S. dollars, while the domestic equipment is only 1.3 million Yuan.

In the case of the breakthroughs in the core technology of photovoltaic cells in our country, many processing equipments of the PV products are still dependent on imports in China. There is still much room for the cost reduction of PV power generation by increasing the independent R & D and comprehensive localization of photovoltaic production equipment.

Fourth, reduce the balance of system (BOS) costs. With the decrease of the price of solar cells and modules, BOS cost including inverters and batteries is close to the module investment cost, the proportion of balance module accounting for the total system investment has increased from 20%～30% to 40%. With the development of large-scale grid-connected inverter and the progress of the energy storage system, the decline in balance components cost is an important direction for promoting the decrease of the cost of PV power generation in the future.

4.2.3.2 Prediction for China's Solar PV Power Generation Cost Declining

Combined with China's resources and cost analysis of technology, it is initially expected that by 2015 the average price of the initial investment of China's solar PV power generation system decline to 15,000 Yuan/kW, power generation cost is less than 1 Yuan/kWh, "grid parity" can be achieved in the distribution side.

By 2020, the average price of the initial investment of China's solar PV power generation system is expected to reach 10,000 Yuan/kW, with the power generation cost of 0.6 Yuan/kWh, "grid parity" can be achieved in the generation side.

By 2030, the average price of the initial investment of China's solar PV power generation system is expected to reach 6,000 Yuan/kW, with the power generation cost of 0.4 Yuan/kWh, lower than the conventional electricity price, used in the large-scale.

Table 24 Cost Decline of Solar PV Prices and the Potential Prediction

Year		2007	2009	2015	2020	2030
Polysilicon price (U. S. dollar/kg)		300～400	60～100	15～45	15～30	15～20
The efficiency of polycsilicon cell module (%)		14.3	15～16	18～20	20～25	25
System price	Module price(Yuan/W)	25～30	14～15	9～10	6～7	4～5
	Balance system price (Yuan/W)	7～10	4～6	3～4	2～3	1～2
Initial investment price (Yuan/kW)		4～5	2～2.5	1.5	1.0	0.6
PV power generation cost (Yuan/kWh)		4	1.3～1.5	1.0	0.6	0.4

4.2.3.3 China's potential market of solar photovoltaic

(1) The Rural PV Market

By the end of 2005, China has about 270 million households of 12 million people without electricity, of which 100 households without electricity need PV and wind power generation system to solve the problem before 2020, there are 500,000 households need using stand-alone PV power system to solve the problem before 2030.

By 2015, according to the anti-poverty standard (200Wp installed capacity per household, annual electricity consumption of 200kWh per house-

hold), the total installed capacity is expected to be 200MWp. By 2020, if estimating by the electricity using standard in remote areas (1,000Wp installed capacity per household, annual electricity consumption of 1,000kWh per household), the total installed capacity is expected to be 1,000MWp (1GWp). By 2030, in accordance with the general city electricity using standard (2,000Wp installed capacity per household, annual electricity consumption of 2,000 kWh per household), the total installed capacity is expected to be 2,000MWp (2GWp).

(2) The Potential Market of BIPV

Now, about 70% of the world's solar cells are used for grid-connected power generation system, while 90% of grid-connected PV power generation projects are installed in the city buildings in the form of BIPV. China's existing housing construction area is 43 billion m^2, with the roof area of 17.8 billion m^2, according to 50% of the roof area can be used to install photovoltaic power generation system, the available roof area is about 8.9 billion m^2, plus with the south wall available area of about 9.61 billion m^2, the total is 18.51 billion m^2. If 120 watts of photovoltaic cells installed per m^2, it can hold 2.2 billion kW of PV power generation system (2,200GWp).

Table 25 China's Housing Construction Area and the Available PV Area Statistics

China's housing construction area (100 million m^2)			
Urban housing construction area	194.1	Rural housing construction area	236.1
Eastern city	122.3	Eastern rural area	96.8
Central city	46.6	Central rural area	85.0
Western city	25.2	Western rural area	54.3
China Housing Roof Area (100 million m^2)			
Roof area of city housing	22.0	Roof area of rural housing	156.0
Urban PV available area	11.0	Rural PV available area	78.0
Eastern city	7.0	Eastern rural area	32.0
Central city	2.6	Central rural area	28.0
Western city	1.4	Western rural area	18.0
South wall area of housing in China (100 million m^2)			
The south wall area	139.0		
PV available area of south wall	96.1		
Easter region	25.6		
Central region	20.5		
Western region	13.2		
Total available area of PV construction	185.1		

By 2015, as the cost of photovoltaic power generation is still high, while the grid access condition is poor, it is expected that one thousandth of the roof area and south wall available area can be used to install solar PV power generation system, then the total installed area is 18.5 million m^2. If calculating with 120Wp/m^2, the total installed capacity is estimated to be 2.2 million kW.

By 2020, due to the rapid decline in the PV power generation cost, plus the construction of the smart grid, the power grid access conditions improve, it is expected that 1% of the roof area and south wall available area can be used to install solar PV power generation system, then the total installed area is 185 million m^2. If calculating with 120Wp/m^2 (without regard to the technological progress), the total installed capacity is estimated to be 22 million kW.

(3) Potential Market of LS-PV Desert Plant

According to China's long-term renewable energy development plan, many sets of 1～10MWp desert test stations (total installed capacity of 50MWp) will be built in Gansu, Tibet and Inner Mongolia before 2010, which will be further promoted during the period of 2010～2020, the cumulative installed capacity of LS-PV desert plants will reach 200MWp by the end of 2020.

12% of China's land areas are the desert, Gobi, wasteland and beaches which can't be used for farming, with a total area of 1.08 million km^2. China's desert resources are mainly distributed in the Northwest with rich light resources, the annual total radiation amount is above 1,600 kWh/m^2. If 40MW installed capacity per square kilometer, and 2.5% of the desert area will install solar cells, the installed capacity will reach 1,000GWp, 2 times of the national installed capacity of power in 2006.

By 2015, as the cost of photovoltaic power generation is still high, while considering the solar energy resources and China's energy strategy, the development is expected to start in some western areas with better resources, the total installed area is one-ten thousandth of the desert area—108 km^2, if 40MWp per square kilometer, the total installed capacity is estimated to be 4.32 million kW.

Table 26 China's Desert Area Statistics

Desert/Gobi	Area (10^4 km^2)
Desert	51.44
Semi-desert and Gobi (desert)	17.60
Potential desertification	15.80
Other wasteland, barren hills, slopes, beaches	23.16
Total desert area of China	108.00
China's territory	960.00
Desert area ratio (%)	11.25

By 2020, due to the rapid decline in the desert PV power generation cost, plus the power grid access conditions improving, it is expected that five ten-thousandths of desert area will be used for the installation of solar photovoltaic power generation system, with the total installed area of 540 square kilometers. If 40MWp per square kilometer (without regard to the technological progress), the total installed capacity is estimated to be 21.6 million kW.

4.2.4 China's solar PV power generation policy

4.2.4.1 PV Market Policies from the Central Government

The incentive policies of China's PV market mostly are subsidy policy. The initial PV market in China is the independent PV power in the area without electricity, built fully by the state investment; but because of the high cost of PV power generation and the lack of long-term incentive policies for the market, then the PV market is at a standstill, and even the "Renewable Energy Law" implemented since 2006 also failed to promote the formation of the Chinese PV market. In 2009, China began to implement the "solar BIPV demonstration projects" and "Golden sun demonstration projects," providing subsidies for the PV power generation system, officially launched the Chinese PV market.

(1) Financial assistance fund for solar PV building applications

On March 23, 2009, the Ministry of Finance issued the notice of " Interim Measures of financial assistance fund for solar BIPV applications",

clearly states the central government will take some funds from the special fund for renewable energy to support the demonstration and promotion of solar PV application in the urban and rural areas construction.

On April 16, 2009, the General Office of the Ministry of Finance together with the Ministry of Housing and Urban-Rural Development jointly issued the "application guidelines for solar BIPV demonstration project", further standardized the content of the demonstration project application.

The state supports the projects with BIPV system and also generating power to solve the building energy using. The main installation types of BIPV include: a) building material type, which refers to the solar cell and the tile, brick, sheet, glass and other building materials combined together into an integral building components or building materials, such as photovoltaic tiles, photovoltaic bricks, photovoltaic roof membrane, photovoltaic glass walls, photovoltaic window, etc.; b) component type, that together with the building components or independent components as photovoltaic building components, such as awning structures and shade structures all composed by the PV modules based on the standard of ordinary PV module or customized module according to requirements; c) flat roof or wall-mounted type, the installation type that installed on the flat roof, the slope roof and parallel to the wall.

Specific subsidy standard in 2009 were: for the building material type and component type BIPV projects, the subsidies should not exceed 20 Yuan/W; for the roof or wall-mounted BIPV project, its subsidy standards is not more than 15 Yuan/W. Subsidies declined in 2010, the subsidy for the building material type and component type BIPV projects is 17 Yuan/W, the subsidy for the roof-or wall-mounted type BIPV projects is 13 Yuan/W. The subsidy standards in subsequent years will be appropriately adjusted according to the industrial development.

The first batch of projects issued in September 2009, the central government provides the budget of 1.27 billion for the first arrangement to start Solar Roofs Plan. There are a total of 111 BIPV demonstration projects in the first batch, the total size of 91MW located in 30 provinces, municipalities

and autonomous regions, with good industrial base and abundant sunshine resources such as Jiangsu, Zhejiang, Inner Mongolia, He'nan and other provinces, to lead the BIPV development, and promote the application of the photovoltaic products with advanced technology.

(2) Golden Sun Demonstration Projects

On July 16, 2009, the Ministry of Finance, the Ministry of Science and Technology, with the National Energy Administration jointly issued "Notice on the implementation of the Golden Sun demonstration project", which clearly states that the central government takes some funds from special funds for renewable energy to support the application and demonstration of photovoltaic power generation technology in all class field and the industrialization of key technology (hereinafter referred to as Golden Sun Demonstration Project).

Financial assistance funds supporting range include: a) the user side grid-connected PV power generation demonstration projects by using the existing conditions of large-scale mining, commercial enterprises and public welfare institutions; b) the demonstration projects of PV power generation, wind and PV power generation and hydro and PV power generation to improve the electricity supply capacity and to resolve the no electricity problem in remote areas; c) The large-scale on-grid solar PV power generation demonstration projects in the resource-rich regions; d) The demonstration projects of key technology industrialization of PV power generation, including silicon purification, control inverter, on-grid operation and other key technology industrialization; e) basic capacity-building of photovoltaic power generation, including solar resource assessment, photovoltaic power products, on-grid technology standards, and construction of testing and certification system; f) the demonstration of BIPV applications implemented in accordance with the "Interim Management Measure of Financial Assistance Fund for BIPV Applications" (MOF and MOHURE [2009] No. 129), the project enjoy the financial subsidy can't be supported by this Measure, but should be included in the implementation plan of Golden Sun Demonstration Projects; g) the photovoltaic power application projects which enjoy the

state's policy of renewable energy tariff share can't be supported by this Measure.

Financial funds assisting projects must meet the following conditions: a) included in the local Golden Sun demonstration project implementation plan; b) the installed capacity of single project not less than 300kWp; c) construction period is no more than 1 year in principle, running period is no less than 20 years; d) the total assets of the owner of on-grid PV power generation projects is no less than 100 million Yuan, the capital of the project is no less than 30% of the total investment. The owner of independent PV power generation project has the ability to guarantee the project long-running; e) projects must meet the following technical requirements: ① photovoltaic products and systems integration is advanced; ② used PV modules, controllers, inverters, batteries and other major equipment must be approved by the national certification bodies; ③ grid-connected projects meet the related technology standards and requirements of grid access; ④ having generation data metering equipment and with normal operation.

Subsidy standard: for grid-connected photovoltaic power generation project, in principle the subsidy is 50% of the total investment of photovoltaic power generation system and its supporting transmission and distribution projects; for the independent photovoltaic power generation system in remote areas without electricity, the subsidy is 70% of the total investment.

The electricity generated by the on-grid photovoltaic power generation projects from user side is in principle consumed themselves, the surplus electricity and the part sent to the public power grid by the large scale photovoltaic power generation projects are all purchased by the local desulfurized coal generation grid price.

In November 2009, the Ministry of Finance announced the Golden Sun demonstration project directory. There are 294 demonstration projects, with the total installed capacity of 642MW, the annual generation amount is about one billion kWh, total investment is nearly 20 billion Yuan by preliminary estimation, which need 2 to 3 years to complete. Based on the request, after the completion of initiation, bidding, environmental impact assessment and

other preparatory work, the demonstration projects can apply for financial subsidies.

200MW projects were ready to start by 2009, taking the lead to receive financial assistance, and entered into the construction phase.

4.2.4.2 PV Market Policies from the Local Government

Besides the Central government policies, in the new situation of keeping capital growth, pulling the domestic demand and promoting the development, all levels of government are working on revitalizing the economy, and introduce the relevant policies and planning:

(1) Jiangsu Province

Jiangsu Province is a big manufacturing province of photovoltaic product in China. On June 9, 2009, Jiangsu province issued "Recommendation on promoting photovoltaic power generation in Jiangsu Province" to develop photovoltaic power generation, and to form the overall size advantage and increase the competitiveness of enterprises. Jiangsu Province plans to set up special fund to support solar power generation for grid-connected PV electricity price subsidies, subsidies for the difference between the aimed price of solar PV generation project and desulfurized coal generation grid price.

(2) Zhejiang Province

November 30, 2009, Zhejiang Development and Reform Commission, Price Bureau of Zhejiang Province, Zhejiang Province Electric Power Industry Bureau jointly issued " Recommendation on the supporting policy for the solar photovoltaic demonstration projects in Zhejiang Province" to promote the construction and the operation of solar photovoltaic demonstration projects, and to promote the further breakthroughs in photovoltaic technology and its industrialization, creating a competitive emerging industry. By 2012, the total installed capacity of policy supporting demonstration projects of photovoltaic power generation is controlled less than 50MW in Zhejiang Province.

The support to PV power generation project in Zhejiang Province is from the local government support and the commitment of PV production suppliers. First, photovoltaic projects are required to be included in the list

of projects supported by national funding, and access to the national and provincial approval procedure for capital construction, the installed capacity of projects isn't less than 200 kW. It also requires to use the PV products and modules of latest technology and competitive advantage produced by the local producer.

Approach is to support tariff subsidies, tariff is determined by the desulfrized coal generation grid price plus 0.70 Yuan/kWh, the amount of the electricity needs tariff subsidies in the province won't exceed the 70% of the total amount of PV generation; the Government support the project site through project funding subsidies. When Zhejiang desulfurized coal generation price in 2009 is 0.46 Yuan/kWh, the photovoltaic power generation projects can get the additional subsidies of 0.7 Yuan/kWh, that is, the PV generation grid price is 1.16 Yuan/kwh in the case of enjoying the state's PV projects subsidies.

(3) Ningxia

On May 7, 2009, Ningxia Autonomous Region released the "Notice on using land related matters of supporting solar and wind power projects and other new energy industry projects," which clearly states the using land policy of no land transfer, no land compensation fees for new construction land and no land management fees, attracting a large number of project developers.

The document provides, giving priority to ensuring the construction of solar energy projects, wind power projects and other new energy projects, the project's land using plans must be included in the annual land using plans to ensure the land available; providing land by allocation with no land transfer; all levels land and resources department must introduce the best preferential policy, project using land is free of compensation fees for new construction land, also no land management fee from all levels land and resources departments; adhering to the lowest cost principle, it is not allowed to collect any other extra charges or increase projects using land costs under any pretext or any item; in principle no land compensation for occupying the state-owned land; the collective land collected from the peasant will be compensated by the minimum standards.

4.2.5 The Problems in the Development Of Solar PV Power Generation

As an emerging renewable energy industry, solar PV industry develops rapidly, while it faces many difficulties and challenges in the economy, technological innovation, policy supporting and ancillary facilities, which shown mainly in:

From the view of economic point, the high cost is still the main obstacle to the application of solar photovoltaic power generation. There is still a long way for Chinese solar PV to achieve "grid parity" . At present, domestic solar cells price is about 12～13 Yuan/Wp, the system investment of 20,000～25,000 Yuan/kW, about 10%～15% lower than the international average, but compared to the thermal power construction investment of 6,000 Yuan/kW and wind power construction investment of 10,000 Yuan/kW, construction cost of solar PV is 4～5 times of the thermal power, and 2～3 times of wind power.

At the same time, the average annual power generation hours of solar power is about 1,300 hours in China, but also much smaller than 5,000 hours of thermal power and 2,000 hours of wind power.

From the industry perspective, the key technology of photovoltaic power generation needs to be further enhanced, while high-end production equipment is still not free from imports. View from upstream polysilicon materials, solar polysilicon industry technology has been upgraded from hundred-ton-class to thousands-ton-class, driven by the national guidance and PV market, initially achieved the realization of the closed loop and the production with environment protection and energy saving; but compared to the international advanced level, there is still a gap in the unit energy consumption.

