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Perface

This book is part of "Research on Renewable Energy Legislation and Recommendation to Renewable Energy of People's Republic of China" completed by Renewable Energy Development Center of Energy Research Institute of NDRC, sponsored by NDRC/WB/GEF China Renewable Energy Scaling-Up Project (CRESP).

With the support of CRESP, Renewable Energy Development Center established specialist group with regard to renewable energy technology and policy, who completed study and research on national and international development of renewable energy technology, policy and legislation as well as made significant analysis on the problems and conflicts China is encountered with in terms of developing renewable energy. As a result, four professional technical research report and one policy research report were completed, they are:

- Study on Wind Power Development
- Study on Solar PV Development
- Study on Solar Thermal Application and Development
- Study on Small Hydro Power Development
- Study on the Incentive Policies and Experiences of Foreign Legislation on Renewable Energy

During the research, great support was offered by relevant departments and people of National Development and Reform Commission (NDRC), Environment and Resource Commission of National People's Congress (NPC), Ministry of Science and Technology, Ministry of Water Resources，Ministry of Construction and National Environment Protection Bureau. Besides, some universities, research institutes, and enterprises home and abroad were actively involved in the discussion. Furthermore, Mr. Richard Spencer from World Bank, Mr. Bill Williams of UNDP/GEF Capacity Building for the Rapid Commercialization of Renewable Energy in China, GTZ of Germany, National Renewable Energy Laboratory (NREL) of United States, Department of Technology and industry (DTI) of UK and IEDA of Spain also made great contribution to the report. Herein the authors would like to take this opportunity to appreciate all the people or institutes mentioned above for their efforts in this project.

Chapter 1 Study on Wind Power Development

1 China has abundant wind energy resource and significance to develop wind power

1.1 China has abundant wind energy resource

For the decision-making of wind energy development on the aspects such as feasibility, scale and potential, it is necessary to have an idea of the wind energy reserves for a region or the whole country. Wind energy reserves depend on the wind speed and the last time of the effective wind speed. We got the wind energy reserves from the data collected by the 900 meteorology stations at 10m height since China did not have any kind of detailed wind energy survey.

China has a large area and long coastal line, rich in wind resources. It is estimated that the mean wind energy density at 10m height is about 100W/m2 and the total wind energy reserves are 3226GW, the effective wind energy reserves are 253GW. Plus the offshore wind energy reserves, 750GW, the total effective wind energy reserves in China could be equal to 1000GW. It is obvious that there is plenty of wind energy reserves and good potential for development. Wind energy must be an important component of energy structure in the future.

1.2 Wind resources mainly distribute in North China and southeast coastland

China has a large area and complex topographic conditions, and the wind resource distribution depends on the topography and the specific location. The wind-resource-abundant regions are mainly located in the southeast coastland and northern China area. Besides , some areas in the inner land and the offshore also have abundant wind resources.

1.2.1 Abundant wind energy belt on the coastland and the islands nearby

The coastal and island area includes the 10km wide terrain near the sea in Shandong, Jiangsu, Shanghai, Zhejiang, Fujian, Guangdong, Guangxi and Hainan provinces, and the annual wind

power density will be higher than 200W/m^2 with the wind power density contour parallel to the coastal line. Some islands near the coastal area have the power density even higher than 500W/m^2, such as Taishan, Pingtan, Dongshan, Nanlu, Dachen, Shengsi, Nan'ao, Mazu, Magong, Dongsha, etc.

The cold air in winter or spring and the typhoon in the summer maybe impact on the coastland and the islands nearby. Considering the narrow pipe effect of the Taiwan straits, the above area becomes the most major belt with rich wind energy. With an 1800km-long coastal line and about 6000 islands, there is a good foreground to make a good use of wind energy in China..

1.2.2 Abundant wind energy area in North China

The wind energy abundant belt in North China is mainly distributed in the regions including Heilongjiang, Jilin, Liaoning, Heibei, Inner Mongolia, Gansu, Ningxia and Xinjiang with the width about 200km, where the wind power density could be more than 200~300W/m^2 and even more than 500W/m^2 in some areas such as Alataw Shankou, Dabancheng, Huitengxile, Huitengliang in Xilinhaote and Chengde paddock.

1.2.3 Abundant wind energy area inner land

Besides the 2 wind energy abundant belt mentioned above, most of the other areas only have the wind power density under 100W/m^2. But some special areas still have abundant wind energy due to the lake and special terrain, such as the area near Poyang lake.

1.2.4 Abundant wind energy offshore

China has a large offshore area and plenty of offshore wind energy in east coastal line with about 2-15m-depth of the sea. Projection based on the same measurement as used in the measuring of the onshore wind energy indicates that the offshore wind energy at 10m height would be 3 time of that onshore, which is about 700GW. For the coastal area is very near to the center of electric power load, the offshore wind farm would be an important sustainable energy in the future along with the technique maturing and economic feasibility of offshore wind farm.

1.3 Wind energy and hydropower could supplement each other

The wind energy is not distributed equally between seasons although plentiful, rich in spring, autumn, winter and poor in summer. In North China and middle/lower reaches of the Yellow River the wind speed reach the top value in the spring and be lowest in the summer, modest in the autumn. The southeast coastal area and the islands nearby have the highest wind speed in the autumn, comparatively high wind speed in the winter and lowest wind speed in the summer.

