CHINA: PROSPECT FOR RENEWABLE ENERGY DEVELOPMENT

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Abstract

Renewable energy is playing and will continue to play an important role in future energy structure all over the world. China government has consistently promoted the development of renewable energy since 1980s. And in the past ten years renewable energy has developed rapidly. In 2005, renewable energy provided 8% of total energy consumption, excluding the traditional use of biomass energy, and renewable power provided near 16% of China's total electricity output[2]. Following the effectiveness of Renewable Energy Law in 1st of January 2006, renewable energy industries have been become one of the hot points, and the development of renewable energy in China will also make a great contribution to the climate change alleviation in the world. The following of this paper presents the development status, legislation and CDM for renewable energy in China.

1 Wind Power

1.1 Resource availability

With its large land mass and long coastline, China has relatively abundant wind resources. According to estimates of the China Meteorology Research Institute, land-based, exploitable wind resources represent a potential power generation capacity of 253 GW. (Note: This estimate is based on wind resources at a height of ten meters above the ground.) The institute has further estimated ocean-based wind resources to represent an exploitable potential of about 750 GW. Thus the total estimated wind power potential of China is about 1,000 GW. From 2003 to 2005, UNEP financed and supported the Solar and Wind Energy Resource Assessment Project, and calculated the wind resources of one-third of total Chinese territory with models and concluded that the total wind resources in China is over 3TW in land at a height of ten meters above the ground[3].

[1] Li Junfeng and Shi Jingli come from the Energy Research Institute, Ma Lingjuan comes from China Renewable Energy Industrial Association.
[2] Li Junfeng and others, Renewable energy development status report 2004-2006
[3] UNEP report for solar and wind resources assessment, 2005

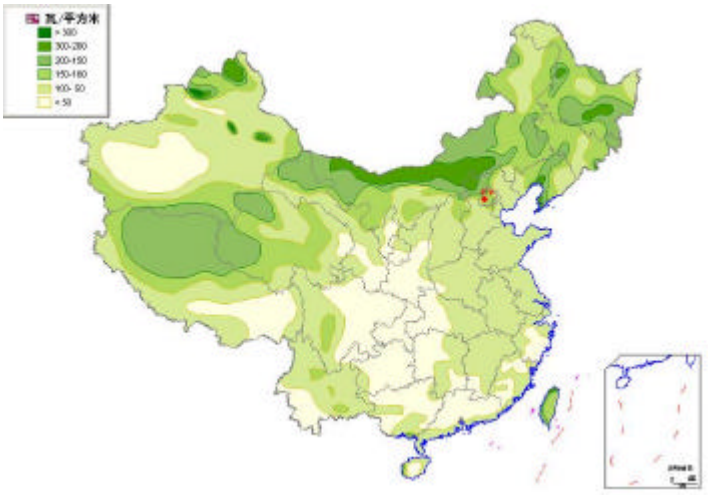

Figure 1 Distribution of wind resource in China

1.2 Market status

By the end of 2005, there were over 60 wind farms distributed in 15 provinces in China, and total grid-connected installed capacity of wind power was 1266 MW (excluding Taiwan). Most of the wind turbines' size ranges from 600kW to 1.5MW. 504MW were installed in 2005, and the annual growth rate was 66% compared to that of year 2004. Currently, China is on the seventh position in the world in terms of total installed wind power capacity. Aside from the grid-connected installations, China also has over 200,000 stand-alone small-scale wind turbines (with installed capacity of 40 MW) that provide electricity to rural households located in remote areas[4].

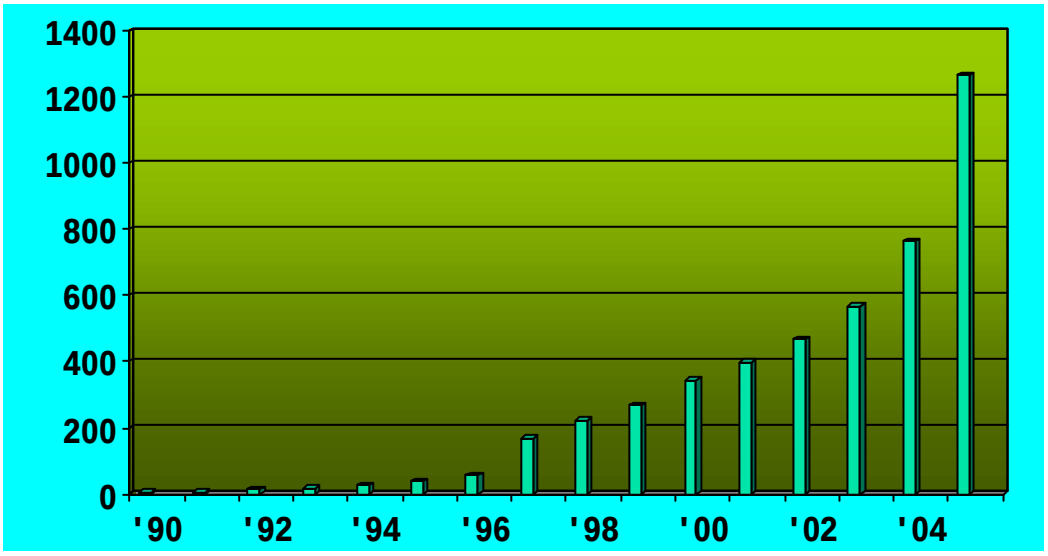

Figure 2 Installed capacity of wind turbine in China (MW)