From the point of solar cell production equipment, the majority high-end equipment of crystalline silicon cell still needs import, such as large size (more than 500 kg) ingot casting furnaces, multi-wire cutting, PECVD deposition equipment, automatic screen printing machine, etc. ; thin film solar cell equipment and technology (including manufacturing equipment) differ greatly from the foreign countries, and the pace of industrialization is slow.

In addition, supporting materials of solar photovoltaic cells is the greater constraints, such as paste, graphite products, quartz products and EVA material. Although some preliminary research has carried out in our country, but it's mainly the imitation of imported products, most of the products with lower grade.

From the point of the government support, the strength and means of policy support is still not sufficient to promote large-scale domestic PV market development, the industry continues the dependence on foreign markets. From the policy perspective, the state has not released generally applicable grid price of PV power generation, most of the PV power generation on-grid project is still in the stage of "case by case" . And "Golden Sun Demonstration Project" is the incentive policy for initial investment subsidies, not conducive to the quality enhancing and long-term reliability of the system.

From the point of macro planning, in addition to on-grid tariff, the state has not yet made the clear plan of solar PV power generation development. While in 2007 the National Development and Reform Commission has published the "Renewable Energy Long-term Development Plan in 2020", but the planning goal of solar photovoltaic power generation is significantly lower, not conducive to the development of the whole industry. The amended "New Energy Revitalization Plan" hasn't been introduced yet. Therefore, governmental plans suitable for China's PV industry will help to create a healthy environment for the development of solar PV industry.

4.2.6 China's Solar PV Development Prospects

China's solar PV power generation should develop step by step, taking the development experiences of the worldwide solar PV industry as the reference and considering the China's own characteristics.

First, according to the actual situation in China, the emphasis is on solving the power supply to the no electricity areas and remote areas before 2015.

By 2005 there are still 2.7 million households of 12 million people live in remote areas without electricity, of which at least 1.5 million households need photovoltaic power generation to supply power (the other residents are

relying on an extension power grid and small hydro power) . At the same time, it should be fully developed that the off-grid PV power generation and the market of distributed utilization of PV power generation, in addition to the power construction in no electricity areas, the solar telecommunications power, oil and meteorology, solar street lamps, lawn lamps, traffic signal power, urban landscape, electric car charging stations and other distributed utilization should be also be vigorously promoted.

Second, with the help of the characteristics and advantages of PV power generation, the emphasis is on the development of distributed BIPV power generation in eastern regions and LSPV desert plants in western regions before 2020.

The cost of solar PV is still high, while the distributed BIPV power generation system isn't constrained by the sending capacity of power grid, which is located in the load center, can generate and consume power locally, then the distributed BIPV system can be promoted in the in the economically developed eastern part; combined smart grid construction and development of the western, to promote the LSPV desert power plant construction in the western region.

Third, considering the shortages of fossil fuel, together with the construction of smart grid and the development of energy storage technology, the emphasis is to develop large-scale and ultra-large scale desert power stations and electric vehicle charging power before 2030.

After 2030, with the technical development of energy storage and the completing of power grid construction, the emphasis should be on the grid-connected large scale PV power plants of the power transmission side or the generating side, which plays an important role in address the energy security in China (after 2030, solar PV power generation will occupy an important role in energy supply in China) .

4.3 Solar Thermal Utilization

Solar thermal utilization mainly includes solar water heater, solar ther-

mal power generation, solar cookers and solar rooms, etc. At present solar water heater as an economic energy saving and emission reduction product, has formed industrial scale, while the new technology and new products continue to emerge, with varying degrees of development.

4.3.1 Steady and Rapid Development of Solar Water Heater Industry

Solar water heater is an economic, energy saving, emission reduction product in China's water heater industry, it's more economical than electricity & gas water heater, market share improved rapidly, see the Table 27 below. For its energy-saving effect, in the area with I～IV class solar energy resources, per square meter solar water heaters can replace 0.16tce a year. Its environmental benefit is obvious in emissions of SO_2, NO_2, greenhouse gases (CO_2) and dust.

Table 27 Market Share of Three Kinds of Water Heater from 2001 to 2009

Year	Electricity water heater (%)	Gas water heater(%)	Solar water heater(%)
2001	30.00	54.80	15.20
2003	44.23	37.57	22.20
2005	45.20	26.57	28.23
2007	42.30	19.20	38.50
2008	49.2		50.8
2009	42.8		57.2

China has grasped the independent intellectual property rights of major solar water heaters, and formed a complete industrial chain, as well as a service chain of raw material-solar collector-water heater product industrial chain-sales-marketing. 2009 annual production of raw materials (3.3 borosilicate glass) is 748,000 tons, with more than 1,700 all-glass vacuum coating lines, annual output of vacuum tube 336 million, and increasing 34.4% compared to that in 2008. Total employment opportunities are more than 3.2 million.

Since 1990 China has been the top listed manufacturer and supplier of solar water heater in the world. The annual production output in 2008 accounted for more than 80% of the world's annual output. But the area of solar collector owned every one thousand people in China are less than that in

EU. In 2009 total output reached 42 million m^2. Market sales of 2009 are about 60 billion Yuan. There are 4 enterprises with output value more than 2 billion Yuan, 2 enterprises with the level of 0.5～1 billion Yuan, more than 20 enterprises with the level of 100～500 million Yuan, The output value of 2009 is 63 billion, increased of 46%. In 2009, the production exported more than 100 countries and export value is more than 200 million U. S. dollars, the annual growth of 66%. In 2008 the exports are 120 million U. S. dollars, with an increase of 84.6%.

Table 28 Annual Production Capacities and Possession of Solar Water Heaters from 1998 to 2009

Year	Total output		Increased over the previous year/%	Possession		Increased over the previous year/%
	Area /1,000 m^2	Thermal installed capacity/MW_t · h		Area /1,000 m^2	Thermal installed capacity/MW_t · h	
1998	350	2,450	—	1,500	10,500	—
1999	500	3,500	43	2,000	14,000	33
2000	640	4,480	28	2,600	18,200	30
2001	820	5,740	28	3,200	22,400	23
2002	1,000	7,000	22	4,000	28,000	25
2003	1,200	8,400	20	5,000	35,000	25
2004	1,350	9,450	12.5	6,200	43,400	24
2005	1,500	10,500	11.1	7,500	52,500	21
2006	1,800	12,600	20	9,000	63,000	20
2007	2,300	16,100	30	10,800	75,600	19.4～20
2008	3,100	21,700	32.5	12,500	87,500	15.70
2009	4,200	29,400	35.5	14,500	101,500	16

Universally calculated in the world: 1 m^2 solar collector is equivalent to the thermal installed capacity of 0.7kW.

China has built and perfected the industrial development guarantee system. There are 20 original national level standards concerning solar water heater, 6 revised in 2009. Three national-level product test centers were established, which are "National Solar Water Heater Quality Supervision and Inspection Center (Beijing)" and "National Solar Water Heater Product Quality Supervision and Inspection Center (Wuhan)." In addition, the National Solar Water Heater Product Quality Supervision and Inspection Center (Kunming) station was basically completed. And three solar water heater certification centers were built, China General Certification Center (CGC) —

Golden Sun signs; China Academy of Building Research Institute (certification) —CABR signs; and China Environmental United Certification Center Co. , Ltd —sign of Shihuan. The first two agencies are carried out on the solar water heater product quality certification, the other agency is to carry out the environmental impact certification of solar water heaters, different focus, but all belong to the voluntary certification.

Engineering market in 2009 accounts for 40% of the total. Due to the policy of "Home appliances going to China side" in 2009, the rural market developed very quickly, while it expends from the developed regions to less developed regions and undeveloped regions. The international market has expanded to more than 100 countries of five continents, with the rising momentum.

China's industry team is becoming mature. Chinese entrepreneurs have the modern industrial development concepts and strategies, experts good at the market and business management are the valuable asset of industry development; a group of practical experience and a variety of professionals are constantly growing; training a worker team of manufacture and installation service, to develop integrated projects.

The industrial policy and preferential policies are more clear and enhancement gradually. China's solar water heater industry and market developed without incentives. At present, the national or local government published incentive policies to promote the introduction of solar thermal use. Such as the policy of "Home appliances going to the countryside" in 2009 which promotes the popularity of the rural market. Also the "solar water heaters mandatory installation policies of new buildings" and "tax incentives policies on strengthening the solar thermal use technology research and development and promoting industrial development" are introduced in some provinces.

4.3.2 New Technologies and New Products

New technologies and new products of solar thermal utilization are emerging. At present there are mainly the following categories:

- Continued to promote and apply dip compact all-glass vacuum tube

solar water heaters, and further improve product quality and reliability, increase productivity and reduce manufacturing cost;

- To develop and promote technology of low-temperature solar collectors, including efficient collectors, thermal energy storage technology, mechanical and electrical integration, and operating technology, auxiliary energy technology, control technology and building integrated technologies;
- To develop highly efficient flat-panel solar collector technology and industrial production, coating solar absorption ratio of about 0.92, emission ratio with no more than 0.10, glass cover solar transmittance of about 0.90, the first heat loss coefficient less than $4W/(m^2 \cdot K)$; supporting advanced production equipment of flat-plate collector;
- To develop, produce and promote separated secondary circuit solar water heating systems and other new type of solar water heating systems;
- To develop and promote solar hot water heating technology;
- To develop technology of middle-temperature solar collectors, 80～250 ℃, to broaden solar thermal applications in the industrial and agricultural production: textile, food, chemical industry, refrigeration, air conditioning and seawater desalination, etc.;
- To develop active and passive solar housing technology, air heater, solar cookers and other products;
- To develop solar thermal generation technologies.

4.3.3 Prospect of Solar Thermal Utilization

In the 3～5 years, to breed 5 to 10 large-scale backbone enterprises with independent intellectual property rights, brands and international competitiveness, with the annual production of about 3 million m^2 ($210MW_t \cdot h$); To form a number of regional enterprises matching the key to industrial development and suited to accessories specialization; to form a number of engineering companies integrated with design, installation and maintenance of solar water heaters and solar collector system.

For Solar engineering market, solar energy can be combined with architecture by unified planning, unified designing, unified installation, unified

acceptance and unified management. The new buildings meet the criteria for installation should not be restricted to install solar water heaters, and the structural elements of solar water heaters installation should be included when designing new buildings. The rural market should be combined with the new rural construction, and to provide financial subsidies to the less developed rural areas or the socially vulnerable groups. The rural market sales account for about 60% of the total sales in 2010. To strengthen the supervision of solar water heater market. To actively explore the international market, we should fully improve the product quality and level, and the products should pass through domestic and international testing and certification.

5 Biomass Energy

5.1 Biomass Resource Status in China

Biomass energy resources include a wide range of sources. Based on generated methods and sources, biomass energy resources consist mainly of two categories, one is all kinds of waste biomass produced by industry & agriculture and life, including crop straw, forestry residues, urban & rural and industrial organic waste; the other is the potential biomass resources of artificial propagation, including various types of energy crops, energy forests, etc.

5.1.1 Total Resources

In 2008, the national livestock and poultry manure total amount is 2.06 billion tons (Calculated according to the amount of livestock statistics from China 2009 Statistical Yearbook), which is expected by 2015 with 2.24 billion tons and by 2020 with 2.54 billion tons. One produced from the large-scale farms accounting for 60% of the total fecal, when 70.3% of the total manure produced from the large-scale farms, 1.58 billion tons; when 75.7% of the total manure produced from the large-scale farms, 1.92 billion tons.

In 2008, the amount of clearing national house refuse reaches 154 million tons (China Statistical Yearbook-2009), and the actual amount of garbage generated will be more than 154 million tons. Although the concepts and measures of comprehensive utilization of resources and residues reuse will be continuously strengthened in the future, as well the growth rate of garbage generated amount would decline, it is projected that by 2015 the amount of garbage generated will reach 200 million tons/year, and in 2020 will reach 230 million tons.

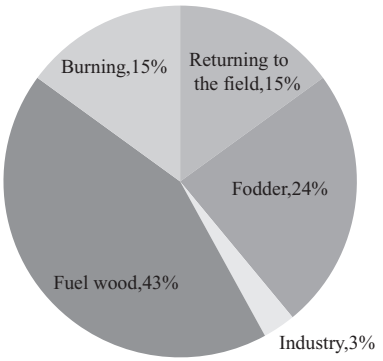
In 2008, China's rice, wheat, corn, beans, oilseeds, cotton, potato straw these seven major agricultural products' total resources amounts are about 553 million tons (Calculated according to the ratio of grass to crops from "energy utilization survey and evaluation of crop straw resources" by the Projects under the State Energy Office) . In addition, a large number of by-products are produced in the primary processing of agricultural product, mainly including rice husk, corncob, bagasse, etc. They mainly come from grain processing plants, food processing plants, sugar mills and wineries and so on, a relatively concentrated place, easy-to-collection and treatment, total amount of more than 100 million tons, equivalent to about 50 million tce.

5.1.2 Available Total Amount Analysis

In 2008 livestock and poultry manure produced by the large-scale farms accounts for 60% of total resources, which can be used as raw material for biogas preparation, 1.236 billion tons. By 2015, manure produced by large-scale farms will account for70.3% the proportion of national total resources, to 1.58 billion tons; by 2020, the proportion will reach 75.7%, to 1.92 billion tons.

Considering the house garbage as the resource category that must be dealt with, the amount of house garbage generated can be seen as the available total amount. Thus, the national available amount of garbage is 154 million tons in 2008, the total available amount will reach 200 million tons by 2015, and in 2020 will reach 230 million tons.

Crop straw is mainly used for returning to field, feed, papermaking, household direct combustion, etc. In addition there are a large number of surplus straw. Based on our field survey result of straw utilization, China's seven major crop stalks of 83 million tons were used to field in 2008, accounting for 15% of the total; 133 million tons used to feed, accounting for 24%; 238 million tons for firewood, accounting for 43%; 83 million tons used for open burning, accounting for 15%; industry or other uses of the 16.6 million tons, accounting for 3%; by calculating these parameters, firewood and burning taking up 58% of the amount of straw (about 320 million



gure 17 Using Classification of Straw

tons) can be used as clean biomass energy, equivalent to 160 million tce.

5.2 Overview of China's Biomass Energy Industry Development

5.2.1 The Implementation of the Renewable Energy Law Propelled the Rapid Development of Biomass Industry

"Renewable Energy Law" was carried out in 2006, and the proportion of renewable energy accounting in the total energy consumption is improved from the current 7% to 15% in 2020.

In the 4th chapter it clearly states China's energy production companies must fully purchase the electricity produced by the Government's approval renewable energy projects. The renewable energy projects gas and heating enterprises complied with on-grid standards should be on-grid; for renewable liquid fuels in line with national standards, oil marketing companies should include in marketing system. In the 7th chapter, it further provides if the electricity, gas, heat and oil sales enterprises violate this Law resulting in economic losses to pay compensation, refused to implement the double penalty. This makes big significance for the development of biomass energy industry, providing a wider impact on the market economy proceeding and sustainable development in the future.

5.2.2 The Country Provides Funds to Overcome Bottlenecks in The Development of Bio-Energy Industry

Biomass industry is a new industry based on renewable sources of biomass as raw material to produce energy, bio-materials and other products, also one important way to promote sustainable development. According to China's biomass resources features and technological development status, aiming at the requirements of social development, in 2009 continued to implement biomass projects of special high-tech industrialization approved by NDRC since 2006. According to the requirements of "Notice on the organization and implementation of biomass projects and specialized high-tech industrialization" and "Temporary measures of national high-tech industry development projects management" published by NDRC, for biomass special projects of high-tech industrialization applied by various relevant departments and provinces, based on organizing the experts to review and advisory body to evaluate, NDRC opened the reporting, examining and approving process of biomass high-tech industrialization demonstration project fund application, and requested the relevant authorities to strengthen management and organization and coordination, speed up project implementation. Strongly supporting a number of biomass industrialization demonstration projects of non-food plant-based bio-energy, bio-materials and bio- raw materials.

The aim for NDRC to implement the specific project is to accelerate the industrialization process of biomass technology development and utilization, to promote the integration and application of biomass industrialization technology development, to provide technical support and application demonstration for the major adjustment of China's energy structure. The special highlights independent innovation and integrated innovation, combined technology development with industrialization, with the core of improving the economics of biomass products and the formation of complete industrial production technology, its main content of the development of biomass raw material, raw material products of industrial processing, an important application of bio-based materials, To promote a new breakthrough in key technologies

and products, and to accelerate the formation of China's biomass industry technical foundation and advantage industries.