There is also abundant water resource in China and the theoretic potential is 676GW, which is 1/6 of that of the whole world. The whole capacity of developable hydropower is 378GW, which is the highest in the world and could produce 1920TWh of electricity a year. The raining season in south China is from March to June or from April to July, and the total rainfall of this period could be 50% to 60% of the whole year; in the north China the total rainfall is much less than South and distributes un-equally, mainly in the period from June to September with about 70% to 80% of the total in a year, with the river flux changing greatly between seasons as the result, and the water resources distribute un-equality. The spring is the typical low water season; the water increases in spring and decreases in autumn, the season of summer could provide most of the water resource in a year (the higher the latitude, the more concentrated water resources in summer).

It is easy to find out that China has abundant wind resource and water resource, compensating each other. Developing wind energy in a large scale could be a supplement to some extent when the low water season, such as winter and spring, could not provide enough electric power.

1.4 The necessary of wind power development

1.4.1 The development of wind power could promote the local economy and manufacture industry development

Western part of China has most of wind resource onland and develop wind energy in a large scale could exert this advantage, protect the environment and accelerate the development of

western China. China has a strong mechanical manufacturing; gearbox and electric generator are important export products and develop wind energy could establish new manufacturing. Wind turbines with large capacity need high technology and they could promote the technique upgrade of the corresponding component providers to even attend the international competitions.

1.4.2 The development of wind power is an efficient way to reduce the emission of greenhouse gas

Wind energy is a kind of endless renewable energy and generating power from wind is a clean energy technology. In the procedure of this kind of energy conversion there are almost no fossil energy consuming and no threaten to environment, so it is an energy answer for the sustainable development strategy. To develop wind energy is also a powerful measure to reduce the emission of greenhouse gas and could contribute to the solving of the world's warming up.

1.4.3 The development of wind power could promote the security of energy supply of China

The security of energy is a basic condition for the sustainable development of economy. The diversity of energy could not only improve the energy supply, but also the security of China. Wind energy may take an active role in decreasing the import of petroleum and natural gas, and then contribute a lot to the variety and security of the energy supply of China.

1.4.4 The development of wind power is an efficient way to solve the problem of deficient energy supply in China

Till now petroleum, natural gas and coal are still the underpinning of the world economy, out of question these 3 kinds of energy have the great contribution on the progress of the society of human being. But in practice it has been find out that this kind of fossil fuel has also the great disadvantage of finite resource and pollution to the environment, and even a threaten to the development of the whole society. Many developed countries have taken some measures to constrain the consuming of fossil fuel and especially constrain the mining industry for the

security of their energy. These countries not only import fossil fuel to fulfill the requirement in a great deal, but also attach importance on the development of wind energy, solar energy, biomass energy with a series of encouraging policy and measures.

The per capita possession of conventional energy in China is comparatively few and the conventional energy has been consumed continuously along with the development of the economy. As to the prognostication of some experts, the energy supply should be doubled to realize the target that the economic gross develop quadruple at the year 2020. At that year the whole electric power capacity of China would be almost 1000GW and the energy supply would be equal to 2.4~3.1G tons of standard coal. Such a huge amount needs half of the petroleum imported and the capacity of coal mining exhausting. For the sustainable development of the society and economy some measures must be taken to solve the problem and modify the structure of energy supply, to explore some new renewable energy have been a pressing and important task. Wind energy, solar energy, tide energy and biomass energy are now being developed as renewable energy. Wind energy is the most matured and commercialized energy technology for electric power generation.

Now China has the electric power capacity about 380GW but the structure was improper, the capacity of thermal plants take most of the share, especially the coal plants even take 75% of the whole capacity. This kind of energy structure brings double pressure from economy and environment protection. China has abundant wind energy and the wind energy reserves at 10m height onshore and offshore is about 1000 GW, to develop wind energy and other renewable energy is an important strategy measure to modify the energy supply structure, promote the harmony development of energy, economy and environment in China.

1.5 The foreground of wind power development in China

1.5.1 The favorable conditions to develop wind power in large scale

1.5.1.1 Rich in wind energy

China has a large area and long coastal line, rich in wind resources. The technical developable capacity onshore at 10m height is 253GW, offshore at 10m height is 750GW, the total is about 1000GW and it could generate about 2000TWh of electricity a year. The wind resources are mainly distributed in north China and southeast coastal areas and the islands nearby. Besides the areas mentioned above the offshore wind energy is more abundant.

1.5.1.2 Power grid conditions

The southeast coastal area is the center of the electric power load and have solid power grid with only a very small share of wind power, so in these areas there is not any technical problem. The western part of China such as Inner Mongolia could have a more solid power grid together with the development of the economy; the development of wind energy would take the same step with the local power grid planning.

1.5.1.3 The promotion of wind farm construction and wind power equipment manufacture

Through the development of several years, there is a professional team in design, construction, maintenance and management of wind farm. It is an advantage to develop wind energy in a large scale. Besides, the key components of 600kW wind turbines have been successfully local made with a rather low price than the import parts; this has lowered the price of wind turbines of this scale. 33% of the new wind turbines installed in the year 2003 were made locally.

1.5.1.4 Power industry system and policy environment

The separating of power grid company and power generation company is an advantage to introduce different investors. Besides Longyuan company, Huaneng new energy company, those company that belongs to the former electric power industry system, Guohua Group, Beijing Guotou company, Huarui Group, Shenzhen energy investment company and even CLP Power China of Hongkong, or some foreign investors have pay attention on the potential wind energy market of China, and even take the wind measurement and site selection work. The Energy Bureau of NDRC (National Development and Reform Commission) has managed several wind power concessions project and would push the wind farm development forward after such experiences.