[4] Shi Pengfei, presentation at the Wind Policy Forum, March 27-28, Beijing China

1.3 Industry status

At present, there are over twenty manufactures in wind power sector in China. Basically China has fully mastered the manufacture of large-scale wind turbines of 750 kW or less and is in the process of developing megawatt-scale turbines. Several sample turbines are installed and in operation in 2005, with capacity of 1.2MW and 1.5MW. However, compared with international advanced technologies, there is a great gap in the design and manufacturing of large wind turbines. China has mastered wind farm operation and management. The nation now has qualified technical personnel in the areas of wind power design and construction, however, compared with the large demand of wind power development in future 15 years, the personnel is not enough. Basically, a sound base for developing large-scale wind power in China has been developed.

Figure 3 Installation of domestic 1.2MW wind turbine in 2005

Figure 4 Wind farm in China

1.4 Development potential

Wind power is one of the renewable technologies that can be applied in large scale in near future as it is in the stage of near-commercialisation. According to the development plan of renewable energy made by the Chinese government, the target of large scale wind turbines is 5GW and 30GW in year 2010 and year 2020 respectively. Furthermore, it is predicted that the total capacity will reach 10GW possibly, considering current wind projects planned by wind farms' developers. By 2020, it is predicted that the cost of wind power will be the same as that of coal power in China. And after 2020, wind power will be in entire commercialised stage and will develop more rapidly. In 2030, the total capacity will reach 150-200GW, and can become the third power resource (behind coal and hydro) in China[5].

2 Solar PV

2.1 Resource availability

China has extremely rich solar energy resources. According to estimates, the total solar radiation hitting China's land area annually is 5 x 10^{22} J, equivalent to about 1700 billion tons of standard coal equivalent (tce). In particular, areas on the Qinghai-Tibetan Plateau receive the largest amounts of solar radiation in all of China.

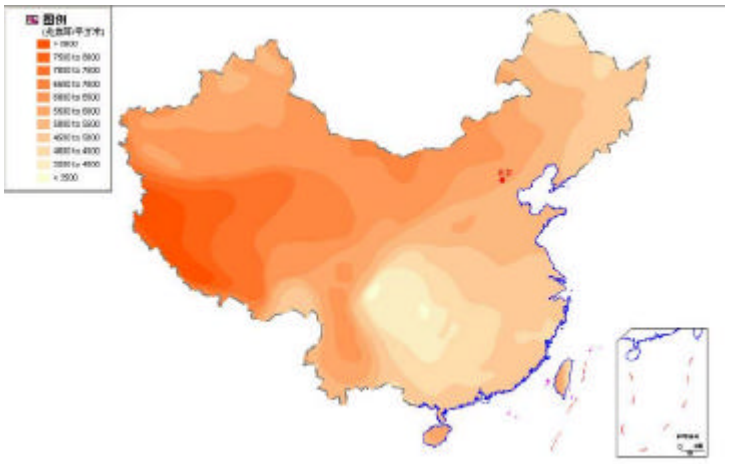

Figure 5 Distribution of solar resource in China

2.2 Market status

Photovoltaic technology (PV) is the main technology used in China for the generation of electricity from solar energy. PV modules are used in both industrial and commercial applications and provide electricity to remote rural areas and urban lighting applications. By end of 2005, China's installed capacity of PV systems in over 70 MW, of which about 50% is used to supply electricity to the residents of remote rural areas, a market that is growing at 20% annually. From 2002 to 2004, China implemented a project of

[5] Li Junfeng & others, Wind-12 in China, 2005

Songdiandaoxiang (renewable village power), and PV systems with capacity of 17MW were installed. At present China has began the demonstration of roof grid-connected PV systems apart from the independent PV systems in remote areas without accessing power gird and the total capacity is 2W. The biggest grid-connected PV station is tin Shenzhen with capacity of 1MW[6].

2.3 Industrial status

Since 2000, PV industry is at a rapid development stage in China, and the total production capacity of PV module increased from 20MW to over 200MW in 2005, and it is expected that the production capacity of PV modules will reach 300MW by the end of 2006. However, the raw silicon production in China is too short and only 200 tons per year. Therefore, there is still a certain unbalance in the PV industry.

Figure 6 Grid-connected PV system in China

2.4 Development potential

Solar energy is a clean, safety, reliable energy source and it is taken as one of major energy source after 2030 in the world. According to the distribution of solar resource in China, except Sichuan basin and its neighbour areas, most areas are with rich solar energy resources. Once the PV power cost is competitive, it will be an important replacing power as it is with potential of hundreds GW. In the near term (before 2010) in China, the major utilization of solar PV will still be to provide power in remote areas and for industry use, and simultaneously, gird-connected PV will be in a stage of demonstration, for setting up several MW stations. The total capacity will be 350MW. In the middle term, grid-connected PV including roof systems and desert systems will be the main utilization and will contribute more in the renewable power structure. The total capacity will be at least 2GW. From the point of long term development, solar PV has the resources of power of hundreds million kW and can become one of important replacing strategy energy in

[6] Wangsicheng, presentation on the APEC Renewable Energy Forum, September 27-28, Beijing, China

China.