5.2.3 All Levels of Government Make Concerted Efforts, the Orderly Development of Biomass Energy Industry

In 2009 focus on implementing held the spirit of a national work conference on biomass energy development and utilization held in the August of 2006. NDRC, the Ministry of Agriculture, the State Forestry Administration jointly issued a circular text, published meeting minutes and requested that the relevant units to implement them seriously. In 2009, the Ministry of Finance continue to implement the " Interim Measures of bio-energy and biochemical raw material base's subsidies management," and " Interim Measures of bio-energy and bio-chemical non-food leading reward fund management," After the policy carried out, a group of advanced enterprise which use non-grain raw sweet sorghum stalk, sweet potato, and animal and plant oils to produce biodiesel and fuel ethanol, received financial support from the Ministry of Finance.

To implement the "Renewable Energy Law" and the 11th Five-Year Plan of Economic and Social Development, unity thinking, enhance understanding, with a clear mandate and deployment, mobilize all forces to speed up the development and utilization of biomass energy, and in 2009, a marked advance of industrial development.

5.3 Biomass Power Generation

By the end of 2009, the national total installed capacity of biomass power generation is 4, 440MW, of which1, 700MW generated by bagasse, 80MW generated by rice husk, 1, 200MW generated by municipal solid waste incineration, 1, 100MW generated by straw and wood waste, biomass gasification power generation, biogas and landfill gas power generation supporting 360MW.

5.3.1 Straw Direct Combustion Power Generation

The technology of straw direct combustion power generation is relatively mature either from home or abroad. Its advantages include: enabling large scale development, high efficiency of energy conversion, and avoiding secondary pollution. Meanwhile, utilization of this technology will effectively solve the problem of large quantity of wasted straw in China. It is considered as a method to develop rural economy, increase farmers' income, and optimize the energy structure in rural areas of China. Barriers in the straw direct combustion power generation technology are to be removed which include slagging and corrosion, domestic boiler and pretreatment techniques, upgrading of equipments and localization of international technologies. With more biomass power projects being operated, imported technologies and equipments start to be tested with various types of Chinese biomass.

Until 2009, China's grid-scale agricultural and forestry biomass power generation projects over 50, with a total installed capacity of more than 1,100MW. In southern China, Guangdong, Guangxi, Yun'nan, it has already formed a certain scale for the sugar industry bagasse used for direct combustion power generation.

5.3.2 The Mixed Fuel Power Generation

The difficulty of the mixed fuel power generation technology is much less than that of the direct combustion power generation, China is fully capable of independent research and development. The study showed that: the amountof biomass into the furnace into the furnace is less than 20% of the total calorific value into the furnace, only one biomass pretreatment equipment is needed to make the boiler operate stably, without any change to coal-fired boilers, or it can even improve the combustion performance.

A number of polices on mixed fuel power generation have been introduced, but in practice it's lack of uniform measurement and monitoring system and methods, so the use of mixed fuel technology are merely in the

phase of demonstration pilot. In 2008, the Environmental Protection Department, the National Development and Reform Commission, the National Energy Administration jointly issued the "Notice on Further Strengthening the Environmental Impact Assessment and Administration of Biomass Power Generation Project [〔2008〕 No. 82]", " the new built biomass power generation project is not allowed to blended with conventional fuels in principle. The state encourages the conventional thermal power project to do the technological transformation of blending biomass. When the amount of blended biomass is less than 80% according to the quality of translation, it should be managed in accordance with the conventional thermal power project" .

Currently, the mixed fuel of coal and biomass power generation projects are less developed, mainly by the enterprise. The first mixed combustion of straw and coal power generation project built in Shiliquan power plants in Zaozhuang of Shandong province operated on December 26, 2005. It introduced the Danish BWE's technology and equipment, and one boiler of the power plant was transformed by the Straw mixed-combustion technology, with the total installed capacity of 140MW, 20% biomass blended, 105,000 tons straw burned per year, it can replace approximately 75,600 tons raw coal. The electricity price of Shandong Shiliquan power plant is 0.594 Yuan/kwh, of which, Shandong Province supports the electricity subsidies of 0.24 Yuan/kWh. The Hong Kong Xiexin Group owns 21 small thermal power plants in Jiangsu, Shandong, Anhui and other provinces, seven of which blend biomass feedstock, including straw, rice husk, bark, reeds, and sludge from the municipal sewage treatment plant.

5.3.3 Gasification Power Generation

During the 9th "Five-Year" period, China's first 1MW rice husk gasification power generation system in Putian of Fujian Province, China's first wood chips gasification power plant in Sanya of Hainan Province, the demonstration project of straw-burning gasification power plant in Handan were built. Recently 20 sets of biomass gasification power generation system using

agricultural solid waste with rice husk and straw, were built by Heilongjiang Land Reclamation Bureau, with a total investment of more than 40 million, the total annual generating capacity of 75,000MW.

4MW of rice husk power plant in Xinghua of Jiangsu Province is one of the "863" demonstration projects by the Ministry of Science and Technology, which installed a Circulating Fluidized Bed Gasifier, with the engines of 1×400kW and 1×600kW, equipped with a waste heat boiler and steam turbine power generation. The project was put into operation in October 2005, and now has accumulated 1,500 hours running, with the longest continuous running time of 1 month. The main fuel is rice husk and cotton stalks, the rice husk ash has a high utilization value due to the high silicon contents. The tar is removed by washing gas, while wastewater is recycled by the way of biological treatment. The plant can use 32,000 tons of biomass (dry) per year, with the annual generating capacity of 28 million kWh.

5.4 Biogas Utilization

5.4.1 Household Biogas in Rural Area

According to Chinese Ministry of Agriculture statistics, the national rural household biogas has grown to 30.518 million households by the end of 2009, the total annual output of methane about 12.408 billion m^3, equivalent to about 8.859 million tce. Among which, the western region accounting for 46% of the national output; the central region accounting for 45%; the eastern region accounting for 9%.

5.4.2 Straw Household Biogas Technology

At present, the straw biogas technology has been introduced to more than 100 counties to conduct pilot and demonstration, and achieved good results. At the end of 2009, cumulatively 178 straw methane gas supply locations supply about 12,000 households. Based on the test results and user surveys, for a biogas tank of 8 m^3, with 400 kg straw or rice husk, adding 1 kil-

ogram fungus and 15 kg ammonium bicarbonate, the normal gas production can provide a family of 5 people to use over 6 months. The human waste of a family with five members into biogas digester can provide gas production more than 12 months, only 10 Yuan per month increased for investment expenditure. However, there are still some strains such as higher prices of bacterial specie, cumbersome management services of feed-in, discharging, daily management, centralized collection of residue, production of organic fertilizer.

5.4.3 Biogas Project

According to the Ministry of Agriculture statistics, by the end of 2009, the number of biogas project for industrial waste treatment is up to 56856, with an annual production volume of about 150 million m^3, supplying gas for about 367,000 households; the installed capacity is about 9,051.5 kW, and annual power generation of about 49.636 million kWh. The number of projects dealing with agricultural waste is 56534, of which the number of large and medium biogas projects running is 22,570, with an annual gas production volume of 670 million m^3, generating about 102 million kWh electricity, supplying gas for 788,000 households. There are 33, 964 small-scale biogas projects, with an annual gas production volume of 95.13 million m^3, supplying gas for about 184,000 households.

5.5 Bio-liquid Fuel

5.5.1 Fuel Ethanol

China's fuel ethanol industry started in the 1990s, after the year of 2000 into the phase of rapid development. After several years of pilot and promoting, the ethanol fuel's production, blending, storage, and distribution developed into more mature technologies. China's fuel ethanol output reached 1.72 million tons in 2009, being the world's third largest ethanol producer after the United States and Brazil.

Although China is the world's third-largest fuel ethanol producer, but there is some considerable gap in the scale and technology compared to Brazil and the United States. China's corn-based ethanol plant consumes 3.1 tons corn and 8 tons water to produce one ton ethanol, and energy consumption of 0.6 to 0.8 tce; while the U.S. energy consumption of one ton corn-based ethanol is 0.4 tce; China's ethanol production cost is about 5,836 Yuan/ton, while the world's lowest cost of ethanol from sugar cane is only 1,881 Yuan/ton in Brazil.

Now substantial progress are made in the technology development of sweet sorghum ethanol, the transgenic technology has been applied to breed the sweet sorghum with high resistibility in Xinjiang, Inner Mongolia and other places, and the ethanol demonstration plant with the production of 5,000 tons/year was built in Heilongjiang Province. ZTE Energy Limited Company has also completed testing the sweet sorghum ethanol, and began to plan an annual output of 30,000 tons of sweet sorghum ethanol projects.

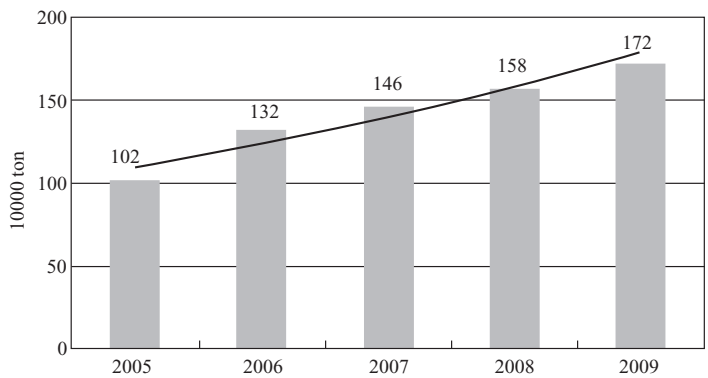


Figure 18 China's Fuel Ethanol Production During 2005～2009

The prime condition of developing non-grain ethanol is to solve the production and supply issues of raw materials, due to the current planting of cassava and sweet sorghum is far from the required scale needed by the non-grain ethanol industry, production also cannot meet the development requirements of non-grain ethanol enterprise, there are certain problems both in the rational distribution of raw materials or in the plant variety or in the yield, largely restricting the process of non-grain ethanol industry. In addi-

tion, cassava and sweet sorghum have the problems of seasonal supply of raw materials and large raw material transportation radius, before large-scale industry promotion, mature industrial development model needs to be confirmed further.

5.5.2 Biodiesel

China is a big consumer of diesel, with the diesel consumption of about 7,000 tons per year, of which one-third comes from imports to balance the market supply and demand. According to the International Energy Agency's assessment, China is the world's second largest oil consumer, following the United States, its dependence on foreign oil increases, the development of bio-diesel can help to reduce the dependence on fossil fuels.

In order to ensure the supply of raw materials for biodiesel, China's large-scale bio-diesel companies and research institutions are exploring more advanced materials. With the support of the State Forestry Administration, the CNPC is stepping up its construction progress of bio-diesel pilot base in Sichuan. The National Development and Reform Commission has approved the safety assessment, environmental assessment and occupational risk assessment of the 60,000 tons oil jatropha biodiesel project in Nanchong in June 2009, the project was put into trial operation in August of 2009. Meanwhile the supporting project of 250,000 Mu Jatropha planting base in Panzhihua of Sichuan Province has been completed. The base will support various bio-diesel refineries of CNPC located in Sichuan Province. Meanwhile, the Derong company in Chenggu County, Hanzhong City of Shaanxi Province, began the construction of the bio-diesel project with annual output of 100,000 tons in June 2008, by taking full advantage of the existing 143 Mu pistache of Hanzhong City.

Currently China's biodiesel industry has formed the pattern of private enterprises, large state-owned enterprises with foreign-funded enterprises jointly participating. The private enterprises are the main force of bio-diesel industry, while large state-owned enterprises and foreign-funded enterprises started late, mostly in the raw material forest base or the factory construction period, less project put into operation.

5.6 Policies on Biomass Energy

5.6.1 Biomass Power Generation Policy

The "Renewable Energy Law" promulgated in 2005, clearly states that "The state encourages and supports renewable energy grid-connected power generation", the promulgation and implementation of which provides a legal guarantee and development foundation for the renewable energy development in China. Subsequently, a number of auxiliary laws, regulations and policies have been put forward, such as "Management Regulations on Renewable Energy Power Generation" (NDRC Energy [2006] No. 13), "Renewable Electricity Price and the Cost-sharing Management Pilot Scheme" (NDRC Price [2006] No. 7), "Interim Measures of Renewable Electricity Price Additional Revenue Deployment" (NDRC Price [2007] No. 44), "Notice on the 2006 Renewable Electricity Price Subsidies and Quota Trading Plan" (NDRC Price [2007] No. 2446), "Notice on Renewable Electricity Price Additional Subsidies and Quota Trading Plan from January to September 2007" (NDRC Price [2008] No. 640), and other publications. Meanwhile, the related departments of State Council have also issued the medium-term and long-term development plan involving biomass energy, and the policy framework and objective system of biomass energy are basically formed. The release of these policies provides a strong guarantee for the promoting and using of biomass power generation technology in China.

5.6.2 Policies on Biogas

For the policies on biogas, the Ministry of Agriculture and the National Development and Reform Commission formulated the "Construction Plan of National Rural Biogas Service System", and developed the construction of rural services in 2007 bond project. In the 11th "Five-Year Plan" period, the rural biogas technology service coverage reached 70% or more, formed efficient rural biogas service system.

The Ministry of Agriculture issued "National Rural Biogas Construction Plan (2006～2010)" in April 2007. The plan covers the rural household biogas, large and medium-sized biogas projects of scale farm, technical support and service system three aspects. In July 2007, the Ministry of Agriculture released the "National Biomass Industry Development Plan (for 2007～2015)". In this plan, the Ministry of Agriculture predicts that by 2010 40 million households use the biogas, about 15.4 billion m^3 biogas per year produced, which is equivalent to the energy consumption of 24.2 million tce, and the annual volume of 9,333,300 m^2 forest land.

5.6.3 Policies on Bio-fuel

Considering from different perspectives of energy, environmental protection and economic development, the Chinese government has actively promoted the development of bio-fuel industry since 2000, and has developed the "Renewable Energy Law", "Interim Measures of Special Funds for Renewable Energy Development", "B100 Biodiesel Standard" and other regulations, standards and management practices to regulate the industry. According to the "11th Five-Year Special Development Plan for Bio-fuel Ethanol and Vehicle Ethanol Gasoline" released in 2006, the Development and Reform Commission also has enacted the "Implementation Details of Vehicle Ethanol Gasoline Expanding Pilots" to regulate the raw material procurement, production, distribution and sales of bio-ethanol industry. In 2009, the Chinese Government put forward to increase the input for the developing alternative fuel vehicles market, planed to provide 10 billion Yuan to car manufacturers within three years, for the technical upgrading and the development of alternative fuel vehicles. This program will significantly promote the development of the bio-fuel industry in China.

6 Geothermal Energy

6.1 National Geothermal Resources Assessment

Geothermal energy is a kind of clean energy, with a huge number compared with traditional fossil energy. According to the scientists' estimation, the total thermal energy of the Earth's interior is about 0.17 billion times of global coal reserves. Each year the heat loss from the Earth's interior through the surface is equivalent to combustion heat of 1,000 barrels oil.

Geothermal resources are mainly distributed in the active tectonic zone and large sedimentary basins. The former has more focused resources, such as Tibet, Yun'nan, Sichuan and southeastern coastal and eastern Liaoning-Shandong area; the latter has wide distribution of resources, such as Beijing, Tianjin, Shanxi, Hebei and other regions. Geothermal resources have conduction and convection types. According to the temperature It can be divided into 3 grades as high-temperature ($T \geqslant 150$℃), medial-temperature (90℃ $\leqslant T <$ 150℃) and low-temperature ($T <$ 90℃). Shallow geothermal energy within a range of depth under the surface of ground is also a part of geothermal resources.

Scientific investigation and assessment of geothermal resources is the foundation of its planning and rational development. The investigate way mainly include analysis of regional geological materials, remote sensing imagery interpretation, investigation on geothermal geology, Geochemistry and Geophysics, geothermal drilling and dynamic monitoring. Since national founding, the geothermal and geological work has been developed in all aspects and there's basic conclusion of national geothermal resources circumstances.

At present, geothermal resource assessment can refer to the national

standard *the Regulations for geothermal resource Investigation* GB11615—89. The resources calculation focus on geothermal energy in geothermal reservoir and geothermal fluid, meanwhile calculate energy in geothermal reservoir (J), amount of geothermal fluid storage (m^3), exploitable amount of geothermal fluid (m^3/d or m^3/a), and its containing thermal energy (J). The temperature limitation of spring vent (wellhead) in mountain area is 25℃, place's temperature lower than that is not going to be evaluated. The area where the geothermal gradient is over 3℃/100m in plat area carries on geothermal resources calculation in unusual area. Calculate the amount of geothermal resources and geothermal water in the area whose depth smaller than 2,000m. According to this standard, it is estimated that storage geothermal energy of the main sedimentary basins in our country is 73.61×1,020J, equal to the heat produced by 250 billion tce. The exploitable hot water is 6.8 billion m^3 per year, containing thermal energy of 963×10^{15}J, equivalent to the heat productivity of 32.84 million tce every year. And exploitable amount of geothermal water in mountain area is 1.9 billion m^3 per year, thermal energy is 335×10^{15} J/a, converting into the heat productivity of 21.42 million tce per year. Exploitable water of geothermal water in mountain and plat area separately account for 28% and 72% of total amount and exploitable thermal energy in mountain and plat area separately amount to 35% and 65% of the total exploitable amount in China.