1.5.2 The thinking on wind power development afterwards

1.5.2.1 Summarize the experiences of wind power concession project, to develop several large scale wind farm with the capacity of 100~200MW; push the stimulant policy of fixed feed in tariff and promote the development of middle scale or small scale wind farm, forming a stable wind energy market.

1.5.2.2 The manufacturers of wind industry absorb the advanced technique abroad, enlarge the production of the equipment, realize the renovation of the product and to

satisfy the demands of MW wind turbines. In the procedure of experience accumulation, promote the ability of new product development and lower the cost of wind turbines manufactory.

1.5.2.3 The development of wind power should adapt to the local economy and the local grid capacity. In the developed areas such as southeast coastal area accelerate the wind farm development; in western part of China the development of wind farm should adapt the increase of the power grid capacity; solve the problem of distribution of wind power across provinces in policy, such as RPS system or green power market.

1.5.2.4 Develop the large scale wind power base and dispersed wind turbines all together. Propose to develop several wind power base with the capacity of 1000MW, develop middle scale or small scale wind farm adjust to local conditions. After the strengthening of the rural power grid propose to develop another method to install individual wind turbine, such as the mode in Denmark and Germany. Although Germany did not has any large scale wind farm with the capacity larger than 100MW, the total wind power capacity is more than 14GW. And decentralized power system would be the trend of the future electric power structure.

1.5.2.5 Offshore wind energy is more abundant than land not only for the high wind speed but also for there is almost no calm wind period. The roughness length on the sea surface is much lower than that of the land, which makes little wind speed variance along the height. This makes the tower of the wind turbine relatively lower to decrease the investment of the wind farm. As to the low turbulence intensity on the sea surface the wind turbines could last a rather long period. For example, the wind turbine that has a designed-life of 20 years on land maybe have a lifetime for 25 or 30 years offshore. Adding the 20% higher wind speed than that on land, this make 70% more of power output. It is proposed to study the experience abroad on offshore wind farm seriously, and preparing resource measurement and demonstration project development. That will provide a good provision of the future offshore wind farm development.

1.5.3 The expectations of wind power development

During the year 2004 to 2005, the second part of “Tenth Five Year Plan”, the two wind power concession project Jiangsu Rudong and Guangdong Huilai should be developed with emphases to get the experiences on large scale wind farm and reach the goal of wind power

capacity 1000MW in the end of 2005.

During the year 2006 to 2010, in the “Eleventh Five Year Plan”, it is proposed to install new wind power capacity of about 3GW and at the end of 2010 the total capacity of wind power reach 4GW. The main projects of this period would include the wind farm of Guangdong coastal areas and islands nearby with the capacity of 400MW, the wind farm of Fujian coastal areas and islands nearby with the capacity of 400MW, the wind farm of Chongming and Nanhui of Shanghai with the capacity of 200MW, the wind farm of Jiangsu and Shandong province with the capacity of 100MW each, the wind farm of north Jilin province with the capacity of 200MW, the wind farm of Inner Mongolia and Hebei province with the capacity of 300MW each, the wind farm of Ningxia and Gansu province with the capacity of 100MW each, the wind farm of Xinjiang Autonomous Region with the capacity of 100MW, etc.

During the year 2011 to 2020, the new installed capacity of wind power would be about 16GW, the accumulated capacity of wind power would be 20GW. In this period the emphasis would be Dabancheng of Xinjiang, Huitengxile of Inner Mongolia, Chifeng Dali, Bashang of Hebei province, Baicheng district of Jilin province and the coastal area near Jiangsu and Shanghai. Each wind energy base mentioned above would have the capacity more than 1GW. Besides, offshore wind farm would be installed near the coastal areas with the capacity about 4000MW. At that time the total capacity of wind power would be 2% of the electric power and the electricity output would be 1% of all the electric power consuming.

After the year of 2020 the fossil fuel would be more expensive and wind power could have more ability of competition to develop more quickly. After the year of 2030 the hydropower would be fully developed and offshore wind farm would develop in large scale.

Wind power has well benefit to the society and environment, together with the technique being matured and cost being lowered; it must be an important energy supply in the 21st century.

2 Off-grid wind turbine generators

2.1 The development history and status of off-grid wind turbine generators

The development and utilization of modern wind turbine generator technology in China

started in the beginning of 1970's. After the development phases of initiate, individual turbine R&D, demonstration application, research on the key technology, commercial promotion, serial and standardization, a great progress has been obtained in research, design and manufacturing, testing, demonstration projects and promotion, both economic and social benefits are achieved.

By the end of year 2002, the annual production capability of off-grid wind turbine generators more than 30,000 units. The main products are 100W, 150W, 200W, 300W, 500W, 600W, 1kW, 2kW, 5kW and 10kW wind turbines. Manufacturers including Neimeng Shangdu Animal Husbandry Machinery Works, Neimeng Huade New Tech Company, Neimeng Tianli Wind Machinery Works, Fenxi Machinery Plant, Nanhang Tech Development Company, Jiangdu Shenzhou Wind Turbine Factory, Qingdao Fengneng Mechanical and Electrical Company, Baoding Tiantai Electrical Equipment Company, ect. During the year 2002 total production are 29758 units (approximately 8888kW) of all models, among them 1484 units were exported. The largest manufacturer is Jiangdu Shenzhou Wind Turbine Factory, produced 9580 units, followed by Neimeng Shangdu Animal Husbandry Machinery Works and Neimeng Tianli Wind Machinery Works, produced 5699 and 3184 units respectively. The major unit capacity is 300W, accounts for 29.3%, the second and the third are 200W and 100W turbines, accounts for 28.8% and 19.4% respectively.