Figure 7 3D of PV system of Beijing Olympic Building

3 Solar Thermal

3.1 Market status

China is with the largest solar water heater market in the world and the industry is also in the first site. Solar water heater is one of renewable technologies that are in commercialisation stage in China. The accumulated installed capacity of solar water heaters by the end of 2005 was 80 million square meters of collect area, with an annual increase rate of 27% in the passed ten years[7]. At present, about 9% families are equipped with solar water heater systems. Presently the issues associated with integration of solar water heaters into buildings have already attracted strong attention from relevant national-level and local government departments, architects and real estate developers, and solar water heater integrated building is the developing trend in this field.

Figure 8 Solar water heating system on roof in China

[7] Li Junfeng & others, a presentation on the Renewable Energy Financing Forum, March 30-31, Beijing, China

3.2 Industrial status

The production capacity of solar water heater in China is 15 million square meters at present, with an annual increase rate of 28% in ten years since 1995. There are over 1000 enterprises and the employees are over 150,000[8]. China is with advanced technology of all-glass vacuum-tube, and this kind of collectors are becoming the main utilization in the market. In 2001 and 2002, three new national standards and three new industry standards for solar water heaters were developed with implementation beginning in 2002. Together the old and new standards are the first step in the development of China's solar water heater standards system. They provide a technical and regulatory basis for the development of the industry and standardization of the market.

3.3 Development potential

In 2020 and 2050 the total installed capacity could reach 300 million and 500 million square meters respectively, with the potential to conserve 180 billion kWh in 2020 and 300 billion kWh in 2050. Potential reductions in peak power loads resulting from these installed capacities would be 120 GW (2020) and 200 GW (2050).

4 Hydropower[9]

4.1 Resource availability

Water resources appropriate to small-scale hydropower are plentiful in China. According to the results of China's latest hydropower resource survey in 2003, the potential total capacity of hydropower that could be feasibly developed in the country is 400 gigawatts (GW), in which small hydropower is 125GW. The resource base is widely distributed, including sites in over 1,600 counties (or cities), spread over 30 of China's provinces (or provincial-level municipalities).

Figure 9 Hydropower station in China

[8] Shi Lishan and others, China's Solar Thermal Industrial Review, 2005.
[9] Li Junfeng & others, Introduction of Renewale Energu Law, 2005, Beijing, China.

4.2 Market status

Hydropower has already played a very important role in China electricity power system, and in 2005, hydropower provided 23% electricity capacity and 15% electricity power. The Chinese Government has implemented policies that strongly support hydropower, especially for small hydropower, which has been included in Chinese rural electrification plans. About one-third of China's counties rely on small-scale hydropower as their main source of electricity. China has further made the building of small-scale hydropower stations a critical component of rural energy development in the Western China Cropland Conversion Program and the Western China Energy Development Program, providing special funds derived from Government bonds for small-scale hydropower development. At present, existing small-scale hydropower stations, with an installed capacity of 50 GW, represent about 40% of the total projected potential capacity.

4.3 Industrial status

China is the leader in the fields of design, engineering, management and facilities manufacturing of hydro-power in the world. At present, China has the ability for manufacturing 700MW hydro turbines. Furthermore, an entire system of planning, design, engineering, operation and management has been set up.

4.4 Development potential

Hydropower will continue to play an important role for Chinese power supply. According to the national targets, the capacity of hydropower will reach 180GW in 2010, and 300GW in 2010 accounting for about 30% of China's total installed power capacity at that time.

5 Biomass energy

5.1 Resource availability

China's main biomass resources are agricultural wastes, scraps from the forestry and forest product industries, and municipal waste. Agricultural wastes are widely distributed. Among them, the annual production of crop stalks alone surpasses 700 million tons; and crop stalks suitable to energy production are estimated to represent a potential of 300 million tons, equivalent to 150 Mtce annually[10]. Scraps from forestry and forest product industries represent a resource equivalent to 200 Mtce per year. Furthermore, with the implementation of China's Natural Forest Protection Program (which includes logging bans and logging reductions over much of the nation's natural forests) and its Sloping Cropland Conversion Program (which calls for the conversion of much of the nation's sloping cropland to trees and grasses), it is expected that the amount of scraps from forestry and forest product industries used in energy applications will increase substantially, with the potential of reaching 300Mtce per annum by 2020. Wastes from the processing of agricultural products and manure from livestock farms in theory could yield

[10] Same note one.

nearly 80 billion cubic meters of biogas. Municipal waste in China is expected to reach 210 million tons per annum in 2020. If 60 percent of this is used in landfill methane applications, two to ten billion cubic meters of methane could be produced. Finally, “energy crops” are a biomass energy resource with the potential for commercialization. There are many types of energy crops that are suitable to grow in China. Chief among these are rapeseed and other edible oil plants and some plants that grow in the wild, such as sumac, Chinese goldthread, and sweet broomcorn. By 2020, such crops could potentially yield over 50 million tons of liquid fuel annually, including over 28 million tons of ethanol and 24 million tons of bio-diesel.