Because currently there is no assessment criterion for the total quantity of shallow geothermal energy, geothermal resource buried deeply more than 2,000m and the resource in the geothermal gradient non-unusual area haven't been evaluated. In conclusion, the estimation is limited instead of all the geothermal resources. The total quantity is still indefinite, the methods of calculation and evaluation are imperfect, so the further researches on national geothermal resource is necessary to make a more actual overall evaluation.

6.2 Exploitation and Utilization of Geothermal

From the application form, the use of geothermal energy can be divided

into power generation and directive use. Currently there are two international development directions, one is Enhanced Geothermal Systems (EGS), the other is the use of shallow geothermal energy (including ground source heat pump). EGS means mining deep geothermal system from the low-permeability rock of 3～10 kilometers underground, with the characteristic of huge energy reserves, high efficiency and stable system. EGS can be used for both power generation, and directive use. United States, Germany, France, Australia, Japan, Switzerland and other countries have built a number of experimental EGS, while Chinese EGS has just begun.

Application of shallow geothermal energy includes both conventional directive application of low temperature hot water, and the utilization by way of ground-source heat pump. China's shallow geothermal energy application is mainly on geothermal heating and cooling, medical bath, aquaculture, industrial washing and so on. Into the 80s of 20th century, the development and utilization of geothermal resources entered into the rapid development stage. Especially after 2000, the development and utilization of geothermal resources has a more vigorous development driven by market demand, with the largest geothermal development depth of more than 4, 000 meters. Currently, all provinces (autonomous regions and municipalities) have carried out exploration and development of geothermal resources, increasingly wide range of applications. By 2009, 259 geothermal fields have been developed, 368 million m^3 of hot water extracted per year (2010 National shallow geothermal energy and geothermal resources management meetings).

According to statistics, at the end of 2009, the equipment capacity of directive use of conventional geothermal energy is 3, 688MW thermal, the total using heat is 46,313 trillion J/year; if together with the application of the ground source heat pump, the equipment capacity and annual total using heat calories is respectively 8898MW thermal and 75,348 trillion J/year. 20% increased in 5 years, which performs that, the conventional use of geothermal heating develops rapidly, total area of geothermal heating reached 30. 2 million m^2 at the end of 2009, double than that in 2004, the average annual

growth rate is about 19%; The traditional hot spring bathing and medical use gradually developed into health care and recreation, reflecting connotations of the humanization and Spa cultural; the fastest growing ground source heat pump technology, maintaining robust growth trend, developed rapidly over the previous 5 years, the annual growing heating (cooling part) area is 1,800～2,300 m^2, by the end of 2009 reached 100.7 million m^2. The equipment capacity reached 5, 210MW thermal, 13-fold increased over 383MW thermal in 2004, (Source: World Geothermal Conference 2010 China National Report).

6.2.1 High-temperature Geothermal Power Generation

The national high-temperature geothermal resources mainly distribute in southern Tibet, western part of Yun'nan, western part of Sichuan and Taiwan. Himalayas geothermal zone is the biggest and most concentrate area of china mainland geothermal resources, especially the high-temperature geothermal potential electricity area, with the potential electricity capacity of 2,781MW; almost high-temperature geothermal potential electricity capacity is about 3,036MW in total. The Tibet area of Himalayas geothermal zone has the most powerful potential electricity.

At the end of 1970s, China began to produce electricity using high-temperature geothermal resource and built industrial geothermal power stations in Yangbajing Langjiu and Naqu of Tibet in succession. Among them the installed capacity of Yangbajing station was 25.18MW. The actual power generation was stabilized on 18.5MW by water vapor (1.095×107m^3 flow, temperature 130～170℃).

About 1970s, some small capacity of geothermal testing power machine sets have been built in Fengshun Guangdong, Huailai Hebei, Yichun Jiangxi, Huitang Hunan, Zhaoyuan Shandong, Yingkou Liaoning and Xiangzhou Guangxi. But most of the testing stations stopped due to low temperature and very limited economic benefits.

By 2009, China's high-temperature geothermal power plants only Tibet Yangbajing plant is still running. The first 1MW testing unit successfully op-

erated in 1977 and by 1991 another 8 sets of 3MW units have been completed, while the 1MW testing unit retired. Since then total installed capacity maintains at 25MW, annual power generation is around 100 million kWh. Nearly 5 years power plants continue to tap the potential and to increase outputs, and the electricity generation amount in 2005, 2006, 2007 and 2008 respectively was 115.4, 126.1, 115.8 and 143.6 million kWh, repeated history high record. By 2008 Yangbajing plant has a total generating capacity of 2.27 billion kWh.

6.2.2 Direct Utilization of Low-medium Temperature Geothermal Energy

In China the direct utilization of low-medium temperature geothermal resource mainly focus on geothermal heating, medical care, bathing, tourism, aquaculture, greenhouse planting, irrigation, industrial production and production of mineral water. And the technologies for step-recycling and energy storage in the aquifers are developed gradually. The whole country has more than 2,700 hot springs, of which about 700 have been developed. There are 1,048 national geothermal fields, 259 have been developed. There are more than 1,800 geothermal exploration wells, and each year about 368 million m^3 of hot water is extracted. China now has 71 thousand employees in geothermal development, the annual economic benefit of 7.092 billion Yuan. Among the application methods, both of bathing and medical care account for 47.6%, heating supply make up 30.8% and others is 21.7%.

(1) Geothermal heating

The application form large-medium cities, such as Beijing, Tianjin, Xi'an, Zhengzhou, Anshang in North and some oil regions including Daqing of Hei Longjiang, Bazhou of Heibei, Guan, Nutuozheng and so on where low-medium temperature geothermal water, tailrace and shallow geothermal energy with 60～100℃ are exploited. In the North, use geothermal heating in different degree getting a good effect.

In 2008 China's heating area by use of conventional geothermal resources was 24 million m^2, and at the end of 2009 it reached 30.2 million

square meters. Tianjin's area of geothermal heating in 2004 was 9.2 million m^2, while in 2008 it reached 13 million m^2. At present, more than one million people live in the houses with geothermal heating in Tianjin, and 4 million people enjoy a geothermal hot water. Tianjin has rich geothermal resources, the majority of geothermal wells can produce the geothermal water of 80～95 ℃, up to 103 ℃, so far the deepest geothermal well is 4,000m deep. After the floor heating reuse water is reheated and recycled by the heat pump system, it can make a general geothermal well to heat more than 200 thousand m^2.

In addition, Xianyang and Xi'an of Shaanxi Province, Dezhou, Dongying, Binzhou, Liaocheng of Shandong Province, Beijing and some cities in Hebei, Liaoning and Heilongjiang provinces, also have the use of geothermal heating.

(2) Medical treatment and health care

Geothermal fluids have high temperature, special chemical constituents and gas composition, a few biological activity ion, radio material and so on. It helps to treat every system and organ in body for medical care. There are all kinds of hydrotherapy, gas therapy and mud therapy conducted by geothermal energy in hot spring sanatorium. A bath of Hot spring Villages or Medical Rehabilitation Centers emerge successively with medical treatment, bathing, health care, entertainment, tourism vacation in our country. The data show that there are 126 geothermal fields for medical care in our country, distributed in 20 provinces (districts, or cities) .

(3) Bathing and tourism vacation

The distribution of this geothermal bathing has been wide-spread almost through all over China. According to incomplete statistics, there are 200 hot spring sanatoriums and 430 bath therapies which focus on medical care. Except sanatorium, in the exploited geothermal fields, geothermal area used fully or partly in bathing reach over 60% of total geothermal field, with both of hot spring public baths and pools of 1, 600. It is estimated that in nationwide scope geothermal water used in bathing is about 138 million m^3 every year, with using geothermal energy of 716.45MW, equal to saving or reduc-

ing the consumption of 771,000 tce, or offering geothermal bathing for 400 million person times.

China has lots of spring areas which are both sanitaria and tourist resort, and also were sportful places only for royal family. For example, there's a pond special for Empress Dowager in Xiaotangshan Beijing, Hall of Glorious Purity Hua Qing Palace in Lintong Shanxi, pond and Ba Gua House built for Empress Wu Zetian's own use in Linru spring in He'nan and so on. Along with the development of tourism, spring recuperate industry develops speedy especially, many investigation have been taken in spring areas on the aspect of geothermal utilization and more and more places for spring and tourism created owing to this.

Not only boiling spring area have geothermal resource of high energy sites, but also have beautiful geothermal landscape attracting attention of common people. For example, Tengchong of Yun'nan province is the only well-preserved volcanic hot spring area with rare volcanic, geothermal sight and rare medical mineral water. Hot spring area in Datun of Taiwan Province also is hot spring recuperate and sightseeing tourist attractions.

(4) Aquatics Breed, first starting from Beijing, Tianjin, Fujian, Guangdong etc.

Now there are 47 geothermal fields, 300 aquatics farms, rearing pond area of 445×10^4 m^2 distributed in 20 provinces (district, city). Nation-wide water consumption of aquaculture make up about 5.7% of total quantity of geothermal water, mainly cultivating tilapia, eel, turtle, bullfrog, fancy fishes etc. and fry over wintering. Moreover geothermal hatching avian, geothermal drying vegetable, heating biogas digester by geothermal water and bathing pool for livestock also get a good result.

(5) Agricultures greenhouse planting and irrigation

Making use of geothermal resources is very adaptive for out-of-season growth of plants and allopatric aquaculture. Geothermal energy can be used to supply heating for greenhouse and geothermal water can be used for aquaculture in warm zone, at the same time, mineral composition can offer necessary geothermal energy for greenhouse planting

215,000 tce/a, accounting for 3.4% of annual produced quantity of geothermal resource.

(6) Industrial production

In Industrial production, geothermal energy is mainly used for textile dyeing and printing, washing dyeing, tanning, pulp wood and grain heat-drying while some industrial material is extracted from part of geothermal water, as getting the sulfur by elutriation method in Rehai area, excavating mirabilite and native sulfur in Jiutai hot spring area of Eryuan. North China Oil field conducted the oil transportation accompanied with geothermal water by using ordovician arranged in deep part of well, taking place of oil transportation accompanied with boiler hot water to get economic and social benefits.

There're brands such as "The village of spring in China" and "The city of geothermal energy in China" created in Guangdong, Chaohu, Xianyang, etc. Thus improving overall standard of geothermal resources' development and utilization in areas and accelerate regional economic development. Meanwhile the stair-type utilization of geothermal water makes apparent progress in economy and has been spread all over China.

6.2.3 The Shallow Geothermal Technologies Application

Ground source heat pump is the energy-efficient air-conditioning cooling system, using underground shallow geothermal resources (also known as geothermal energy, including groundwater, soil or surface water, etc.) either heating or cooling. By inputting a small amount of high-grade energy (eg. electricity), Ground Source Heat Pump can achieve the transfer from low grade thermal energy to high grade thermal energy. Supplying heat of geothermal source for constructions in winter, and then cooling source would be offered to building in summer. Nowadays China has improved the engineering technologies, mechanical equipments, and system of monitoring and controlling.

Ground source heat pump in China has developed rapidly since 2004, the annual growth area of heating (cooling part) is 1,800～2,300 m^2, annual

growth rate over 30%. In 2009 the total using area of Ground Source Heat Pump is 100.7 million square meters, and the total using power is about 5,210MW thermal, more than 13 times of 383MW thermal in 2004. Beijing and Shenyang is the areas with developed ground source heat pump.

More than one ground source heat pump system was used in 2008 Beijing Olympic Games. Ground source heat pump was used for summer cooling and winter heating in the Olympic Tennis Centre competition hall. Olympic badminton hall and the Olympic Sports Center of Tianjin have conventional geothermal utilization and ground source heat pump system. Ground source heat pump is also partly used in the Olympic National Stadium, National Aquatic Centre, National Stadium, Olympic Village and Paralympic center. Ground-source heat pump heating breaks a new path for environmental protection and clean energy use. It partly replaces the traditional fuel boiler heating, not only saves the traditional fuel sources, but also reduces pollution, and the environment has been markedly improved.

6.3 The Policy Developments of Geothermal Energy Utilization in 2009

6.3.1 Partial Revision of "Ground-Source Heat Pump Systems Engineering and Technical Norms"

On March 19, the Ministry of Housing and Urban-Rural Development of the PRC issued No. 234 Notice, issued an approval of partial revision of "ground source heat pump system engineering and technical norms" (GB50366—2005), onwards since June 1, 2009. New "ground-source heat pump systems engineering and technical norms" was partially amended combined with the practical problems appeared in China's ground source heat pump projects in recent years, the relevant provisions were added and improved, to make it with more guidance and operational performance, which will positively promote the comprehensive development of the application of ground source heat pump technology.

6.3.2 "Shallow Geothermal Energy Exploration and Evaluation Norms" Issued

"Shallow geothermal energy exploration and evaluation norms" has been compiled since 2006, meanwhile comments of the experts and relevant units were asked for several times. In August of 2009, it was approved by the Ministry of Land Resources and issued as the ministerial standards, numbered DZ/T0255-2009. The release of this standard unified the standard for the ongoing evaluation of shallow geothermal energy resources in the provinces, municipalities and autonomous regions.

6.4 The Demonstration Projects of Geothermal Energy Use in 2009

(1) Shunyi International Flower Port Geothermal Greenhouse

Beijing Shunyi International Flower Port is the only large-scale flower industry park in Beijing, covering an area of 400 m^2. 42 modern intelligent greenhouses with a total area of 220,000 m^2 have been completed, mainly for flower development, breeding, production and display. Shunyi International Flower Port is the first large-scale self-developed geothermal energy projects on agricultural facilities, with a total investment of 260 million Yuan to build the heating and cooling systems of ground source heat pump and comprehensive utilization of geothermal, the total heating load is 46MW. The system includes four geothermal wells, 33 water-source heat exchanger wells and 2,000 soil-source heat exchanger holes with 150 m depth. The underground hot water will be recharged after the system using to protect the sustainable use of the heat source. The system provides heating in winter, and cooling in summer. It's energy efficient, renewable and non-polluting, and can save 2/3 energy compared to the electric boiler, and 1/2 energy compared to the gas-fired boiler, it's about 60% of normal central air conditioning, the annual running costs is only 53 Yuan/m^2, which can save 38 million tons coal per year.

(2) Large-Scale Operation of Geothermal Heating in Xiong County

This year Xiong County in Hebei Province achieved the large-scale geothermal heating operation coving 0.37 million m^2 of the county, of which 0.21 million m^2 are new-built, the rest are re-integration of scattered old geothermal heating system. Sinopec Star Petroleum Company completed this development and construction task. Sinopec Star Petroleum Company, Iceland Enlai Lakes (China) and Xiong County People's Government signed the "Xiong County Geothermal Resource Development Cooperation Agreement" in October of 2009. Luyuan Company formed by the former two companies quickly built a branch company in Xiong County to start work, drilled two geothermal recharge wells, successfully conducted geothermal recharge test in Xiong County for the first time, and laid the resource basis for sustainable geothermal heating. The geothermal projects Department of Star Petroleum Company scientifically planned and finally achieved the target of large-scale geothermal heating. After the completion of the first phase project, the company's next goal is to achieve the whole county's geothermal heating with 100 million m^2, to construct Xiong County into the "Smoke-Free City".

(3) Beijing Xiaotangshan Geothermal Recharge Tracer Test

Since 2001, Beijing Geological Engineering Institute has continuously carried out geothermal recharge experiments in Beijing Xiaotangshan, and gradually expands the test content and research projects. The scale of productive recharge has formed since 2004. Now 7 groups of 16 geothermal wells are in the recharge, the recent recharge rate reaches to 40%～60% of extraction amount. The geothermal pressure head reserved by geothermal field changes from the original down 1～2 m per year into local recovery and then to the overall increase. Although new exploration of the geothermal recharge mechanism is found each year, tracer recovery is finally detected in this year's testing. Testing is still in progress at present, but the latest results of the geothermal recharge mechanism are expected to obtain in the geothermal recharge during the heating season of 2010.

7 Ocean Energy

7.1 Classification and Definition of Ocean Energy

Ocean renewable energy consists of tidal energy, wave energy, ocean/tidal current energy, ocean thermal energy and salinity energy. Except that tidal energy and tidal current energy derive from the moon and the sun's gravitational force, other ocean energies originate from solar radiation directly or indirectly.

7.1.1 Tidal Energy and Tidal Current Energy

The gravitational attraction (is vector sum of centrifugal force, inertia force, and gravitation between moon and sun) generated during the process of relative motion among earth, moon and sun, lead to periodic change of sea levels— the tidal phenomenon. Generally, water level changes in vertical direction and it's called tide, the regular seawater flow caused by tide called tide current. The energy carried by the movement of seawater fluctuating is divided into two parts: the energy carried by vertical movement is potential energy, e. g. tidal energy; the energy carried by seawater's flow is kinetic energy, e. g. tidal current energy. Tide energy between tidal prism and tidal range (the difference between highest and lowest water level in one cycle) is direct proportion. Besides, tidal energy also can be used in water storage and new land.