By the end of year 2002 the cumulative production of off-grid wind turbine generators were 248477 units, the output of each year see table 1-1.

Table 1-1 The annual output of off-grid wind turbine generators in China

Year	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
Units	3632	13470	12989	19151	20847	25575	16649	7458	4988	5537
Year	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Units	6100	6481	8190	7500	6123	13884	7096	12170	20879	29758

After nearly 30 years of R&D, manufacturing and application promotion, 100W, 150W, 200W, 300W, 500W, 600W and 1000W wind turbines are commercialized in China. The major technology is fixed pitch, three blades, upwind, passive yaw regulated rpm, with permanent magnetic low speed generator, hinged tail vane, mast, foundation, geywire and anchor. The turbines are in stable operation, with reliable quality and lifetime more than 15 years. The maximum power coefficient raised from 0.30 in the beginning to 0.4, and lower the cut-in

wind speed, start running at 3m/s.

2.2 The significance of developing off-grid wind turbine generator

According to the statistic data, by the end of year 2002, there are 20 million people in China without electricity service, especially farmers, herdsmen and fishermen living in remote area, it is very difficult and not economy to build transmission line to supply electric power for scattered and low load residents. For windy areas it is a better solution of power supply by Chinese made off-grid wind turbine generator.

During last 30 years, cumulative installed off-grid wind turbine has been up to 190,000 units nation-wide. Among them the majority of unit rated power are 50W and 100W. Some wind turbines reached their design lifetime (15 years), replaced by new and larger turbines is needed, this is a potential stable growing market.

Another potential end users are boarder guard forces, navy and fishermen on islands, microwave relay stations, TV transmission stations, meteorological stations, expressway and railway stations, observation platform in forest, oil and natural gas pipe line, aquiculture farms along coast and islands (the coast line of China more than 7000km), etc. most of them are get electricity from diesel or petrol generators, the cost as high as RMB 3 yuan/kwh. However, the above mentioned locations are rich in wind energy resource, to develop wind/diesel or wind/PV hybrid system could guarantee 24 hours power supply every day, fossil fuel and funding could be saved, and the pollution will be reduced, economic and social benefits are notable.

Along with the China's rural economic policies put into effect, more investment for crop cultivation by farmers, some of them contract to plant trees on barren mountain, or cultivate wasteland, living at the location without power grid, small wind turbine would be a reliable power source.

In addition, many lakes in southern China where fishermen living on their own boat, electricity is generated by diesel engine, make noise and pollution, off-grid wind turbines are in urgent need to improve their power supply for daily life.

In recent years, the number of export Chinese small wind turbines increased year by year, the products sold to the USA, Germany, Greece, Belgium, Sweden, Japan, Argentina, Indonesia,

Malaysia and Mongolia, etc. According to the incomplete statistics, cumulative exported small wind turbines more than 5000 units. The message from foreign trade agencies showed, that many countries in African continent, southeast Asia and Latin America, are very interested in Chinese small wind turbines, the overseas market to be broad prospects.

The domestic market for off-grid wind turbines will be further expand, follow the demonstration and promotion programs to be implemented, such as the national "Brightness Project", "GEF/World Bank China Renewable Energy Commercialization Promotion Project", "UNDP/GEF China Renewable Energy Commercialization Capacity Building Project", as well as many others.

2.3 How to facilitate the development of off-grid wind turbines

2.3.1 To formulate incentive policies, regulations and systems, protection of the legal benefits of investors and managers, to encourage the production enthusiasm, keep the wind industry sustainable and stable growth. It is necessary to provide subsidy to poor people living in rural areas without power grid, make them affordable to purchase small wind turbine and generate electricity for house appliances, achieving social and economic benefits by wind industry.

2.3.2 Supporting technical innovation in major manufacturers, and R&D of wind turbine products, improve technology and quality of products, make them more competitive in the international market.

2.3.3 To develop tens KW size wind turbine and its power supply system, support demonstration and promotion projects for these size application, to realize commercialization as soon as possible.

2.3.4 Off-grid wind turbine products are wind energy converter, without consuming conventional energy and not harmful to environment, it should be exemption from tax or reducing tax for the manufacturers. At least reference to the agriculture machinery products, to levy 13% of VAT instead of 17%, lighten the burden of enterprise, help them become stronger quickly.

2.3.5 The potential market of off-grid wind turbine, wind/diesel and wind/PV system are located in remote rural areas, where are isolated from current information and the economy are less developed, usually are identified as the main area of national "help the poor", the

government should provide funding support and human resource for popularization of science, demonstration projects, and create the market.

3 The development of grid-connected wind turbine generator

3.1 The development of wind power in abroad

3.1.1 Status and development trend of wind power in abroad

3.1.1.1 Review of the history

After the oil crises in 1973, developed countries in the USA and western Europe were looking for alternative energy to substitute fossil fuel, a great funding input to R&D of modern wind turbine generator, by utilizing the resource from high tech industry, including the state-of–art new technologies, such as computer, aerodynamics, structure dynamics and material science, to create a new era of wind energy utilization.

During 1970's to the mid of 1980's, R&D of wind power technology were developed in totally different way, the government of USA, UK and Germany invested much capital in the development of MW size large wind turbine, the reason was large would be economy, the projects were implemented by famous giant enterprises, with very strong technical and financial background, for example, Boeing developed 2.5MW and 3.2MW wind turbine, the later one was installed on Oahu of Hawaii, with rotor diameter near 100m and tower height 80m; 3MW wind turbines were developed by British Aerospace and MAN of Germany respectively, those are the biggest turbine in 20 century. However, due to the complex conditions on real wind site were underestimated, none of these giant machines was operated and unable to be commercialized.