5.2 Market status and industry development

At present, biomass energy resources in China are utilized mainly through conventional combustion technologies. Biomass gasification, biomass liquefaction, and biomass power generation technologies, however, are gradually being developed. For gasification, the main method being promoted and used is anaerobic fermentation, at the same time technology for the direct gasification of biomass resources is being developed. China currently has a total of over 17 million household biogas digesters and over 1,600 industrial-scale biogas plants, which together produce over eight billion cubic meters of biogas annually. In terms of biomass liquefaction technology, China is in an investigative and experimental phase. Currently the main technologies developed and in use are ethanol fuel technology and bio-oil technology. China has already established two ethanol fuel production bases, one in the north and one in the south with a total annual production capacity of over one million tons, and ethanol fuel are used in nine provinces. Production of bio-oils in China has reached about 500,000 tons annually. Biomass power generation in China, with an installed capacity of almost 2,000 megawatts (MW), consists mainly of combined heat and power (CHP) in sugar mills and power generation using rice husks. Other types of biomass power generation, such as that achieved through biomass gasification or hybrid fuel technologies, have not yet reached significant scale in China.

Figure 10 Biogas project of food process factory in China

5.3 Development potential

In 2005, the total installed capacity of biomass power generation was 2GW, with power generation of 8TWh. It is predicted that the capacities will reach 5.5GW and 30GW, with 20TWh and 120TWh of annual power generation in 2010 and 2020 respectively. Furthermore, the potential for biogas utilization will be 19 billion cubic meters and 44 billion cubic meters in 2010 and 2020. The biomass fuel capacity will also reach 2 million tons and 10 million toms.

6 Other renewable energy

Besides biomass energy, wind power, hydropower, and solar energy, which have all been developed on a relatively large scale in China, the Chinese Government has been paying closed attention to the development and utilization of other renewable energy resources, such as geothermal resources, ocean energy sources, and hydrogen. The Government has set up several pilot projects and demonstrations in geothermal power generation, wave power generation, geothermal heating and cooling and other areas. Geothermal pumping technology, in particular, has already begun to play a meaningful role in building energy conservation in China.

7 National legislation for promoting renewable energy

7.1 Renewable legislation[11]

The Government of China has been attaching great importance to the development and utilization of renewable energy for many years. In the 1980s, the State Council issued several Recommendations on Promoting the Development of Rural Energy, which made renewable energy a part of the plans for the development of rural energy and rural electrification. With the maturation of renewable energy power generation technologies, particularly wind power technologies, in 1994, the then Ministry of Power issued Several Recommendations on the Construction and Management of Wind Farms, establishing a firm foundation for wind power in China. In 1999, the Chinese Government issued Several Policy Recommendations on Promoting the Development of Renewable Energy, making further progress in removing barriers to the development of renewable energy. In 2003, the Government began to set about formulating its Promotion Law for Renewable Energy Development and Utilization. The goals of this law are to: (1) confirm the important role of renewable energy in China's national energy strategy; (2) remove barriers to the development of the renewable energy market; (3) create market space for renewable energy; (4) set up a financial guarantee system for the development of renewable energy; and (5) and

[11] Shi Jingli and others, Renewable Energy Legislation in China, a presentation at Shanghai Renewable ? nergy Forum, July 12, 2005, Shanghai, China

create a social atmosphere conducive to renewable energy. The basic principles of the law reflect the integration of: (1) citizen obligations and Government responsibilities; (2) Government promotion and market guidance; (3) present needs and long-term development goals; and (4) international and domestic experience. Through the means of this legislation, the following critical systems are set up: (1) a system of Government responsibility, requiring the Government to formulate development targets, strategic plans, and guarantee measures for renewable energy; (2) a system of public cost sharing (realized by a grid cost-sharing system), whereby all citizens will be required to share the extra costs associated with developing renewable energy; and (3) a system of punishment and reward, which will encourage the entire society, particularly companies, to develop and use renewable energy, and will punish financially those companies and individuals that do not meet the obligations set out for them in the law. China Renewable Energy Law was issued on Feb. 28th, 2005, and ii has been effectiveness on 1st of January, 2006. As the Law is relative in principle, at present, suggested by the national People's Congress and acquired by the State Council, several related governmental commissions and ministries are drafting the detail regulations for the Law's implementation, including the Management Measure of Renewable Power, Regulation on Renewable Power Price and Price-sharing, Guideline of Renewable Energy Industry Development, Management Measure of Renewable Energy Fund etc., and several necessary related standards are also in preparation.

7.2 Planning & strategy development[12]

At present, the Chinese Government is in the processes of formulating its Medium and Long-term Energy Development Strategy and Plan to 2020. This work will set forth the basic principles, strategic targets, and relevant guarantee measures for renewable energy in China up until 2020. The basic principles of the energy strategy and plan as relates to renewable energy are as follows:

- Support the harmonious development of society, the economy, and the environment, with priority on the development of renewable energy technologies that are closely related to the realization of achieving China's goal of a basic level of comfort for all citizens. These technologies include mainly PV, small hydropower and other renewable energy technologies, which can resolve the basic needs for electricity in rural areas. This principle also calls for improvement in the quality of energy used by rural residents, which can be achieved through biomass energy technologies, particularly biogas technology, which can promote the development of ecological agriculture and organic food products.
- Stress should be put on the development of small-scale hydropower, solar water heaters, geothermal heating and other renewable energy technologies that are already competitive on the market. The share of renewable energy in

[12] Song yanqin & others, report to EWEA, 2005

overall energy consumption should be raised as rapidly as possible, so as to make a strong contribution to the adjustment of China's energy consumption mix.