7.1.2 Wave Energy

Wave energy refers to the kinetic and potential energy reserved in the sea waves. It is a kind of mechanical energy, which is generated by wind and

stores in short-period waves with the form of kinetic and potential energy. Wave energy is in direct proportional to the square of wave height, wave movement period, as well as the width of opposite wave face. Wave energy is the most volatile energy. It is mainly used for power generation, and can also be used for transportation and pumping water, heating, desalination of seawater and producing hydrogen.

7.1.3 Ocean Current Energy

The gradient of density and pressure of seawater caused by asymmetrical distribution of seawater temperature and salinity, or windward upon sea surface and so on, these reasons lead to basically stable flow of seawater, called ocean current. The kinetic energy carried in ocean current is ocean current energy. Compared to wave energy, ocean current energy is more stable and regular. In general, there is practical value for ocean current energy development if the largest flow rate is above 2m/s along the channel.

Similar to tidal current energy, its energy between square of velocity and flow is direct proportion. It has similar principle with wind power generation. Tidal current energy is the prime in china, therefore ocean current energy ranged in.

7.1.4 Ocean Thermal Energy

The most quantity of heat that radiated by sun are taken in by seawater from surface and radial circulation of ocean that conveying heat and so on, lead to the phenomenon that sea surface (by the sides of equator) temperature is relatively high and deep water is cold. As there is temperature difference between surface seawater and deep seawater in low-latitude area, there exists thermal energy, whose size is directly proportional to the quantity of heat water in area that has enough temperature difference (generally no less than 18℃). Ocean thermal energy used for power generation, meanwhile deep seawater can be used for aquaculture and open cycle can desalt seawater.

7. 1. 5 Ocean Salinity Gradient Energy

In the area along river bank or sea coast, the chemical potential difference between seawater and freshwater, or seawater with different salt concentration (concentration difference of solution) carries a kind of energy-ocean salinity gradient energy. There're many expression of ocean salinity gradient energy, the most attractive is a potential energy showed by osmotic pressure. So called osmotic pressure, is that fresh water will go to seawater through semi-permeable membrane (only allow solvent to pass) when putting one between two kind of solution with different concentration, the water level of one side will keep on rising because of additional water and this process won't end until the difference in height reach h, which is called osmotic pressure. How big the osmotic pressure is decided by concentration difference. Size of ocean salinity gradient energy is directly proportional to the quantity of fresh water and osmotic pressure.

7. 2 Development of China's Ocean Energy Resources

The first ocean energy resources investigation started in 1958 in China, finished second census on coastal tidal resources in 1985 and accomplished regionalization of coastal ocean energy resources in rural area in 1989. Coastal salinity gradient energy and maritime, adjacent waters' wave energy and ocean thermal energy resources have not been investigated formally with only several scholars' research.

7. 2. 1 Tidal Energy

According to the statistic of *census on coastal tidal energy resources in China* and *regionalization of coastal ocean energy resources in rural area in China* to the 426 dam sites that available installed capacity over 200kW, the national coastal tidal energy resources that can be developed has total installed capacity as high as 2.179×10^7kW, with an annual generation capac-

ity of 6.24×10^8 kWh. The resource is accounted for up to 80% in Fujian and Zhejiang provinces, then only 5% in Guangdong province and 4% in Liaoning province, other areas are even less.

Zhejiang and Fujian have done lots of investigation, design planning and feasibility research on the sites of coastal tide power station. There're 10^4 kilowatt class medium tide power station that obtain development condition in Jiantiao port of Sanmen Zhejiang, Huangdun port of Ninghai, Bachimen of Fuding Fujian, Daguanban of Lianjiang and Maluan gulf of Xiamen recently.

7.2.2 Wave Energy

Using the wave materials observed by 55 ocean stations for one year as representation and refer to regionalization of coastal ocean energy resources in rural area in China, the average power of national coastal wave energy resources is 1.2843×10^4 MW. Taiwan holds a maximum of China's total coastal wave power, about 33% of the national total wave energy. It is followed by Zhejiang, Guangdong, Fujian and Shandong, about 55% of the national total. Other coastal provinces and cities possess relatively small.

The Bohai Sea straits (Beihuang city), north and south side of Taiwan Island (south Taiwan and from Cape Fugui to Cape Sandiao), mid Zhejiang (Dachen Islannd) and to the north of Haitan Island in Fujian (Beishuang and Tai Mountain), Xisha area and Yuedong (Zhelang), etc., these areas have high wave energy density relatively in the coastal areas of china.

7.2.3 Tidal Current Energy

According to statistical calculations of *regionalization of coastal ocean energy resources in rural area in China* from 130 costal channels, the theory average power reached 1.395×10^4 MW. Zhejiang province holds a half of national total ocean current energy, which is maximum. It is followed by Taiwan, Fujian, Shandong, Liaoning provinces, accounting for about 41.9% of the national total ocean current energy. The rest provinces have less.

In nationwide coastal water channels, north of Hangzhou gulf, Jintang channel in Zhoushan Islands area, Guishan channel, Xihoumen channel, Laotieshan channel of north of the Bohai Sea Straits, northwest of Sanduao and Sandujiao of Fujian and southwest of Yuweng island of Penghu Islands area in Taiwan province have superior tidal current energy resources.

7.2.4 Ocean Thermal Energy

According to the calculation of mainland scholars and estimation of power company in Taiwan province, the available installed capacity of ocean thermal energy resources of maritime and adjacent waters in China is about 1.840×10^{6}MW, of which 90% distribute in South Seas.

The northern side of South Seas is China mainland and Taiwan province, the southern side Daxunta Islands while Philippine Islands stands at east and Zhongnan Peninsula, Peninsular Malaysia in western part. Both the eastern and western sides of waters are channels and connected with the Pacific Ocean and Indian Ocean, and also a semi-enclosed epeiric sea. It's the biggest, highest of energy density and most ample resources among maritime and adjacent waters in China.

The benthic topography of the eastern area to the Taiwan Island are intensely declining from east shore of Taiwan to the Pacific Ocean and greatly changed in maritime depth of water. The area whose depth reach 1,000m is really close to the shore and there're lots cliff on the shore which it's very benefit for exploitation so that is a good place to build plant going on development.

7.2.5 Ocean Salinity Gradient Energy

According to statistics, China's average flow rate per year of all the coastal rivers is about $1.7\sim1.8\times10^{12}m^{3}$, it has been calculated that the correspondingly theoretical power of China's total salinity gradient energy is about 1.14×10^{8}kW. Opening area of the Yangtze River, the Pearl River and the Minjiang River to sea, the flow quantity is very huge and salinity gradi-

ent energy changes slightly, meanwhile there are quite developed cities so that become ideal places for future development of ocean salinity gradient energy.

7.3 Ocean Energy Industry of China

7.3.1 Tidal Energy Industry

76 tidal power stations were built at the beginning of 1980s in China. By the end of 2009, there're only three tidal power stations still in work which are Jiangxia, Haishan and Baishakou tidal power station, all the others have been torn down or out of running.

(1) The Jiangxia Test Tidal Power Station in Zhejiang Province

Jiangxia test tidal power station is the biggest tidal power station of our country currently. It's located in Jiangxia port in southwestern Wenling of Zhejiang, 16 kilometers from the city. Jiangxia test tidal power station belongs to China Guodian Corporation as Pic. 1 shows and is in charge of subsidiary company-Longyuan power group corporation.

Pic. 1 The Jiangxia Test Tidal Power Station

Pic. 2 Reservoir of the Station

Now the total installed capacity of station is 3, 900kW and power generation ability reaches 7 million kWh per year. Not only much power energy but also lots of benefit from aquaculture or tourism obtained after the power station's establishment. The reservoir created because of dam and is able to store water for 1.37 square kilometers, also can be used to develop aquaculture. The affection of nature environment is very small, lots of nutrition contained in water owing to fresh water so that the salinity of seawater reduce,

therefore Aquatic Products always harvest. According to incompletely statistics, reservoir can make over 15 million Yuan/year.

Pic. 3 Plant of the Station

Pic. 4 Facilities of the Station

During the process of construction and production, many scientific experiments task have been finished. All of these experiments demonstrate that there's no need to immigrate, no disposable of energy consume, no threaten of flood, no pollution and no harm to the eco-system of tidal power station. There're 76 people work in the station and more than 30 people retired. Considering both company's benefit and cost of running, the price of on-grid electricity in Zhejiang is 2.58 Yuan/kWh.

The expansion project of the No. 6 unit of Wenling Jiangxia test tidal power station, is to attach a new two-way (rising and falling tide) 700kW lie-axle-bulb through-flow power unit to No. 6 using the former hole and channel. Compared with five former units, the forward and reverse operation conditions of pump are additional and thereby enhance function. After No. 6 unit's expansion, the station installed capacity increase from 3,200kW to 3,900 kW. The plan and design work are in the charge of Hangzhou Machinery Design Institute belongs to the Water Resources Ministry and the task are classified in the national "863" Plan. In addition, the project won the first prize of Advance of Science and Technology Award of China Guodian Corporation in June, 2008.

(2) The Haishan Tidal Power Station in Zhejiang Province

The installed capacity of Zhejiang Haishan tidal power station is 2×125kW and the water turbine made by turbine production in Hengchuan He'nan, design to generate power 400 thousand per year. It'll be enlarged to 3×

250kW, planned by local government in 2008. The area of station's reservoir reaches 418 mu, seawall dam is more than 2,000m in height. It's the first double reservoirs, one-way and full-tide small tidal power station that store fresh water and energy for power generation, meanwhile develop aquaculture using reservoir. It's a key program of "sixth-five" of Science & Technology Commission in Zhejiang.

Pic. 5 The Haishan Test Tidal Power Station

Pic. 6 Reservoir of the Station

Pic. 7 Tail Water Gate of the Station

Pic. 8 Unit of the Station

Haishan tidal power station renamed to "Zhejiang Yuhuan Double-current Tidal Power Ltd." in May of 2008, is attached to Yuhuan Water Resources Corporation. There're five staff now, working on operation, maintenance, management of the tidal power station and aquaculture. The price of on-grid electricity is 0.46 Yuan/kWh, among which the cost of power generation is 0.63 Yuan/kWh. It's obvious that the station's running can't rely on selling electricity but turns to the income of aquaculture.

(3) The Baishakou tidal power station in Rushan Shandong

Shandong Haiyang Suoyin Shoal, a natural bay that absorb water when tide is rising and drain water conversely. Its waters area is four square kilo-

meters, coastline is 12 kilometers in length and water is two meters in depth. It's the biggest natural and inland tidal lake in china so far.

Pic. 9 The Baishakou tidal power station

Pic. 10 Plant of the station

Pic. 11 Reservoir and dam of the station

Pic. 12 Facilities of the station

The design installed capacity of Baishakou tidal power station is 6 × 160kW and its generator is made by Chongqing Electrical Machinery Factory, the speeder is produced by Hangzhou Gear Factory, the units assembled by themselves and can generate power like 4000kWh a day on average. By the end of July 2008, the tidal power station has made power of 38.20 million kWh in total. The area of reservoir reached 32 thousand square kilometers when the station established. But the area is getting smaller and smaller due to the development of tourism and real estate that the reservoir is filled in partly. There're six units in the factory at the beginning, but No. 5 and No. 6 unit have out of running because of serious corrosion.

There're seven people working in Baishakou tidal power station, taking charge of the operation, maintenance and management of the tidal power station and aquaculture. But the price of on-grid electricity is only 0.32

Yuan/kWh, the power generation can't support the station along, benefit from aquaculture contributes to.

7.3.2 Wave Energy Industry

Wave energy device has been formed only one kind of good that beacon lamp 10W oscillating water column (OWC) device. The device was a kind of wave energy power generation equipment specially designed for pharos buoy in the sea-route by the Chinese Academy of Sciences Guangzhou Institute of Energy Conversion. According to the recent application on the sea, the device will make the navigation lights illuminate bright and stable, greatly improve the navigation conditions.

Pic. 13 10W beacon lamp

Since this device takes wave as the driving force and gets electricity locally for navigation light, it will no longer need to replace the cell, saving maintenance costs, and reducing labor intensity of navigation workers. It has obvious economic and social benefits. This devise is designed and manufactured by Guangzhou Energy conversion Institute. And 2008 annual output is 10 units, one of which exported to Japan.

7.4 2009 China's Ocean Energy Events

7.4.1 Key Technology Research and Demonstration of Ocean Energy Development and Utilization

May 10, 2008, the Ministry of Science and Technology issued "key technology research and demonstration of Ocean energy development and utilization" application guide of key projects topics supported by national science and technology program. National science and technology program funds allocated 32 million Yuan in total. From May 2008 to April 2011, program,

aimed at China's power shortages in remote islands of the status quo, focus on China's ocean energy key technologies of development and utilization, and establish relevant procedures and detection methods, and overcome the key technologies of our wave energy, tidal energy, ocean thermal energy, and carry out on-site demonstration test and improve our independent innovation capability of ocean energy development and utilization, lay the industrial development foundation of China's ocean renewable energy exploitation and utilization.

Guangzhou Institute of Energy in 2008 won the project approval of the ministry of Science and Technology project. Ministry of Science and invested 13.4 million to support the four projects:

- Floating wave ocean energy independent stable power generation system (863 Exploration Project).
- Application technology of floating direct drive wave energy (863 Exploration Project).
- 100kW floating wave energy power station (the project sub-topics supported by science & technology).
- 100kW off-bank stationary and swinging wave energy plant (the project sub-topics supported by science & technology).

The goals of these projects and issues are to complete a canard-10kW floating wave energy device in 2009 and a 10kW direct drive oscillating float floating wave energy device in 2010, and a floating canard 100kW wave energy power station in 2011, as well as 100kW fixed offshore wave energy power station. In October 2008, the floating wave energy device with efficiently anti-typhoon ability got through the initial destructive testing, in December of 2008, and it completed a preliminary test on real sea conditions.

7.4.2 863 Plan Supporting New Technology of Ocean Energy Utilization

May 20,2008,863, in the field of advanced energy technologies, issued renewable energy technologies topics, and plan to allocate 600 to 700 million in funds in 3 years, to support the new technologies of the ocean energy utilization. The ministry of Science and Technology demands each R&D to fo-

cus on the current, and look forward to the future, and vigorously develop energy-saving, development of clean and efficient energy, and Conversion and utilization technologies, and actively develop new energy technologies, promote energy diversification; Capture a number of energy development, utilization and energy-saving key technology and equipment, form a number of new growth point for the energy industry, and establish energy technology sustainable innovation platform, to support economic and social sustainable development in the provision of clean and efficient energy technologies.

A 1kW underwater floating horizontal-axis tidal current device is developed by Northeast Normal University. It consists of underwater mooring system, generator, flexible shaft and horizontal-axis hydraulic turbine. A high efficiency hydraulic turbine was employed. In order to avoid paddle-distance adjustment and decline of the efficiency at reversed flow condition, this device used flexible shaft, which connected the horizontal axis hydraulic turbine and the vertical-placed generator, making sure the hydraulic turbine faced against the flow direction. The research was supported by most 863 exploration projects of 11th "Five-Year Plan". It began in November 2006 and will be completed in December 2008.

7.4.3 Special Fund for Ocean Renewable Energy Interim Measures

On June 1st of 2010, the Ministry of Finance and the State Oceanic Administration jointly promulgated the "special fund for ocean renewable energy Interim Measures", focusing on support to ocean renewable energy technologies research and industrialization demonstration projects focus on resolving the island's power supply problems.

The Measures as the special support policies for the promotion of ocean renewable energy development and utilization, will make up the gaps in lack of ocean renewable energy-related policies and measures, greatly strengthen the government's guiding and promoting role in the field of ocean energy development and utilization.

The Measures provide that, the special funds support the independent power system demonstration projects in remote islands, large-scale ocean

power integration systems demonstration projects, demonstration projects about key technology industrialization of the development and utilization of ocean energy, technology research and pilot projects about comprehensive development and utilization of ocean energy, ocean energy development and utilization standards and supporting service system. The ocean energy demonstration projects have been adopted by national technology plans, and the ocean energy development and utilization projects which have enjoyed the national renewable energy tariff policies can not apply for special funds.

The Measures also require the conditions and technical requirements must be met for the project applying for special funds. It announces clearly that the best system integrators and key equipment of ocean energy power generation projects should be chosen by way of tender. In addition, the Measures also clarify the management of declaration, approval and supervision.

7.4.4 MW-Class Tidal Power Plant Construction in Fujian

China's largest new energy power generation companies LongYuan Electric Power Group has started the work of choosing the site of MW-class coastal tidal power plant since 2008 in Zhejiang, Fujian. Finally Taizhou Sanmen JiantiaoMW-class tidal power plant was decided as the recent development project.