The development of wind power technology in Denmark was in another direction, government funding support was not go to manufacturer directly, but in the form of subsidy to users who bought wind turbine, at the beginning the subsidy accounts for 30% of turbine cost, along with the development of the industry, this amount reduced gradually until 1987, the industry growth strong enough and the subsidy stopped. On the other hand, Danish government levy energy tax and CO_2 emission tax to coal fired power, and made feed-in-tariff

of wind power favorable to the owners of wind turbine. Originally farmers bought wind turbine for satisfy their family demand of electricity, later they buy wind turbine to generate electricity and sale to the utility to make profit as a new investment, a stable market for wind power was create in Denmark.

In order to satisfy the demand from farmers to install wind turbines, small and medium enterprises in Denmark, especially agricultural machinery manufacturers, such as Vestas and Bonus, etc. were very active in the development of wind turbines, at the same time the government established a wind turbine test station within Risoe National Laboratory, for facilitating the development of wind power technology and ensuring the safety of products. Risoe was authorized to issue certificate for those wind turbine type which eligible to safety requirements, and only the wind turbine products had been certified were enable to obtain government subsidy. The station also provided consultancy on solutions for the problem during the test, to help manufacturers to improve their products. Danish wind turbine manufacturers got supports from research institutions, learnt experience from on site operation, and had opportunities to get orders from market continuously, keep the improvement on product, unit capacity from small to large step by step, only when the type technology matured then upgrade, the major product size were 30kW, 50 kW, 100 kW, 400 kW, 600 kW, 750 kW, 1MW and multi MW size, good reputation was established in market, both on performance and reliability. During past 20 years, even though some companies went into bankruptcy, but stable wind power market still exist, through reorganize the assets and combination, the number of manufacturers reduced from more than ten to four, but each one expand to large scale, become public multinational corporation, wind turbine industry growth up as a pillar cornerstone industry for Danish export.

Germany, Spain and other European countries formulated incentive policies for the development of wind power, the core is a long term fixed purchase price for wind generated electricity, these countries become the quickest expanding area of wind turbine market, Danish manufacturers set up joint ventures in other countries, to produce wind turbines with Danish brand. At the same time, local manufacturers growth up quickly, to occupy the market share in their own country, for example, Enercon of Germany, a famous company producing gearless wind turbine, and GAMESA of Spain.

The development of wind turbine technology from many kinds of structure type to a few

types, this is the result of market selection, only high reliable and cost effective types are able to survive in the market. Currently most of the wind turbine use asynchronous generator, the rotation speed is controlled by the frequency of the power grid, almost keep constant value, the complicate synchronize device is not needed. However, the tip speed of rotor varied with wind speed, it is difficult to keep high conversion efficiency. The technology of variable speed constant frequency wind turbine has been matured, it keeps the optimal tip speed ratio of rotor, to achieve maximum power coefficient and harnessing more energy, it becoming the main stream of the product.

The development trend of wind turbine technology are increasing unit capacity, reducing the weight of per kW and increasing conversion efficient.

Wind power plant consists of many wind turbines installed at good wind resource area, forming an array according to terrain and prevailing wind direction, connecting to power grid as power source, usually mentioned as wind farm, it is an effective way to utilize wind energy in large scale. The development of wind farm start in the beginning of 1980's in California of USA, stimulated by US government favorable policies for renewable energy, including 25% of tax credit both from federal government and California state government, valid until the end of 1985; in addition, utilities must purchase the electricity generated by renewable energy by law, and the price would be stable in long term. Such policies attracted huge amount of funds to purchase wind turbines, due to the limit production capability in USA, it had to imported from Denmark, gave an opportunity to Danish wind turbine manufacturers put into large batch production and improve the quality. In 1986 wind installation reached 1600MW in USA, after that almost no growth due to expire of favorable policy, until the late 1990's the new policy of production tax credit was approved, the development start again in the USA.

India is a developing country in serious lack of power supply, many incentives were set by the government, for example, the enterprise which invested in wind power, the quantity of electricity generated by wind can be "stored", during the period of limitation for power supply, the enterprise with "stored wind electricity" to be able to get power in priority. Wind power grows very quick in India, new installation within 2003 up to 420MW, and cumulative is 2130MW.

The development of wind power has been taken as a measures for the commitment of CO_2 mitigation by the EU (European Union), the driving force of wind power development is environment protection pressure, Denmark, Germany and Spain set relatively high feed in tariff, and keep stable high growth rate, after 1996 the annual growth rate over 30%, wind is the fastest growing clean power source. In 1991 the goal of EU for wind power in year 2000 was 4000MW, this was achieved in 1997, 479MW were realized and a new goal had to be set, just doubled to 8000MW, in fact 13630MW were real installed by the end of 2000, it is 70% excess the goal. In 2003 the EWEA set a goal of 75GW for year 2010 and 180GW for year 2020, accounts for 10.6% and 21% of total installed power capacity at that time in EU respectively.

3.1.1.2 Current status of wind power development in abroad

Table1-2 Word wind power development during 1983 to 2003

	Cum. Installed capacity (MW)	Average Annual Growth rate (%)	Wind electricity (TWh)	Total electricity (TWh)	Proportion of wind (%)	Average Unit Capacity Installed In Denmark (kW)	Cost (US cent /kWh)
1983	140					30	15.3
1985	940					55	10.9
1987	1440	27				100	7.2
1989	1710	9				150	6.6
1991	2160	13				200	6.1
1993	2980	19				300	5.6
1995	4840	31				500	5.4
1996	6070	26	12.2	1360	0.09	600	5.3
1997	7640	26	15.4	1390	0.11	600	5.1
1998	10150	33	21.3	1430	0.15	687	5.0
1999	13930	37	23.2	1470	0.16	750	4.9
2000	18450	32	37.3	1520	0.25	931	
2001	24930	35	50.3	1560	0.32	850	
2002	32040	29	64.8	1620	0.40	1443	
2003	40300	26	82.2	1670	0.50	1988	

Source： BTM Consult.