- The commercialization of new and developing renewable energy technologies should be promoted actively. In particular, wind power and biomass power generation, for which resources are vast and commercialization prospects good and which both can play a very important role in improving the structure of China's energy mix in the future, should be promoted through adoption of necessary measures to stimulate market demand, technical progress, and growth of manufacturing capability.
- Long-term technical progress should be integrated with short-term development and utilization. Renewable energy technologies that have both a market at present and great potential for the future should be actively developed. PV technology should be developed so as to serve in speeding up the realization of rural electrification in the short term and to accumulate technical results for large-scale grid-connected PV in the future. Ethanol gasoline and bio-diesel technologies should be developed through pilots and demonstration projects in the short-term to establish the necessary basis for future development; and strategies and technologies for long-term development should be pursued, so as to realize large-scale use and the supplementing of China's insufficient petroleum supply.

The strategy for renewable energy development in the Government's energy plan calls for making use, by 2020, of most of the available resources for small-scale hydropower, solar thermal (i.e. solar water heaters), geothermal, and other renewable energies that are already competitive on the market. It further calls for actively promoting the commercialization and development of related manufacturing capacity for wind power, biomass power generation, and solar energy-based power generation, so as to basically realize full commercialization and large-scale application by 2020.

7.3 Economic incentives

Although there is no comprehensive financial incentive system for the development of renewable energy in China at present, government support has been provided for a long time. In 1990s, with the emphasis on environmental protection and sustainable development, the government reinforced its support for renewable energy. The technologies receiving support were extended from small hydropower, biogas and fuel wood saving stoves to wind power, solar energy, including photovoltaic (PV) power and biomass utilization technologies and so on. The types of support changed from supply subsidy to tax reduction or exemption, preferential price and credit guarantee, etc. These measures have contributed greatly to the renewable energy development in China. However, compared to the support needed for reaching the ambitious target mentioned above, these measures are not systematic and strong enough. Therefore, it is necessary to improve renewable energy policy in conjunction with the Promotion Law for Renewable Energy based on the analysis of the existing policies taking into

consideration of the local condition and experiences of other countries to reach the development plan. The major financial incentives that are in existence are as follows:

Subsidies: Subsidies, which are provided by the central and local governments, are one of the most popular economic incentives for renewable energy development in China. The following are the major subsidy measures taken:

- **Management support**: This mainly refers to operating expenses and other expenses of renewable energy managerial institutions in several commissions of the central government. There are about 100,000 staff at different levels for the management, R&D as well as training, equipment certification, inspection, etc for renewable energy development, especially for the rural energy application. Assuming 20,000 Yuan per staff per year, the total administration cost was about 2.0 billion Yuan, which was a big subsidy for renewable energy development.

- **R&D:** The central government subsidies R&D on key renewable energy technologies through National Development and Reform Commission (NDRC) and Ministry of Science and Technology (MoST) as well as local government. For example, R&D funds on renewable energy offered by MOST during the Ninth Five-Year Plan period was 60.0 million RMB Yuan. While during the Tenth-Five-Year Plan period, it increased to 200 million RMB Yuan. In addition, by Most, the central government also supports the R&D of renewable energy technologies through national programs including 863 program (which is for the near-commercialization technologies) and 973 program (which is for fundamental technologies). Therefore, the total fund for R&D of renewable technologies through MOST was 1 billion Yuan. Furthermore, there are some subsidies for demonstration projects and training courses by NDRC, Ministry of Finance (MOF) and MOA.

- **Investment subsides**: Central government and some local governments provide the investment subsidies for the development of renewable energy through several big national programs, for example, rural small hydropower program, rural household biogas program, and providing subsidies to small scale PV systems and wind systems in remote areas. One of large project with investment subsidy was the Township Electrification Program implemented in 2002-2003, and the central finance and local finance provided over 4 billion Yuan to install over 1000 renewable village power systems, to meet the power needs of public utilities and residents of un-electrified townships in remote areas. The central government also supports the development of renewable energy using the money of National Debt. For example, in 2000, the former State Economic and Trade Commission (SETC) implemented the National Debt Wind Program, by using the special fund of forth-national-debt, to support the installation of wind farms of domestic wind turbines. The Mnistry of Water Resource (MWR)

provided low-interest loans of about 300.0 million RMB Yuan for small hydropower development during Nine-Five-year period. Besides, the government also provided interest subsidies (50% of commercial bank loan interest) to some government approved renewable energy projects. In the end of May, 2006, the Ministry of Finance, published a special document to indicated that a national special fund to be set up to support the development of renewable energy technologies. However, the documentation did not mentioned how much of money will spend for this purpose.

- **Taxation:** Based on collection and distribution rights, tax can be classified as central government tax, local Government tax and shared tax. Following the implementation of the new tax sharing system introduced in January 1, 1994. Taxation for renewable energy in China can be classified as shown in the table 1. For example, VAT (value added tax) is about 17% in general, however, favorite taxation rate can be applied to some renewable energy, such as wind, biomass and small hydropower. VAT reduction made a great contribution for the price of renewable energy power. Take wind as example, there is about 0.05-0.07 Yuan per kWh to be reduced, according with the cost different in the various wind farms.