Sanmen Jiantiao tidal power plant is located in the south of Sanmen bay, which is a normal semidiurnal tide with larger drop, the difference of the average flood tidal range and ebb tidal range is 4.19 m, the average duration of flood tide and ebb tide are both 6 hours. According to the "Zhejiang Province Jiantiao tidal power plant project proposal", the installed capacity of the station is 20,000 kW, with the annual utilization hours of 2,550 hours, static investment per kilowatt of 33,400 Yuan, static total investment of 668 million Yuan, electricity price including tax of 1.95 Yuan/kwh, which currently is the best one of the tidal power station sites.

8 Development of the International Renewable Energy

Since the 21st century, major countries in the world have given the priority to the renewable energy in the strategy of energy development. Renewable energy is considered as the key technological choice for addressing the energy and climate change issues. A set of laws, planning, policies and encouragement mechanism have been carried out to promote the renewable energy development. By the end of 2009, the world's installed capacity of wind power had exceeded 0.15 billion kW, the biomass power of 50 million kW, solar power of 230 million kW, geothermal power of 10 million kW and Bioliquid fuel of more than 68 million tons. For some regions, the supplementary power of renewable energy has become the important substitute energy to regular powers.

Due to the relatively high cost of renewable energy, the encouragement mechanism and policies by the governments still function as the major pushing force of the renewable energy development. However, the financial crisis brought new changes to the global renewable energy industry. On one hand, the industry has become the crucial measure for stimulating the economy and the new energy administration. On the other hand, the tremendous financial pressure in developed countries made the investment of renewable energy decline while the R&D and marketing are promoted.

In terms of technology development, new trend in the development of renewable energy appeared in 2009. First the investment to the technology of renewable energy increased. Major Powers of renewable energy including European Union, the United States enhanced the input of the new generation of renewable energy technologies such as off-shore wind power and solar thermal power generations. Second, the world's leading countries and regions proposed the technological solving plans and R&D methods to remove the barriers of the large-scale grid-connected electricity generation by way of in-

tegrating the smart grids. The third aspect is the researching and exploration of the liquid bio-fuel. As the R&D and pilot projects of the second generation of bio liquid fuel are accelerated, major powers with the joint efforts of the top transnational corporations largely increase the investment of the biodiesel exploration. Fourth, many leading countries increase the input for the terminal consumption of renewable energy. Typical cases include "Thousands of Roofs" plan of the US and the "State Solar Power Plan" of India.

8.1 The United States

As the biggest economy in the world, the United States is also a super power in the field of exploration and utilization of renewable energy. The US takes the first place in the areas of bio liquid fuel, wind power, solar power, and biomass power, as well as geothermal. In the bio liquid fuel industry, the country produced 10.5 billion gallons (31.4 million tons) of bio-ethanol and 0.5 billion gallons (1.63 million tons) of biodiesel. With the accomplished 200 corn-ethanol factories and 75 biodiesel companies and 30 cellulosic ethanol pilot projects, the country has already established a developed industrial system of bio liquid fuel. Regards to the wind power generation, by the end of 2009 the accumulated installed capacity of wind power reached 35 million kW which provided 1.8% of the power supply of the country in that year. The newly increased capacity of 10 million kW covered 39% of the total increased capacity of the year. In the field of solar power, by the end of 2009 the installed capacity of photovoltaic reached 1.1 million kW while the solar thermal reached 432 thousand kW. By the end of 2009, US' accumulated installed capacity of biomass reached 10.5 million kW among which the city solid waste accounted for 3 million kW, direct-fired generator contributed 2 million kW, industrial waste of pulp covered 5 million kW and the co-production of heat and power contributed 0.5 million kW. Apart from the above, the country's geothermal power has the capacity of 3 million kW while there is still 6 million kW under construction.

The United States is also a leading country in terms of technologies of

wind power equipment, bio liquid fuel, solar power generation and photovoltaic. Besides the traditional manufacturing giant of the General Electric, US also grooms emerging renewable energy enterprises including the First Solar whose technology of thin-film cells contributed 1. 1 million kW, ranking first among the solar cells enterprises of the world. The Applied Materials is one of the major thin-film cells lines suppliers in the world. Companies including Boeing and Honeywell are dedicating to the R&D of the aerospace bio fuel. In addition, the country owns the leading researching and exploring agency of renewable energy—the National Renewable Energy Laboratory (NREL) .

To address the financial crisis, create job opportunities and dominate the technology field, the Obama administration advocates vigorously the development of new energy including wind power and solar power. The 787 billion dollars' Massive Stimulus Bill spares 16 billion dollars for renewable energy investment which involves the extension of the holding period of renewable energy tax, expansion of the application range of renewable energy investment tax, the Clean Renewable Energy Bonds and the direct allowance for the renewable energy equipment. As for the concrete goals, the president proposed at the assuming that the renewable energy output would increase by 100% within the next three years with power generated by renewable energy reached 10% by 2012 and 25% by 2025. In the coming 10 years the US will establish the "Clean Energy Research Fund" with 150 billion US dollars for the R&D and promotion of solar power, wind power, biomass power and other clean substitute energies.

The US Congress in June 2009 passed the "America Clean Energy Security Act" which for the first time determined the national emission-reducing plan as well as the country-level renewable energy goal that in 2020 the electricity generated by renewable energy would account for 20% of the total demand. The 15% part would be realized by the renewable energies including wind and solar powers while the rest 5% would be contributed by the efficiency improvement. For those states that are not able to achieve the ratio of 15%, they are allowed to make it 12% but the efficiency improvement must reach 8% accordingly.

8.2 European Union

European Union is the first economy that developed the renewable energy with greatest efforts and remarkable achievements. As early as the end of the last century, EU started to set and constantly improved the regional goals for renewable energy development. The recently proposed "20-20-20" plan indicated that with the goals of emission and energy consumption reductions of 20%, the community would achieve the goal of making renewable energy 20% of the total terminal consumption by 2020, which is the most ambitious target among the major economies till now. Besides, the EU Council released the model of "Renewable Energy National Action Plan" in June 2009, requiring the member countries delivered their legally binding plans by the end of June 2010.

EU clarified the goal of developing the renewable energy to the 20% ratio of the total energy supply in December 2008 by 2020. In July 2009, the union signed the "European Strategy Energy Technology Plan" (SET-Plan), asserting to spare 51 billion and 23.5 billion Euros for low-carbon energy and the R&D of the supporting technologies. The Council determined to establish the Directorate General Energy and Directorate General Climate Action, integrating the duties that distribute in the departments of transportation and international affairs so as to efficiently coordinate the energy and climate policies. Apart from the key strategy for economic growth, renewable energy also serves as a powerful tool for the unification of EU.

Renewable energy situations for member countries of EU:

8.2.1 Germany

According to the latest report released by the Department of Environment of Federal Germany in March 2010, the ratio of renewable energy in the total energy consumption which entailed heating, electricity supply and fuels rose from 9.3% in 2008 to the 10.1% in 2009. The country is on track to realize the goal of making renewable energy account for 18% of the total

consumed among which the biomass contributes 7.0%, wind power 1.6%, hydropower 0.8% and others 0.7%. The ratio of the electricity generated by renewable energy rose from 15.2% in 2008 to 16.1% in 2009. The generating capacity rose from 45GW in 2008 to 50GW in 2009. Renewable energy accounted for a third of the newly increased generating capacity and the capacity of ethane doubled. Despite of the −5% economic growth rate, the investment for the renewable energy of the country increased by 20% to 18 billion Euros in the year of 2009. The job opportunities provided by the industry increased by 8% and 0.3 million people were employed. That the increase in the utilization of renewable energy brings a decrease in the emission in energy industry creates a favorable condition to achieve the country's reduction target of 40% by 2020.

As one of the major powers in renewable energy equipment manufacturing, Germany takes a leading place in technologies of wind power equipment, solar power generating and photovoltaic. With ENERCON, which is the world's biggest direct-drive turbines supplier, the country has Siemens as another well-known supplier of wind turbines. Germany leads the world in the fields of the technology and production of poly-silicon and solar cells for which Q-cell ranks the third. Fraunhofer Institute and its affiliated bodies form the world-class research agency of wind and solar power. Additionally, Germany is one of the members that actively advocate the *European Desert Electricity Plan* (*Desertec*) and promoted the establishment of International Renewable Energy Agency (IRENA).

8.2.2 Denmark

Denmark acts as a pioneer of the world renewable energy. Since 1970s, the ratio of renewable energy in the total energy consumed increases year by year and reached 29% in 2008. In the past 25 years, the economic output of Denmark has increased by 75% but the energy consumption remains unchanged, which is considered as the unique "Denmark Model". The wind power provided 25% electricity of the whole country. According to the medium-long term plan of Denmark, the percentage of wind power will reach

35% in 2015 and 50% in 2030. By the end of 2008, Denmark had been equipped with 5,200 wind power sets with the total installed capacity of 3200MW. Given the wind velocity of 10 meters per second, the wind turbines would meet the demands of all of the households in the peak. Off-shore wind power plants have become a new selling-point in recent years. Currently, there are 11 off-shore wind power plants that have been accomplished or are under construction with the installed capacity of 750MW among which there is the world's biggest plant "Big Horn Wind Farm". It is estimated that by 2012 more wind power plants of 0.4 million kW would be established in Denmark.

Denmark is also a leading country in the renewable energy technology. The value of the equipment and service of renewable energy contributed by Denmark to the world amounted to 5.7 billion Euros in 2008, accounting for 7.2% in its total export volume. Wind power industry has become the second largest export industry after the pharmaceutical industry. Among the wind power enterprises Vestas outstands with 35% output of the world's wind power supply. In addition, RISO national laboratory is one of the top research centers of renewable energy. Denmark also leads other countries in bio liquid fuel especially in the field of cellulose bio ethanol technology. Novozymes is the only supplier of enzyme preparations for cellulose bio ethanol in the world.

8.2.3 Spain

Spain is another major power in the utilization and manufacturing of renewable energy with the world-class installed capacity of both wind and solar powers. Three Spanish enterprises among which Gamesa is the world's third largest wind turbine manufacturer ranked in the first 15 in 2008. Besides, Spain is also a gathering place for the developers of renewable energy power generation. Three out of the top ten wind power developers are Spanish. Iberdrola, which is the biggest developer in the world, has the installed capacity of 9 million kW, pervading Europe and the United States. The country created the world record of installing solar power with the capacity of 2.6 million kW within a

year in 2008. In addition, Spain has made commendable attempt in solar thermal generation, owning the most advanced solar thermal power plant in the world.

8.2.4 Britain

The British government proposed in 2009 the "Roadmap of Low-Carbon Economy" which determined by 2020, the country would make the low-carbon energy 40% in its total electricity power. The 40% energy comprises of 30% from renewable energies including wind power, wave power and tidal power while the rest 10% would be generated by nuclear power. To achieve the goal, the government carried out the concrete stimulus measures: 0.12 billion pounds' fiscal investment for off-shore wind power; 60 million pounds for the development of wave and tidal power technology; and 6 million pounds for geothermal resource exploration. The majority of the investment was spent on the industries which are endowed with great potentiality and for which the country has the technology advantages.

8.2.5 France

The French government in 2009 showed to the world its firm resolution of developing the country in a low-carbon way. The government proposed that it would impose carbon tax directly and independently from the group of European Union, making the "carbon label" for all of the consumption goods. It is predictable that with the smooth going of the two policies, the French manufacture industry will transform to the "low-carbon" mode under the favorable encouragement of tax reduction, by which the low-carbon technology and industry would be driven. As one of the engines of the EU economy, the country is certain to exert an influence on the union's policies in future. With the background of trade globalization, the policies will clearly make changes to the manufacturing and interflowing of the global commodities.

8.3 Other Leading Countries

8.3.1 Japan

Japan has promulgated a series of policies and laws to promote the utilization and development of new energies such as wind power and solar energy. The two most important documents, the "Basic Principles of the Promotion of Utilization of New Energy" in 1997 and the "New Energy Law" in April 2003, were both implemented. The latter clarified that Japan adopted the Renewable Portfolio Standard (RPS) to promote the development and utilization of renewable energy. In June 2006, the prime minister Yasuo Fukuda proposed the energy development target known as "Fukuda Vision" which planned to increase the installed capacity of solar power by 40 times. In 2009 Taro Aso's administration set the ambitious goal of ranking first in world's solar energy, specifying Fukuda's target into reaching 28 million kW in 2020 and 56 million kW in 2030 with the new Roadmap of Photovoltaic Development, which revived the solar power allowance policy that had stagnated for two years. The solar power market was also restarted. The long-term goal of Japan is to make the ratio of renewable energy 50% of the total supply by 2050 and to reduce 80% of the GHG emission through improving energy efficiency and utilizing renewable energy.

With the basis of "Roadmap of PV Development of Japan" in 2004, the country released the new solar energy development strategy "PV2030+" which set the goal of the PV development in 2050 that by then the solar power would cover 5% to 10% of the primary energy consumption of Japan. The cost of PV power generation will decrease largely to 14 Yen/kWh for PV grid parity at consumption end in 2015 and 7 Yen/kWh for supply channel in 2025. The efficiency of cells will also increase, with the converting rate of 40% in 2050.

As for the use of PV, 150 to 200 GW installed capacity will be used in building integrated PV for the consumption end; 150 GW will serve for the

power supply of agriculture and industry departments; and 150 to 200 GW will provide the power supply for the fuel substitute technology of cell-driven cars. By 2030, the annual installed capacity of PV cells will reach 12GW. From 2030 to 2050, the PV power will increase annually 25 to 30 GW and the scale of the industry will reach the value of 4,000 billion Yen in 2050.

"PV2030+" also sets the clear vision for the related technology. The converting rate for silicon cells will reach 25% with lower cost of the materials. The converting rate for silicon thin-film cells will reach 18%. The plan emphasizes the grid-friendliness of PV system also.

8.3.2 India

Addressing the energy shortage considered, India particularly established the Department of New Energy and Renewable Energy to lead the country's renewable energy department. India dominates Asia in wind power industry as well as the installed capacity. The country established the solar power development strategy, aiming at developing 20 million kW capacity of PV power by 2022. In addition, the country's 11th "Five-Year Plan" determined to increase the installed capacity of renewable energy by 15,000MW from 2008 to 2012 when the total value of the renewable energy will reach 19 billion dollars and the investment will reach 15 billion dollars. The Indian government has spared 1 billion US dollars for the allowance of renewable energy.

The Indian government promulgated the "National Solar Power Plan" which was also known as "Nehru Solar Power Plan" in November 2009. The plan was divided into three phases. The task for the first phase is to increase the output of solar power of 1,300MW by 2013. The target for the second phase is to reach the connected installed capacity of 5,000MW in the years from 2013 to 2017. The third phase, which is from 2017 to 2,022, is set with the goal to integrate PV plants with solar thermal plants efficiently, expecting to create off-grid capacity of 2,000MW and accumulated capacity of 22,000MW.

The plan is featured with great feasibility. According to the plan, the In-

dian government will approve 15 to 20 solar power projects for which the investment will amount to 200 billion rupees (4.4 billion US dollars). Besides, the plan clarified the 20% to 25% allowance for the PV and solar thermal cells companies.

In addition, in the field of bio liquid fuel, Indian government approved the national bio fuel policy and the implementation plan. Meanwhile, it also established the National Bio-fuel Coordination Committee and the Bio-fuel Steering Committee. The new policy is dedicated to promoting the utilization of the local biomass materials so as to achieve the best result in bio-fuel development and production.

The outstanding points of the new policy include: to produce biodiesel by farming oil-seeds on deserted, degenerated and fringe areas; to realize the goal of making integrated bio-fuel which include biodiesel and bio ethanol 20% by 2017; to price reasonably for the farmers by periodically adjusting the MSP and MPP for the inedible oil-seeds; to give priority to the farming, processing and producing of the first and the second generations bio-fuel oil seeds as well as the research, development and demonstrating through fiscal encouraging measures including allowance and bonus. The country will establish national bio-fuel fund if necessary.

8.3.3 Brazil

Owing to the abundant renewable energy resource reserves, Brazil is another leading country in renewable energy utilization. In 2009, renewable energy contributed 47% to the total energy consumption of the nation, covering 89.9% of the electricity consumption. Endowed with sugarcane and carnauba, the country was the first to realize the non-straight fuel supply in the world. The output of bio liquid fuel in 2007 was over 17 million tons, and it has been proposed that in 2025 the annual output will reach 75 million tons. The land and weather of Brazil provide a favorable condition for biomass energy. The output of the bio ethanol in 2009 was 30 million tons, accounting for 40% of the total in the world, which made the country one of the largest producers of fuel ethanol. Besides, Brazil has established its de-

veloped industrial system of the production, sales, management, allowance, standards and R&D for fuel ethanol. The ratio of bio liquid of the transportation use has reached 18.8%. The country also signed the Agreement on Common Market of Bio Liquid Fuel with the United States, placing bio liquid fuel as a strategic resource for the international trade of the country in future.