By the end of 2003 the cumulative installed capacity worldwide was 40300MW, and wind generated electricity in 2003 was 82.2TWh, accounts for 0.5% of the total power generation, 1670 TWh. Along with the improvement of technology and large batch production, the cost of wind power would be decrease continuously, from 20 US cent/kWh in the beginning of

1980's, down to 5 US cent/kWh in 1998, see table 1-2.

According to the statistics of world wind power installed capacity and sales of the industry by BTM Consult, Denmark, new installation in 2003 is 8340MW, compare to 2002 increased 1120MW new installation. The trend of wind growth rate higher than other power source continued, the five year average growth rate is 31.7% during 1999 to 2003.

The world top ten countries of wind installations in 2003 see table 1-3, sum of the ten to be 36550MW, accounts for 91% of the world total.

Table 1-3 The world top ten countries of wind installations in 2003 (MW)

2003	Germany	Spain	USA	Denmark	India	Netherlands	Italy	Japan	UK	China
New	2670	1380	1690	220	420	230	120	280	200	100
Cum.	14610	6420	6360	3080	2130	940	920	760	760	570
Prop.	36.3%	15.9%	15.8%	7.6%	5.3%	2.3%	2.3%	1.9%	1.9%	1.4%

Source： BTM Consult.

Electricity generated by wind depends on local wind resource, efficiency and reliability of the wind turbine, the annual wind generated electricity in table 1-4 was estimated by the cumulative installation in 2003 and the average capacity factor of each country.

Table 1-4 The annual wind generated electricity in 2003

Country	Germany	Spain	USA	Demark	India	Holand	Italy	World
Installed Capacity (MW)	14610	6420	6360	3080	2130	940	920	40300
Estimated Annual full Load hours	1850	2100	2300	2250	1800	2100	2000	2041
Estimated Capacity factor	21%	24%	26%	26%	20%	24%	23%	23%
Annual generated electricity (TWh)	27.0	13.5	14.6	6.9	3.8	2.0	2.0	82.2

Source： BTM Consult.

The unit capacity increased continuously, MW size turbine has been main stream of market share, in 1997 and before it was less than 10%, in 2001 was more than half and in 2003 it reached 71.4%, see table 1-5.

Table 1-5 Market share of MW size turbine increased during 1997 to 2003

	1997 and before	1998	1999	2000	2001	2002	2003
New installed MW size (MW)	153	417	1076	1779	3570	4485	5956
Units of new installed MW size	128	332	802	1293	2436	2776	3704
Average unit capacity of new installed MW size （kW）	1195	1256	1342	1376	1466	1616	1608
Proportion to total new installed capacity	9.7%	16%	27.4%	39.6%	52.3%	62.1%	71.4%

Source： BTM Consult.

The top ten wind turbine manufacturers and their market share in 2003 see table 1-6, the total market share of top ten was more than 90%.

Table 1-6 Top ten wind turbine manufacturers and their market share in 2003

	Production in 2003 (MW)	Market share in 2003 (%)	Cumulative (MW)	Cumulative Market share (%)
Vestas (Denmark)	1810	21.7%	8400	20.8%
GE Wind (USA)	1500	18.0%	4430	11.0%
Enercon (Germany)	1220	14.6%	5760	14.3%
Gamesa (Spain)	960	11.5%	3940	9.8%
NEG Micon (Denmark)	860	10.2%	6400	15.9%
Bonus (Denmark)	550	6.6%	3370	8.4%
REpower (Germany)	290	3.5%	890	2.2%
MADE (Spain)	240	2.9%	1270	3.2%
Nordex (Germany)	240	2.9%	2220	5.5%
Mitsubishi (Japan)	220	2.6%	810	2.0%

Source： BTM Consult.

In Europe due to limit area with rich wind resource on land, to install more huge wind turbines will effect natural landscape, usually offshore with abundant wind resource and vast area, suitable for large wind power development, in mid of 1990's there are two demonstration offshore wind farms were built in Denmark, the successful operation showed that the technology is feasible. After 2002 several commercial demonstration offshore wind farms were constructed, the size of each one between 40MW and 160MW, in 2002 the biggest offshore wind farm was complete in Denmark, with 80 wind turbines and 2MW each, 160MW in total; in 2003 another more bigger one was online, consists of 72 units and 2.3MW each, 16.6MW in total, worldwide offshore wind installation up to 530MW. After 2005 large offshore wind farm development will be in Germany.

Along with the construction of offshore wind farm, larger size wind turbine to be needed, 3.6MW wind turbines have been put into operation, 5MW size machine still on the drawing

board. The largest prototype wind turbine installed in 2002 was E112 type made by Enercon of Germany, with rotor diameter of 112m and rated power of 4.5MW, the second was GE3.6 type made by GE of USA, with rotor diameter of 100m and rated power of 3.6MW.

3.1.1.3 Development trend of wind power in abroad

Near term estimation

BTM Consult of Denmark estimates that average annual growth rate of world wind power new installation will be 11%, cumulative will be 21% during 2003 to 2007, before real "take off" of the European offshore wind farm, moderate growth would be kept. The estimation of world wind power growth during 2003 to 2007 see table 1-7.