Table1. Classification of Taxation in China

Items	VAT	VAAT (Value-added annex tax)	Income Tax
General	17%	8% of VAT	33%
Small hydro power	6%	8% of VAT	33%
Biogas	13%	8% of VAT	15%
Wind	8.5%	8% of VAT	15%
Landfill gas	0	0	33%

Note: The VAT on wind power and urban refuses for power are newly issued in early 2001.

- **Custom duties:** To be consistent with the international market, import customs duty in China has been adjusted several times, and the average duty has been decreased to 23%. Although there is no specific government document that clearly states low customs duty rates on renewable energy products, the main components of wind turbines, wind turbines themselves, and PV modules all enjoy favorable customs duty rates. In 1980s and early 1990s, the applications to reduce or exempt customs duty on wind turbines and related equipment imported with international assistance were all approved so that the actual duties paid were very low. However, this policy may not be applied to all renewable energy equipment importation and it depends on the kind of equipment to be imported. Customs duty exemption depends on whether the equipment is considered high-tech. Some renewable energy equipment such as power generator for biogas or some component of wind turbine is classified as high-tech and therefore is exempt from customs duty.

- **Pricing:** recently, NDRC (National Development & Reform Commission) issued a new document[13] for pricing renewable energy for power, which indicated that a feed in tariff system will adopted for all the renewable energy power. For example, the biomass for power's price will be calculated as coal fired power price plus 0.25 Yuan per kWh, wind power will adopt the tendering price and lowest bidder's price will be used as the fixed power purchase price for 30,000 hours and solar as well as other renewable energy price will adopt the project based approval price.

7.2 Effectiveness of national legislation and target[14]

The renewable energy incentives and national target make a great contribution for the renewable energy development. In fact, China became one of the leader countries for renewable energy development. For example, due to the national financial subsides for small hydro-power, a national program for rural electrification based on small hydro-power has been conducted about 50 years and there are about 1/3 of the rural regions with the power supply from small hydro-power in China and the total small hydro-power has been reached about 35 GW by end of 2004. Another example is the household sized biogas digesters (6-8 cubic meters each, for supply 60-70% of cooking fuel and light fuel for rural household), there were about 17 million small biogas digesters have been built up in rural China, with financial subsides from centrol and local government (1/3 of the investment from the subsides). The legislations have also made great contribution for the scale up of renewable energy technologies, Following the effectiveness of Renewable Energy Law, only in the 2005, 500 MW of wind farms had been installed with annual growth rate more than 60%. In other words, the legislation and national target requirement supplied a investment environment for renewable energy development in China. However, due to the Law was just effectiveness for about half year, the long term impact could not been evaluated.

8 cooperation potential priorities

The international operation potential is based on the need of Chinese renewable energy industrial development. However to meet the national target of 16% of 2020 or beyond, there are so many problems are the potential for cooperation. The major problems of Chinese renewable energy development are as bellowing;

8.1 Personnel skill

Renewable energy technology R&D talent is generally weak and dispersed, which cannot meet the need of large-scale development. So far in China's renewable energy industry, there is no specialized renewable energy generator technology research and development body. Such an organization is so important in tracing and learning

[13] NDRC document no7, 2006

[14] Eric Martinot, Renewable 2005, Global status review, Beijing international renewable energy conference, November 7-8, 2005

international advanced technologies, and in training renewable power system designing, manufacturing, testing, and operational management experts. More importantly, it can conduct leading research on renewable energy technologies so that Chinese renewable energy technology can compete at international market.

According to an estimate, only tens of specialists in overall China conducting renewable energy policy studies, project planning, and R&D activities and they work in more than 10 different organizations. This situation is far from 2020 strategic objectives and more than 100 thousand research persons and engineering technicians. Organizational capacity building and personnel training is a significant step in fulfill China renewable energy strategic targets.

Along with China's fast development of renewable energy industry, requirement of technical training for renewable energy generator design, manufacture, installation, operation, and repair will be rapidly increased since the current very limited number of the qualified. Furthermore, there are few technical and economic service providers and intermediary agencies for renewable energy farm construction and operation and renewable energy equipment manufacturing. With more and more new renewable energy farm projects, large number of expertise are needed for related technical consultancy and technical service in renewable energy farm preparation projects and developer support, pre-construction consultancy, renewable energy resources survey, site selection, planning, design, construction supervision, management services, installation engineering, operational management, monitoring, examining and repair, and follow-on services, etc. Therefore, training is imperative for the fast renewable energy industry development needs. Meanwhile, the third industry of renewable energy technology consultancy and technical services needs to be developed actively to meet the new market requirement of specialized talents on design, engineering, operation management, and maintenance in the fast developed renewable energy industry in China.