9 Status and Tasks of the Renewable Energy Development of China

9.1 Situations of the Renewable Energy Development

9.1.1 Renewable Energy and Addressing the Climate Change

Climate change always has great influence to life, affecting the living environment of human beings. Statistics of the National Oceanic Bureau shows that more than 2,000 m^2 of China's territory has fallen to below the sea level. More than 1,000 m^2 land of the Pearl River would be covered and lands of other regions would be eroded if the sea level rises another 0.3 meter. With the territory desertified and air eroded, the Prime Minister Wen Jiabao mentioned for 18 times that we should never make Minqin (in Gansu Province) another Lop Nur. Climate change also destructively causes air and water pollutions which were the breeders of 30 new diseases in the past 20 to 30 years, when some controlled diseases returned because of the climate change, which is one of the major factors of the transmission of the infectious diseases.

Climate change makes the water shortage and food crisis of the country stand out. The extreme weathers raise the frequency of these natural disasters. The extreme weathers of the first half of 2010 caused the serious drought in the four provinces in the southwest of China and more than 20 million people suffered from water shortage. The consequences by climate change are irreversible.

Meanwhile, climate change is altering the development mode of developing countries. The international community sticks their eyes on the increase of the emission per person of China of which the policy choices are disadvantaged. Compared to the unlimited emissions of the developed countries during the industrial age, China today has to develop in a low-carbon way. It must

be noted that with the continuous and fast growth of the economy, China now ranks first in the GHG emissions of the globe, which arouses more concerns from other countries. As one of the core countries in climate change, China's pressure of environmental diplomacy increases yearly.

The international community has acknowledged the situation and attached great importance to climate change since early 1990s. To address the problem, the "United Nations Framework Convention on Climate Change" and the "Kyoto Protocol" have been passed. Today climate change has upgraded from a single environment problem to an issue that concerns politics, economics, national defense energy security as well as environment protection. It has become a focal problem in the dispute between the developing countries which struggle for the future development space and the developed countries which strive to occupy the new commanding height and to control the world, which was completed illustrated in the Copenhagen conference.

Copenhagen conference passed the "Copenhagen Accord", on which currently 39 Annex I countries (developed countries and transition economies) have submitted their medium-term quantitative reduction targets by 2020 (Table 29) and adhered to the "Accord". 67 developing countries also recognized the "Accord" and announced to the Secretariat their national actions for proper reductions (Table 30).

As a responsible major developing country, China promised that by 2020 the carbon intensity would be reduced by 40% to 45%. Carbon intensity, which refers to the unit carbon dioxide emission of unit GDP, is not an absolute amount so that the promise does not equal to stopping the increase of carbon emissions in future.

Measures addressing climate change concerning, countries in the world all adopt the use of renewable energy as one of the crucial approaches to reduce GHG emission and to moderate climate change. Addressing climate change has become a main force to promote the renewable energy use and development. According to the latest assessment by the United Nations' Intergovernmental Panel on Climate Change, renewable energy will contribute 10% to the GHG emission reduction by 2030.

Table 29 Reduction Targets of Economies Covered by Contracting Parties of Annex I

Parties of Annex Ⅰ	Quantitative Reduction Targets by 2020 of Economies Covered	
	Emission Reduction of 2020	Base year
Australia	−5%(unconditional) −15% (agrees with the Accord, but no commitment to the carbon intensity of 450 pp; major developing countries to restrict the emissions; the reductions of developed countries are comparable) or −25% (with the global agreement of 450 ppm)	2000
Belarus	−5%～10% with the premise of the flexible mechanism, technology transfer and capacity building of the Kyoto Protocol	1990
Canada	−17%, which is linked to US'legislation situation	2005
Croatia	−6% temporarily, to adhere to the standards of EU after the entry	1990
Europe Union	−20% (unconditional) −30% with the global agreement of comparable reductions of developed countries and sufficient contribution by other developing countries according to their responsibilities and abilities	1990
Iceland	−30% work with EU, with the global agreement of comparable reductions of developed countries and sufficient contribution by other developing countries according to their responsibilities and abilities	1990
Japan	−25% with the premise of an international agreements adhered by major powers with ambitious targets	1990
Kazakhstan	−15%	1992
Liechtenstein	−20% (unconditional) −30% with the global agreement of comparable reductions of developed countries and enough contribution by other developing countries according to their responsibilities and abilities	1990
Monaco	−30%	1990
New Zealand	−10%～20% with a global agreement in which the temperature increased controlled as 2℃, comparable to the reductions of developed countries, reduction actions of advanced developing countries with big emissions according to abilities	1990
Norway	−30% −40% major emitters join the global agreement; the temperature increased controlled as 2℃	1990
Russia	−15%～25 %, reasonable calculation of Russian forest carbon sink and legally binding reduction obligations of other major emitters	1990
The United States	Around −17%, subject to the national energy and climate legislation which will entail the reduction goals of 30% by 2025, 42% by 2030 and 83% by 2050	2005

Table 30 Part of the National Reduction Actions of Non-Annex I Contracting Countries

Non-Annex Ⅰ Contracting Countries	Actions	Conditions and Notes
Brazil	The GHG emission by 2020 will reduce by 36.1% to 38.9% in BAU, including measures of deforestation reduction, grassland recovery, compounding system of corps and stocks, biological nitrogen fixation, energy effectiveness improving, promotions of biomass fuel, hydropower, substitute energies and steel industry.	Voluntary and spontaneous reduction action; subject to the funding and technology transfer supports of developed countries on item 4.7 of the convention. See the Item 12.1(b) for more information
South Africa	The GHG emissions will reduce by 34% in BAU by 2020 and 42% by 2025. the maximum will be seen between 2020 and 2025. The absolute quantity will reduce after ten years' unchanged quantity	Subject to the funding and technology transfer supports of developed countries on item 4.7 of the convention. See the item 12.1(b) for more information.
India	Compared to 2005, the emission intensity of GDP will be reduced by 20% to 25% (excluding agricultural emissions)	Subject to the national legislation and the funding and technology transfer supports of developed countries on item 4.7 of the convention. See the item 12.1(b) for more information
China	By 2020 the CO_2 emission of unit GDP will reduce by 40% to 45% of that of 2005. Non-fossil energy will reach 15% of the primary energy consumption. Forest area will increase by 40 million hectares and forest storage of 1.3 billion m^3 than those of 2005	Voluntary and spontaneous reduction action; subject to the funding and technology transfer supports of developed countries on item 4.7 of the convention. See the item 12.1(b) for more information
Korea	To reduce 30% in BAU by 2020	—
Mexico	The Mexican 2009 Climate Change Special Program states that the reduction will reach 51 million tons in BAU by 2012 and 30% in BAU by 2020	A global agreement which entails sufficient funds and technology supports of developed countries
Singapore	To reduce 16% in BAU by 2020	A legally binding global agreement; and other countries are sincere to fulfill the obligations
Marshall Islands	To reduce carbon dioxide emissions by 40% of that of 2009 by 2020	Subject to sufficient international supports
Moldova	With the global market mechanism, to reduce at least 25% GHG emissions, 1990 as base year	
Israel	To reduce 20% in BAU by 2020	
Costa Rica	To achieve carbon neutral by 2020	
Maldives	To achieve carbon neutral by 2020	Voluntary; unconditional

9. 1. 2 Renewable Energy Development and Energy Revolution

The human society has experienced the age of firewood, the age of coal and today it comes to the age of oil and gas. The excess use of the fossil energy has made energy more and more precious to the economic development as well as the ecology on which the mankind live. Since the Industrial Revolution, the development and exploitation of renewable energy by modern technology has had a century history. The two oil crises in 1970s aroused people's concerns for the fossil energy shortage in the future. The increasing attentions paid to the environmental problems and the common idea of sustainable development of the international community make the development and use of renewable energy the widely concerned focal point, which marked the first wave of the modern technology use in developing and exploiting renewable energy in history.

Since 21st century, the problems of energy security and energy environment triggered by high oil price urged many countries to give the strategic priority to renewable energy in their energy development. The countries lead and encourage the scale development of renewable energy through different measures, starting the second wave of renewable energy development. The significant results include the lasting decrease of cost, the expanding market shares and the renewable energy's transform from the supplementary to the substitute.

Meanwhile, the worldwide economic recession by financial crisis made countries in the world work out their economic stimulus plans to recover the development. Many countries set the development of clean energy, such as renewable energy as the new point of growth and carry out investment plans which again brought a trend of renewable energy use, creating an opportunity for leap-forward development of the industry.

The global wind power market has kept the annual growth rate of 28% in recent 10 years. The annual growth rate of photovoltaic is over 30% and that of bio liquid fuel reaches 15%. Statistics show that the global yield of bio liquid fuel reached 23. 5 billion gallons (70 million tons), the newly increased

installed capacity of wind power was 38.1 million kW and the increased capacity of solar power was 7.3 million kW in 2009. The global investment of renewable energy heating and generating was around 150 billion US dollars that year.

The thirty years of opening and reform have step-by-step achieved the ambitious goals set at the earlier stage of the reform. However, the acceleration of industrialization and urbanization worsens the problems of energy and environment through excessive consumption of fossil energy for material fortunes. The global environmental problem, that is, the climate change, has become a common challenge for all the countries in the world and the sustainable development of energy is crucial in the economic and social development of our country. Renewable energy, which includes wind power, solar power, biomass power, hydropower, geothermal power and ocean power, is featured with wide distribution, great potentiality, small environment pollution and perpetual use and it is significant to the harmonious development of human beings and the nature. Strategies concerning, developing environmental-friendly renewable energy and making it play important roles in the energy supply security is the reasonable choice of China's sustainable energy strategy.

The 17th National Congress of the Communist Party of China proposed the idea of "strengthening the energy-saving, ecology-protecting and the sustainability of renewable energy". Besides, the notions of "developing clean energy and renewable energy" and "the remarkable increasing ratio of renewable energy" were also involved in the report. In October 2009, the General Secretary Hu Jintao pointed it out that in his inspection tour in Shandong that making great efforts to develop the renewable energy such as wind power created the necessary condition to grasp a position in the new round of energy resolution of the world. He hoped that renewable energy enterprises could seize the precious opportunities to concentrate on the scientific research of the front edge technologies, to constantly make breakthroughs in core and key technologies and to hold the high ground in future development. His words illustrated the long-last and great concerns for the renewable energy

cause of the leaders of both China and the Party.

The development of renewable energy relies greatly on the equipment manufacturing industry. The market of renewable energy technologies is a market of globalization and who grips the technologies will be control the market. The development and exploitation of the renewable energy stands comparison with a new world energy resolution. The global financial crisis triggered by the subprime crisis brought the opportunity of leap-forward development of renewable energy as well as the turmoil, the differentiation and the reorganization. The economic transfer aroused by the crisis is constantly stimulating the profound revolution in energy industry. Countries in the world rise to carry out economic stimulus plans with great efforts to recover the economic status. With the pressure of climate change, many governments have placed the energy industry, esp. the supports of renewable energy and clean energy, as the priority in the recovery plans of economic stimulus. America and European countries all increase their input in renewable energy technology development and exploitation through governmental investment plans. Great amount of government funds are used to support the advanced research of renewable energy technologies and the quick transfer of the technological achievements, leading again the trend of renewable energy development and exploitation.

The diversity of energy resources and low-carbon development is an irreversible trend. In spite of the small ratio of wind power, solar power and biomass power in our country's energy supply, we will make it one of the fundamental energies in thirty to forty years in the middle of this century, if we keep promoting the industrialization and the development in scale with persistent efforts. By then the energy supply security will be truly sustainable.

9.1.3 The Demanding Task of the Goal of 15% of Non-Fossil Energy in 2020

The energy structure of China has long been presided by coal and the energy supply relies heavily on high-carbon energies. With the extensive economy and high-level energy consumption, the country ranks first in the

GHG emissions in the world. At the same time, the accelerating development of industrialization and urbanization determines the increasing energy consumption in the next 20 to 30 years and the growing pressure of GHG emissions reduction. The development of renewable energy which is expected to offset the emission by high-carbon energy will effectively moderate the increasing pressure of China's GHG emission. The "National Plan for Coping with Climate Change" promulgated in 2007 and the "Resolution of Actively Coping with Climate Change by NPC Standing Committee" approved by the tenth meeting of the eleventh National People Congress Standing Committee made renewable energy development one of the main measures of addressing climate change.

The following 20 years, fast development and promotion of the industrialization and urbanization will be seen in the country. The upgrading of the residents' consumption structure such as housing and cars will drive the optimization and upgrading of the industry structure. The sustainable development of the industrialization will promote the urbanization. The economic growth still demands sufficient energy supply. Thus, the growth rate of total energy consumption of China in the long term in future will still remain fast. With the annual growth rate of energy 8% to 9% by 2020 and the 9% after 2003, the energy demand of 2020 will reach 8 billion tce which will unimaginably cover half of the current total consumption of the world. However, with active promotion of energy saving and emissions reduction, the energy consumption can decrease 20% of unit GDP for every five-year, which will largely decrease the demand of energy to 4.6 to 4.8 billion tce in 2020.

Research agencies in and abroad also start researches on the prediction of the energy demanded: a) 2030 National Energy Strategy of Scientific Development by National Energy Administration notes that in 2020 the energy needed will reach 3.8 to 4.9 billion tce. b) "Research on Medium-Long term Development Strategy of Energy" of Chinese Academy of Engineering with the base year of 2008 predicts the energy demand of 2020. Given the growth rate of GDP remains at 8% from 2010 to 2020, concerning the possibility of energy efficiency technology advancing and the industrial energy improve-

ment, the demand will be controlled at 4.03 billion tce with 5% annual saving rate through energy-saving policies of effective construction and transportation energy savings. c) The National Center for Science Information Systems, NDRC's energy research institute and Tsinghua University in recent years have also jointly done related predictions of the energy demand. Results show that with the normal economic trend and policies the annual growth rate of GDP will remain at 7.5% to 8.1% before 2030 and in 2020 the demand will be around 5 billion tce. d) International Energy Agency and the Energy Information Administration state that in the coming 25 years China's growth rate of GDP will remain at 6% to 6.4% with the annual growth rate of energy needed of 3% to 4%. By 2020, the total energy demanded will be over 4 billion tce.

Conclusion can be drawn through the research findings that with the economic growth rate of 8% to 9% before 2020, the annual growth rate of population of 0.54%, the annual growth rate of urbanization of 0.9% to 1% and the annual saving rate of 4%, the demand of energy in 2020 will be 4.7 tce.

Adhering to the Renewable Energy Law of People's Republic of China, NDRC established and promulgated the Medium-Long Term Development Plan for Renewable Energy of China in September 2007, proposing that in 2020 the renewable energy consumption will cover 15% of the total primary energy consumption. In addition, General Secretary Hu Jintao also stated the goal of making non-fossil energy 15% of the total primary energy consumption in 2020 during the UN climate change summit in 2009. It should be noted that the 15% goal raised was based on the total demand of 3.3 to 3.5 billion tce in 2020 when the developed resource of renewable energy is expected to be only 0.5 billion tce. Currently, the more scientific prediction is that in 2020 the energy demand will reach 4.7 billion tce. The goal of the 15% will be achieved only if the developed amount of renewable energy would reach 0.7 billion tce, that is, 0.2 billion tce more than the original plan.

To achieve the 0.7 billion tce target, by 2007, the installed capacity of grid-connected power generators will be increased to 0.15 to 0.2 billion kW

from the 30 million kW as the original plan. The installed capacity of solar power will be increased to 20 million to 40 million kW from 2 million kW. The capacity of biomass will remain at 30 million kW due to the resource limit. The installation area of solar power heating system will increase by 0. 3 billion m^3 than the original plan. The accumulated investment of renewable energy will also rise to 3,000 to 4,000 billion Yuan from 2,000 billion Yuan. Apparently, it will be a demanding and difficult task to achieve the goal of making non-fossil energy 15% of the primary energy consumption.

9. 2 The Strategic Position of Renewable Energy

The strategic positions of renewable energy are set differently among the countries in the world. It is a strategic measure to address the climate change for developed countries whereas for developing counties it is designed to solve the energy supply for rural and remote areas. General Secretary Hu Jintao noted in his address to the 2005 Beijing International Renewable Energy Conference that it was a must to promote the development and exploitation of renewable energy in our reply to the worsening energy and environment problems.

Despite the shortage of the regular energy resource, China plans to achieve the strategic transfer of energy resource to secure the long-term development of the country as well as to complete the task of modernization and the revivification by the middle of the century. Based on the long-term energy situations and the overall requirement of energy development strategy, the development of renewable energy is crucial in both energy reassurance and security of the country.

Concretely, developing renewable energy is of great necessity for implementing the Scientific Concept of Development, achieving the sustainable development of the economy and society, and building ecological civilization. It is the main approach to address the climate change and to promote the environment protection. It is an effective way to improve the energy structure, to achieve the diversity of energy supply, to guarantee the energy security, to

solve the energy supply for remote areas and to promote the economic restructuring and regional development. By no means will the complete restructuring of energy supply succeed without the development of renewable energy. In other words, the earlier it is developed, the earlier we can gain the initiative.