Table 1-7 World wind power growth during 2003 to 2007 (MW)

	2003	2004	2005	2006	2007
New installation	8970	9260	9700	11000	12300
Cumulative	40970	50230	59930	70930	83230

Source： BTM Consult.

Long term estimation

The estimation of world wind power development has been made by many international organizations, "World Energy Outlook 2002" of IEA (International Energy Agency) estimated for "Reference Scenario", wind power would be 55GW in 2010, 112GW in 2020 and 195GW in 2030, as regard to electricity wind would accounts for 1% in 2020. Compare to the goal of 75GW in Europe in 2010 set by EWEA (European Wind Energy Association), IEA's estimation may be conservative.

In 2002 EWEA and Greenpeace International published a report "WIND FORCE 12", the subtitle is "A blueprint to achieve 12% of the world electricity from wind power by 2020", this document was signed by the leaders of these two organizations. The report mentioned that this document is not an estimation, it is a feasibility study. Following are the main viewpoints of the report, as a good reference for future wind power development in coming 20 years.

The research pointed out that the driving force of the development of wind power is climate change, there is not any green house effect gas emitted by wind power, and it is able to develop in large industry scale in power grid. The quota of mitigating green house effect gas by Kyoto protocol has been assigned to region and country, it would be increasing the proportion of renewable energy, including wind energy.

The reason of fast growing wind power is that the cost has been reduced dramatically in market, currently the cost per unit of wind generated electricity equivalent to one fifth of that in 20 years ago. The size of wind turbine increase continuously, the biggest commercial turbine up to 3600kW. The high growth wind business attractive to financial and investment market, new investors such as oil companies were enter this market. Germany, Denmark and Spain in Europe, the USA in America and India in developing countries, have important successful experience in wind industry. The new emerging market would be offshore wind farms, only in the north of Europe 20GW will be built.

Main factors are mentioned in the report, for 12% of the world's electricity from wind power.

The world's wind resources and geographic distribution: A number of assessments confirm that the world's wind resources are extremely large and well across almost all regions and countries. The total available resource that is technically recoverable is estimated to be 53000TWh/year. This is over twice as large as the projection for the world's entire electricity demand in 2020, geographic distribution see table 1-8.

Table 1-8 World's wind resources (TWh/year)

West Europe	East Europe & former Soviet Union	Asia	Latin America	North America	Australia	Africa	Total
4800	10600	4600	5400	14000	3000	10600	53000
9.1%	20.0%	8.7%	10.2%	26.4%	5.7%	20.0%	100%

Source: 1994, Michael Grubb & Niels Meyer.

Remarks: the estimation based on one tenth of on land area with annual average wind speed larger than 5.1 m/s at 10m height, assuming 300kW wind turbines are used.

The entire European abundant wind resources may satisfy at least 20% of electricity demand in 2020, especially consider the new emerging offshore wind market. The offshore wind resources in Europe see table 1-9.

Table 1-9 The offshore wind resources in Europe (TWh/year)

Water depth	Offshore 10km	Offshore 20km	Offshore 30km
10m	551	587	596
20m	1121	1402	1523
30m	1597	2192	2463
40m	1852	2615	3028

Source: 1995, Garrad Hassan & Germanischer Lloyd.

The growth of world's electricity demand and the capacity of power grid: Future electricity demand is assessed regularly by the IEA (International Energy Agency), the IEA's 2002 World Energy Outlook assessment shows that by 2020, total world demand will reach 25578 TWh/year. For wind power to meet 12% of global consumption it will therefore need to generate an output in the range of 3000 TWh/year by 2020. There are no substantial obstacle to the integration of these increased quantities of wind power into the electricity grid. In Denmark, peak levels of up to 50% have been managed in western part of the country during very windy periods, at present in Europe the cautious assumption adopted is that a 20% penetration limit is easily attainable.

Trend of wind power market development and potential growth rate: From current wind power development trends, the average annual growth rate of new installation assumed to be 25% during 2002 to 2008 is feasible, it is the highest rate in the timescale of study. This rate fall to 20% during 2008 to 2014, then fall again to 15% until 2017, during 2018 to 2020 fall to 10%. The results of calculation shows cumulative wind installation 210GW and annual wind electricity production 452 TWh/year in 2010, cumulative wind installation 1.23TW and annual wind electricity production 3021 TWh/year in 2020, accounts for 12% of world electricity demand, it is projected to be 25578 TWh/year.

The choice of parameters and assumptions underlying this 12% scenario, has been based on historical experience from both wind energy industry and from other energy technologies. The main assumptions are:

- Annual growth rate: Growth rate of 20-25% are high for an industry manufacturing

heavy equipment, but the wind energy industry has experienced far higher rates during its initial phase of industrialization. Over the last five years the average annual growth rate of turbines installed has been closed to 36%. After 2013, the scenario growth rate falls to 15% and then to 10% in 2018. In Europe an important factor will be the opening up of the offshore wind market.

- Growth of wind turbine size: The average size of new turbines installed is expected to grow over the next decade from today's figure of 1MW to 1.3MW in 2008 and 1.5MW in 2013. Larger turbine sizes reduce the number of machines required.
- Comparisons with other technologies: Both nuclear power and large scale hydro are energy technologies which have achieved substantial levels of penetration in a relatively short timescale, nuclear reached a level of 16% globally and large hydro a level of 19%. Nuclear power from 1000MW in 1960 grew to 343000MW in 1997; and large hydro from 45000MW in 1950 grew to 714602MW in 1996. Wind power is today a commercial industry which is capable of becoming a mainstream power producer. The time horizon of the 12% scenario is therefore consistent with the historical development of these two technologies.