8.2 Technological skill

Human resource and technology are closely related. Nationalization and localization of renewable energy generator technologies have become a bottleneck restricting China's renewable power system development. These technological obstacles exist in multiple dimensions in system design, component manufacturing, and renewable energy turbine test and authentication to name a few. For example, currently about 82% installed wind power turbines in China are imported. Reasons include that first, made-in-China wind power turbines do not have enough continued operational time to be proved and tested by authorized certification system, and secondly, compared with imported products, locally made systems have no cost advantage. The limited market share affects new product investment by Chinese manufacturers so that MW class wind turbine manufacture is still blank in China. This will certainly not meet the large-capacity generator market for Chinese renewable energy farms. Mean while, it is difficult to lower the unit cost because of small production capability, and the high cost in turn has restricted increase of production size. In order to resolve the dilemma, manufacturers need to continuously improve their technology and product quality and

reduce the cost from inside potentials, as well as national support policies and renewable energy farm developer's confidence in using homemade renewable systems. Anyway only China develops its large-capacity renewable systems with Chinese technologies it can follow up with the world advanced renewable energy technology development steps.

The second obstacle in technology aspect is the large fluctuation of renewable energy output due to the uncertainty of renewable energy, which makes electricity grid peak regulation even more difficult or requires larger grid backup capacity. This is the inhere disadvantage of renewable energy generation and therefore is one of the fundamental reasons why renewable energy is not welcomed by utility companies. Along with larger proportion of renewable energy generation in the entire grid installations, this problem will be more conspicuous.

8.3 Resource assessment skill

Abundance of renewable energy resource is one of the most fundamental and key factors in renewable energy farm site selection and construction. This will directly decide success or failure of a renewable energy farm project. Importance of renewable energy survey and appraisal is well recognized in the renewable energy advanced countries. For instance, the US energy department, European Union, and India Administration of Unconventional Energy have all input special fund in their thorough renewable energy resource surveys and worked out detailed renewable energy resource atlas and computerized renewable energy resource databanks, which provide project owners with credible data in renewable energy farm appraisal. After gaining enough experience of demonstration projects, Europe has started building commercialized off-shore wind farms.

However, there exist some difficulties in resource appraisal in China. China's renewable energy resource is less proved. Lack of credible data becomes one of the common problems. Without detailed resource data, for example, a series of difficulties are hard to overcome in wind farm project approval, site selection, and project planning. This would result in project delay such that some wind farms are approved before the project evaluation. These premature projects often result in big unnecessary loss. So far China has never organized a national level renewable energy resource assessment, while the current renewable energy resource assessment is completed by Chinese Meteorological Research Institute. Based on data collected at over 2000 meteorological stations, they worked out the all country on-land solar energy and wind resource map. The map shows the abundance of China's wind and solar energy resources. However it can not meet the requirement of selecting renewable energy project site and project proposal, even though it is generally significant for a guideline of Chinese renewable energy industry development.

8.4 Project development skill

Pre-development phase investment is not enough. There lacks of capital for renewable energy farm project preparation. There is no regular budget source for government organizations to do renewable energy planning, which have resulted in

lags in renewable energy pre-project assessment and evaluation, overall planning, and project design. Small list of potential projects has made the national and provincial-level renewable energy development planning a very difficult task. Offshore renewable energy resource data is still blank. China has a long coastline with abundant offshore renewable energy resource potential near the load center. Offshore renewable energy will definitely be a key resource in the future Chinese renewable energy development. Especially, it is very important to conduct offshore wind energy resource assessment and appraisal.

8.5 Driven force for cooperation

The driven force for international cooperation comes from two trials, one is basic needs mentioned above and the second one is the driven force from the market. Based on the government target, China will be one the leaders of renewable energy development and the manufacture of different equipments is the basic needs for the commercialization of renewable technologies. Recently, NDRC issued a special document, which request that all the wind turbines installed should be with 70% local components. Without local suppliers, no one supplier can meet such kind of standards. Therefore the driven force make the international manufacture should have one local partner or should build its own factory for wind in China. Meanwhile the cost reduction of the renewable energy technologies will also to put the international cooperation in this area.

8.6 Comments for cooperation

The following cooperation priorities would like to recommended based on the basic needs of the renewable energy development both in China and in the world:

1) Policies framework

- Put renewable energy strategically cooperation into agenda of G8 or G8 plus 5 or more.
- Set up a long term partnership for renewable and other clean energy cooperation, for example like APP (AP6) between UK-China or EU-China
- Organize policies dialogue for exchange information and best practices for policies implementation in the stakeholders' countries.

2) For R & D

- Put the R&D of RETs cooperation into the bilateral and multilateral co-operation framework between UK-China and EU China, especially for the renewable for power and bio-liquid fuels.
- Encourage Chinese experts to participant EU or UK R&D program and also supply research assistant to Chinese R&D program.
- Promoting joint research and development involved by UK and Chinese institutions and enterprises and technologies transfering included RETs

manufacturing and management.

3) For marketing and commercialization

- Improve the national standards system for China, according to the experiences of EU or UK for various renewable energy system and products.
- Help China to set up testing and certification system for renewable products and equipment based on EU best practice.
- Promoting investment in China for the commercial development of RETs, especially for wind and other low cost technologies.
- Promoting the business cooperation for scale up the utilization renewable energy, include industries, consulting and commercial based research institutions.

9 Renewable energy contribution for GHG mitigation and CDM

Chinese government dose make any official commitment for the mitigation of Green House Gas (GHG), however, renewable energy has made a great contribution to the mitigation of GHG emission in China. Based on a roughly calculation, 400 million tons of GHG emission reduction has been made every year, since 2000 and it will be reached about 1 billion tons of GHG emission reduction by 2010 and it will be doubled again by the end of 2020.