We should guard against two tendencies in the development of renewable energy which is a rising industry.

The first tendency is to make negative judgment against the current technologies, industrialization and the market bottleneck. it is believed that renewable energy will not play any important roles even in future. The energy, environmental and social values of renewable energy is underestimated.

The second tendency is featured with blind optimism but ignoring the difficulties in the development of new technology and rising industry. It focuses on the fast expansion of the industry instead of the technology innovation and quality, which are essential for leading the market. The industry is in danger of being misled by this rush approach.

It should be noted that both tendencies are prevalent in the market while the latter one seems to be stronger, seen from the waves of renewable energy development in different areas. The underestimation of the future value of renewable energy will miss the ideal opportunity of the industry while the ignorance of technology and quality will sure to bring more harms by hurting the staying power of the industry. What should be done is to clearly notice the features of renewable energy, to give necessary importance strategically and to properly estimate and acknowledge the arduousness and the protracted nature of the cause. The promotion of the development should be down-to-earth, step by step with great persistency.

9.3 The Strategic Goal of Renewable Energy

9.3.1 Overall Target

The strategic goal of renewable energy of China is that by 2020 the re-

newable energy will be one of the effective supplementary energies in the energy supply system, providing annually supply that is equivalent to more than 0.7 billion tce. The renewable energy will cover more than 15% in the total primary energy consumption. In addition, the current technologies will be grown by then with potentiality to develop in a larger scale.

By 2030, renewable energy will be dominant in newly increased energy system as one of the mainstream energies in the system. Renewable energy will supply annually power that is equivalent to more than 1 billion tce, covering more than 20% in the total primary energy consumption.

By 2050, the scarcity of the resource determines that fossil energy will be decreasing year by year instead of increasing. This requires the increase of renewable energy which is expected to be the main energy in the supply system. By then the renewable energy will contribute annually power that is equivalent to more than 2 billion tce, sharing more than a third in the total primary consumption and achieving a radical change in energy consumption structure.

China has abundant resources of renewable energy to guarantee the mainstream or even dominant position of renewable energy in the future. Though there is still a long way to go in China's estimation of renewable energy, and the existing results show that the country is facilitated with resource potentiality and assurance to develop renewable energy in a larger scale. The technology value of wind power resource will reach the scale of billions kW. A great part of the territory is endowed with abundant solar power. Compared with Europe, all of the areas in China are usable of solar power resource with a favorable condition that the solar power absorbed annually by the earth is equivalent to 1,700 billion tce. The biomass power in the country is also diversified with crop stalks, animal manure, forestry residuals, industrial organic waste, and urban organic waste and energy crops. Developing in accordance with local conditions, the potentiality of the resource can reach the level that is worth thousands of millions tons of standard coal. Apart from the above, the country also enjoys abundant reserves of geothermal power as well as oceanic power.

9.3.2 The Target of Wind Power

The development concept of wind power is "primarily developing the onshore and grid-connected, attaching importance to the distributed development and accelerating the industrialization." In the short-term the onshore wind power plant will be dominant and the key areas include the northwest, north China, the northeast and the coastal areas in the east. Specifically, these areas are Hebei, Inner Mongolia, Jilin, Gansu, Xinjiang, Jiangsu, Zhejiang and Shandong which are endowed with favorable conditions for large-scale wind power farms. For those areas limited by the landforms and grid conditions, wind power farms at small and medium scales can be designed in accordance to the localities. In short term, off-shore wind power farms will basically function as demonstrating projects including testing off-shore wind power plants built in Jiangsu and Shanghai to accumulate experience and technologies for larger-scale off-shore wind power farms in future. It has been predicted that as the technologies grow mature, it would be a better time for large-scale off-shore wind power plants from the year of 2015.

9.3.3 The Target of Solar Power

Great efforts should be paid in the thermal application technologies that integrate with building constructions in the field of solar power industry. The balance development of solar power-photovoltaic industry chain should be also attached great importance. Due to the sufficient developable areas for solar power, there are big markets for solar heating system in both urban and rural areas. The industry should be promoted with gradual use of mandatory policies so as to achieve the goal of 1 m^2 of solar power per person. Solar houses and solar cookers are of great use in the west especially in the rural and remote areas in the northwest and should be paid attentions.

Grid-connected solar power generation should be pushed forward. In the short-term, the primary task is to promote the roof grid-connected system in

large and medium size cities such as those in the Yangtze River Delta and the Pearl River Delta where photovoltaic industry is developed. The applications are also to be integrated with large-scale landmark buildings such as Asian Games venues in Guangzhou. The desert PV power plants will in short-term function as demonstrating projects. According to the plan, large-scale grid-connected PV system will be installed in Hexi Corridor, Qingzang Xian, Ningxia and the edge of Inner Mongolia desert when the technologies grows mature. These areas have the advantages of rich solar energy, miles of desert and they are adjacent to the miles of desert and the load center.

9.3.4 Application Goal of Biomass Energy

The technologies for biomass energy are diversified. The development of biomass energy should be with the premise of "not taking crops from the people, not taking land from the crops, not taking water resource from fields and not taking feeds from livestock" . As time goes on, biomass product that is non-grain-oriented and substitute to patrol-oriented should be the focus of the strategy. The biomass energy generation should be in accordance to the localities. Co-combustion technology for biomass energy, which is relatively mature, should be developed through encouraging the projects of co-combustion generation from both coal and biomass in areas that are favorable. As for the areas with abundant forestry waste, co-generation and heating project of environmental-friendly biomass with high efficiency and small-medium scale projects should be advocated. The projects of biomass gasification generation and the concentration of methane from farms should be promoted so as to accelerate the development of rural biomass energy generation in distributed pattern.

The non-grain-oriented technology of biomass transportation fuel should be developed in an active and steady way. In short term, when sufficient resources as the premise, non-grain-oriented ethanol fuel and biodiesel should be focused with the basis of experimenting and testing. According to the actual localities, the cassava should be the original materials in Guangxi and Hunan; sweet sorghum which suits saline-alkali fields should be the material

for ethanol fuel project in Shandong, Heilongjiang, Inner Mongolia and Xinjiang and the Jatropha should be planted in Sichuan, Yun'nan and Guizhou to serve the biodiesel projects. The medium-long term task is to develop the second generation of bio-liquid fuel, car-use methane and biomass-oriented industrial products in areas with resource advantages. Biomass solidification fuel should be developed in suburb areas and the areas between the urban and the rural. With the premise of meeting the demand from rural areas, it can also serve as the substitute fuel for urban use.

9.4 Major Problems in Renewable Energy Development

Currently, the major problems faced by renewable energy development are still the high cost and low competitiveness of the market. With no regard to the external environmental cost of the regular energy, except the solar power heating system, most of the products of electricity, heating and liquid-fuel by renewable energy are featured with higher cost than that of regular energies, which is a serious drawback that makes the self-commercialization difficult in the economic competition. The radical way to lower the cost and to make it competitive in the market is to promote and improve the industrialization and development in scale of the renewable energy industry. However, this approach is challenged in the follow aspects.

9.4.1 The Immature Market and the Insufficient Support Capabilities

In spite of the hard works done in the market construction of renewable energy, there are still many problems remaining. Concretely, the insufficient understanding of the strategic, protracted and arduous features of the market; the lack of the recognition of the society and the developing market environment due to the high cost and other product features, for example, the way that the power grid receive the renewable energy power; patrol enterprises and households' suspicions towards bio-liquid fuel purchasing and the building developers' objections to the use of solar power heating system.

9.4.2 The Incomplete Policy System and the Inconsistent Measures

Though China has carried out the renewable energy law which determines a relatively complete requirement for regulation building, the policy measures do not go in consistency with the regulation building, which cannot meet the demand of renewable energy development. Problems existing are a) The special planning and roadmaps for renewable energy development are not worked out in time and there is still a lack of clarified leading mechanism for the target planned. b) The lack of supervision for the market which defines the responsibilities, rights and obligations of energy monopolies. c) The lack of a coordination mechanism to be in charge of planning, approving, special funding arrangement and pricing. d) The lack of transparency of the planning, goal setting and project decisions making. e) The lack of report of law enforcement and the system of supervision and self-improvement. f) The lack of coordination mechanism and policies for the development of renewable energy and the social-ecology-environment protection. Specifically, there is the need of corresponding policies for migration, land use and ecology protection for hydropower and biomass power projects.

9.4.3 Insufficient Input for Technology Development and the Incompetent Innovation

The tasks of lowering the cost and removing the limitation of external supporting condition such as power grid rely largely on the constant technology innovation and the application of industrialization. Though China has improved in the key technology application and innovation, the overall level is still left behind by the developed countries. Specifically, a) The basic research of renewable energy is weak; the basic research and innovation were started late at a low level; PV and cellulosic ethanol industries, for example, are in the lack of technology support for large-scale development. b) The lack of a strong supporting platform for technology research. There is not any country-level laboratory or public research center for renewable energy to supply

with basic research and public technology services for the industry. c) The lack of a clear and systematic development route and long-term development concept and the lack of a continuous and cycling investment plan for technology research. d) The shortage of funding for research in both governmental level and the industrial level.

9.4.4 The Weak Industry Structure and the Incompetent Supporting Abilities

The fast development of the industry in recent years owes to the sufficient investment from both in and abroad. Technologies concerning, China is inferior to the most advanced countries with its incompetent products. In terms of key techniques, equipment and original materials supply, the industry relies heavily on imports, being subject to the technological monopoly of other countries, for example, bearings of the large-scale wind power turbines, core production device for solar power cells and the highly efficient bioenzyme for cellulosic ethanol. Though the years' of works have improved the situation, the weak industry system still remains the major problem for the industry development in long run.

9.4.5 The Superficial Resource Assessment Limiting the Scale Development

The estimation started and statistics gained in the renewable energy resources are not qualified for the energy development and exploitation in high efficiency and scale. The resource store quantity and distribution data are both roughly drawn from the observations in the existing meteorological stations, featured with limited completeness, reliability and usability. These data can support only part of the need in related strategic plans and implements of some development and exploitation projects. In the aspect of resource estimation of biomass power, currently the data collected in resource store of agriculture, forestry and industrial waste is only at its paper talk stage. There is still a lack of systematic research and supporting data in the fields of usable lands, traits

of qualified energy plants, usable water condition and biodiversity. Data for geothermal energy and oceanic energy are also rough.

9.5 Major Measures to Promote Renewable Energy Development

Renewable energy development, which is considered as a long-term strategic task of our country, should be carried out with persistence. A complete framework of policies and the system is necessary for the long-term, active and steady support for the industry. To satisfy the domestic demand and build an industrial system with world-class competitiveness, efforts should be paid in strengthening legislation, building improved policy framework, emphasizing basic research and establishing a complete service system including talents training so as to promote renewable energy development in an all-round way.

9.5.1 National Legislation and Medium-long Term Development Planning

Experiences of the international community tell that countries of developed renewable energy industry such as Germany, Spain and the US are all facilitated with strong legislation and legally binding actions plans. The industry develops in the lead of law which secures the market and technologies.

The renewable energy in China borrows the experiences of these advanced countries and combines them with the locality of China. The crucial position of renewable energy in the sustainable development of the society and economy has been clarified, making a base for a complete framework of renewable energy laws and showing to the world the resolution of developing clean energy and addressing climate change actively. The Renewable Energy Law has been functioning actively in the renewable energy development in the past four years since it was promulgated, driving forward the cause into a new historical stage.

Adhering to the Renewable Energy Law, China in succession promulgated the "Medium-long Term Renewable Energy Development Plan" and the "Renewable Energy Development Plan during the 11th" Five-Year Plan. However, owing to the weak resource base when the plans were made and the fact that renewable energy is an emerging industry with rapid change, the plans promulgated are not scientific enough to some extent. Besides, there is a contortion with the plans of the overall energy and other electricity power. On December 26th, 2009 the NPC's Standing Committee ratified the "Amendment of Renewable Energy Law" which was an improved version of the original one. The healthy development of the industry requires scientific planning, sensible designing and the independent assessment mechanism for supervision of the law enforcement on the basis of the revised law.

Table 31 The Plan of the Renewable Energy Covers 15% of the Primary Energy Consumption in 2020

	Year 2020			
	Scale		Annual Output	
1. Electricity Generation	65,600	10 thousand kW	23,350 (100 million kWh)	70,200 (10 thousand tce)
Hydropower	30,000		11,000	
Grid-connected Wind Power	20,000		4,400	
Photovoltaic Power	5,000		750	
Biomass	3,000		1,500	
Nuclear	7,600		5,700	
2. Gas Supply		100 million m^3	175(100 million m^3)	1,056
Livestock Manure	138			988
Straws Gasification	37			68
3. Heating			8,000 (10 thousand m^2)	
Solar Power heating System	80,000	10 thousand m^2		9,600
4. Bio-liquid Fuel			1,200 (10 thousand tons)	
Ethanol Fuel	1,000	10 thousand tons		1,025
Biodiesel	200	10 thousand tons		286
Total				82,167

9.5.2 Regulations and Relevant Supporting Policies

Renewable energy development in its initial phase is featured with low

market competitiveness so that the political measures are essential. To promote the renewable energy development, the countries in the world encourage the business through mandatory market shares, purchasing at fixed prices and favorable tariff policies.

Since the promulgation of the Renewable Energy Law, more than 20 related policies have been carried out by the NDRC, Ministry of Finance, Ministry of Construction, State Electricity Regulatory Commission, and the National Standards Committee. These policies, which concern allowance for electricity price, fees splitting and investment subsidy, establish primarily the framework of renewable energy policies, promoting the improvement of the industry. However, up till now the law only defines the purchasing relationship between power generation enterprises with grid companies and there is still a lack of regulating methods for government's mandatory quotas for power grid companies. The purchasing relationship defined earlier is meaningless without any changes of the current situation.

Besides, an overall consideration for the use of the added revenue from electricity prices is in need. The diversity of renewable energies, resource stores, technology types, the industrialization levels and management departments makes the supporting regulations and technology standards setting complex. So it is of necessity for the relevant departments to function on the specific goals, resource stores, technologies and industrializations of different energies. Policies and measures for pricing, practical generation quotas, favorable investment mechanism, complete regulations, standards and testing and renewable energy funding should be improved.

9.5.3 Basic Research and Independent Technology Development

Basic research and technology development are the keys to keep the competitiveness of the rising industry. Renewable energy, as a technology-oriented industry, should be paid more attention on its abilities of basic research as well as the innovation of technologies. Currently the countries which are advanced in renewable energy development are all backed by the cultivation of basic research and technology innovation. For example, the

United States established the National Renewable Energy Laboratory, which specializes in the technology research and takes a lead of researches all over China. Denmark owns the largest wind power enterprise in the world Vestas of which the core technologies are contributed by the national laboratory RISOE. The country-level laboratories integrate the technologies with the industry, promoting the country's innovation as a whole.

Led by the Renewable Energy Law and the supporting policies, China has established the industry system through introducing, assimilating and absorbing the technologies abroad. It should be noted that most of the core technologies are imported. Independent innovation, technology upgrading and talents grooming are crucial to the fates of the new energy industry of the countries in the world as the industry is being concerned by the world and stepping into a competitive phase in the international market. At this, it is a must to enlarge the input which includes establishing talent tanks, experimental wind power farms, and public testing platforms for supporting the basic research and innovation so as to enhance the technological level.

9.5.4 Cultivation of Innovative Talents

As an emerging industry, renewable energy industry creates job opportunities for many countries. On the one hand, these countries build up high-level talents tank through basic research, promoting the technologies and the improvement of the industry. On the other hand, the enlarging scale of the industry creates new jobs and becomes a crucial part in the economic growth.

The cultivation and gathering of talents for the new industry is time-consuming. Though China has established a talent base in new energy such as wind power area, most of the technicians are professionals in related areas without systematic studying and training on the technology. Besides, there is a lack of compound talents who can deal with both high-end technology development and management and who are the keys to the solving of technological bottleneck. The shortage of talents and talents store has become the major problem that confines the sustainable development of the

new energy industry. The talents cultivation should be given the first priority in the industry development by integrating the national innovative teams and the innovation abilities building. Efforts must be paid to groom decision-making talents of strategic visions and talents of high-end technologies. Pace-setters of national levels, technological talents of company levels are both the supporting forces for the healthy and independent development of the new energy industry of the country.

9.5.5 Enhancing International Cooperation

Renewable energy development, as a crucial measure to address the global climate change, needs joint efforts of the world beyond nationalities. Though China is endowed with abundant resources, the development of the resource demands high technologies and depends on the development of equipment manufacturing industry. The renewable energy market in the future will be a market of the world.

Thus, it is of extreme importance to cooperate with other countries. We should positively join the international energy organizations and agencies with world influence after reasonable analysis, for example, the International Renewable Energy Agency which has involved more than 130 countries. We must exert influence and grasp the first chance to share the market in case that there are new regulations in the future renewable energy markets.