By the 12th of May 2006, about 50 projects had been got the LOA (letter of approval) for CDM, and among them, more than 80% are renewable energy based projects.[15] Therefore, renewable energy has been recognized as one of the most important priorities of CDM in China. Based on the estimation made a joint study of CREIA (China Renewable Energy Industrial Association), until 2020, the major renewable technologies for CDM projects will likely be wind power, small hydropower, biomass power, and LFG utilisation. From 2005 to 2010, it is estimated that the capacity of newly installed projects using these technologies will reach 25 GW, and carbon emissions reduction will be 37 million tonnes. From 2010 to 2020, these technologies may reach 55 GW in capacity, with 101 million tonnes in reduced carbon emissions.

In conclusion, the total potential for renewable energy projects under the CDM by 2020 will be about 138 million tonnes carbon-equivalent per year, or 506 million tonnes of CERs. Considering a life cycle of 15 years for these projects, the accumulated carbon emissions reduction are estimated to be up to 2 billion tonnes of carbon-equivalent, or 7.5 billion CERs in total[16].

10 improving efficiency of CDM administration

The whole system of CDM is basically running well, while there is still space to improve the effectiveness and reduce administrative costs, however, there are some potential to improve the effectiveness and reduce administrative costs associated with CDM through

[15] Song Yanqin and other, CDM Development Status Report, presentation of May 25, 2006, in Hangzhou Zhejiang
[16] Li Junfeng & others, CDM Country Guide in China, 2005

project bundling and standardisation of processes. An outstanding barrier faced CDM development is the complex methodologies. As developed by scholars instead of the project implementers, most of the CDM methodologies are academically and not always adapt to the real projects. This causes unnecessary complications to the project process, such as the PDD development, and also makes the validation and certification complex. Each individual project is requested for a PDD regardless the project size. This raises the CDM development cost, especially for the small-scale projects. In practice the PDD composing takes a considerable part of the working time of completing a CDM project. Plus the local language problem, additional valuable time and costs are spent on the translation. In the view of this, two options are suggested to address the barrier:

- PDD Standardisation: To design standard format of the PDD document for each category technology, based on which to develop PDD format in local languages. The PDD for specific project shall apply the format with only slight changing on the words like the appropriate data. In this way the PDD development working will be reduced dramatically, as well as the PDD review and validation. Accordingly the costs will be decreased.

- Bundling: Encourage the project bundling and bundling PDD. The experience shows that bundling is an efficient way to scale up the project size and reduces the development cost. If it's possible to apply a PDD for bundling project, which means only one PDD needs to be developed for one bundle of projects, more projects may be recognized with tremendous time and costs saving.

11 Technologies transfer are dominated by market driven

There are a lot of evidence and examples to support the view that the transfer of technological capacity and capabilities are fundamentally market driven. The concept of technology transfer is the transfer of systematic knowledge and know-how. It's distinct from the product enterprises. For renewable energy, the key technologies are kept by the enterprises in some developed countries, instead of by the institute or university library. For industry, those technologies are their ground to survive in the market competition. The only driving force for the enterprise to sale the technology and know-how is the expecting of acceptable return from the transfer. It might be driven by policy temporarily but the success rate is low since the enterprises are not obligated to promote the advanced technology all over the world.

It's common realised that technology transfer is an important instrument for developing country to speed up their Industry development track. But if we review the technologies have been transferred till now, we regret to see most of them are out of date and have lost the competition capability, such as those transferred by RE Power, Flendur and so on. The core and up-to-date technologies are hold by the enterprises as GE, Vestas and Gemasa. Another example we can give is for PV Industry. The fundamental of PV Industry is the technology of low-cost feedstock material manufacturing. There is few case of transfer of

this kind of technology, and the transfer cost is incredibly high. With apparent reasons above we can conclude that the fundamental of technology transfer capability is market driven. How to build up an effective technology exchange market is a valuable topic.

12. Why REEEP is successful

REEEP is a bottom-up partnership. It has major donor countries, as UK but the donor countries are not the bodies to direct the program. The decision-making is done by the Governing Board and Program Board formed by representatives from the partners. All strategies are set by the board members with various prospects, based on and welcome feedback from the 'bottom'. The partnership structure ensures that no single country or organisation can dominate the program. The running of the program is open to the partners, and the members of REEEP are with equal right and capacity to comment and influent the program.

REEEP doesn't determine to run isolate. It is not only active in the REEEP funded tasks and welcomes the outside parties to join, but also willing to participate the outside activities. Most of REEEP activities are conducted on the cooperation base and doesn't act as an ambitious leader. This helps REEEP to be accepted more easily and build up good relationship with many other partnerships, organisations and so on. REEEP has its fund circle and supports certain amount of projects. This help to enhance the impact of REEEP in the sector.

Summary

Renewable energy is at a rapid development stage in China, and some technologies are commercialised or near commercialised and have large development potential from resource, technology and industry points. Renewable energy has begun to play a role in the energy structure, and it has the potential for large scale development and occupies a certain ratio. According to the national target, renewable power will be 16% of the total power capacity in China in 2020. It is expected that it will reach 30% or even more in 2040s and renewable energy will be important substitute energy at that time. Meanwhile, renewable energy will make more and more contributions for global climate change