Investment, Costs and Employment of 12% scenario: The annual investment required to achieve the deployment of wind power outlined above starts at USD 8.6 billion in 2003 and increases to a peak of USD 90.2 billion by 2020. The total investment needed to reach a level of almost 1200GW of capacity by 2020 is estimated at USD 809 billion over the whole period. The cost per kWh of wind generated electricity has already been reduced dramatically, this study starts with the basis that a "state of the art" wind turbine in 2002 in the most optimal conditions has an investment cost of USD 988 per installed kW and a unit cost of 4.66 US cents/kWh. Taking into account improvement both in the average size of turbines and in their capacity factor, the cost per kWh of installed wind capacity is expected to have fallen to 3.52 US cents/kWh by 2010, assuming a cost per installed kW of USD 748. By 2020 it is expected to have reduced to 2.81 US cents/kWh, with an installation cost of USD 596 - a substantial reduction of 40% compared with 2002. The employment effect of the 12% wind power scenario is a crucial factor, a total of 1.79 million jobs will have been created around the world by 2020 in manufacturing, installation and other work associated with the industry.

Environment benefits of 12% scenario: On the assumption that the average value for carbon dioxide saved by switching to wind power is 600 tonnes per GWh, the annual saving under

this scenario will be 1813 million tones of CO_2 by 2020, the cumulative savings would be 10921 tonnes of CO_2 by 2020.

The report "WIND FORCE 12" studied the possibility for 12% of the world's electricity from wind power, it must have related policies and measures to realize the scenario. The assumptions and conclusions in the report more suitable to Europe, for example, the report mentioned that wind installation will be 230GW in OECD Europe by 2020, this estimate maybe reasonable. However, the wind installation would be 170GW in China by 2020 mentioned in the report, from the economic status this figure maybe too high.

3.1.2. Incentive policies and measures of wind power development in abroad

3.1.2.1. Incentive policies in some countries

Denmark

Many additional tax on household electricity consumption were levied by government, among them the electricity tax, CO_2 tax and SO_2 tax were DKK (Danish krone) 0.40, 0.10 and 0.009 krone per kWh respectively, after sum of them another VAT (Value Added Tax) will be levied again. The tariff of household electricity consumption is in the order of 1.0 to 1.2 krone per kWh, the formula as follows:

(0.38+0.4+0.1+0.009)*1.25=1.11 krone /kWh。

The policies for wind power were fixed price to purchase wind generated electricity, return CO_2 tax and providing subsidy. The power company has an obligation to allow wind turbines connected to grid by law, and purchase wind generated electricity according to 85% of average sales price without tax (0.38 krone /kWh). The government return to the owner of wine power 0.10 krone /kWh of CO_2 tax, and providing 0.17 krone /kWh subsidy. Finally the private owner may get feed in tariff in the order of 0.60 krone /kWh, the formula as follows:

0.38×0.85+0.10+0.17=0.593 krone /kWh。

Due to the reform of electric power system, Danish parliament intent to adopt the policy of market power price (currently is 0.044 Euro /kWh) plus green certificate subsidy (the highest

is 0.01 Euro /kWh), during the transition period most of wind turbines operated less than ten years may get a fixed feed in tariff of 0.057 Euro /kWh.

Germany

"The Renewable Energy Feed in Law" approved by federal chamber become effective on 1 January 1991, the power company has to purchase wind generated electricity according to 90% of average sales price was regulated, this price will be checked and ratified every year by each state statistic agency follow the price of previous two years.

The new "Renewable Energy Law" become effective on 1 April 2000, the policy of feed in tariff had been further improved, the duration of favorable feed in tariff has been identified as 20 years, during this period there are two different high and low feed in tariff, according to wind condition of the sites. For example, the first five years of feed in tariff would be 0.09 Euro/kWh for wind turbines in all sites, after that the feed in tariff will be different depending on wind resource at the site, for high wind site not lower than 0.06 Euro/kWh and for low wind site not higher than 0.08 Euro/kWh. For the offshore wind farms built before 2006 may get at least 0.09 Euro/kWh within nine years.

In addition, for the wind project online after 1 January 2002, the feed in tariff will be reduced 1.5% each year.

"Renewable Energy Law" identify that the power grid operators have the obligation to purchase electricity generated by renewable energy, the costs of upgrade and expansion of power grid system for connecting renewable power source have to be borne by power grid operators.

UK

The measures to encourage the development of renewable energy was NOFFO (None Fossil Fuel Obligation), fossil fuel tax was levied to end user of electricity as a foundation, used for subsidy to none fossil fuel power generation, through tendering competition make the project with the lowest feed in tariff to win the bid. In 1990 the wind power contract price was 10.0 pence/kWh by the first phase of NOFFO, the wind power contract price reduced to 3.8

pence/kWh by the fourth phase of NOFFO.

A renewable energy obligation was passed by the House of Commons in UK, set a goal of 10% renewable energy power generation in 2010, and a green certificate trade system will be established.

USA

There is no national goal for the development of renewable energy, there are more than ten states have RPS (Renewable energy Portfolio Standard) implemented. Currently the main incentive for wind power is PTC (Production Tax Credit) of 1.7 US cent/kWh, valid for the electricity generated by wind during the first year of operation. Originally PTC was valid before the end of 1999, after that it has been extended several times, recently this was expired on 31 December 2003.

India

India is a developing country which is seriously lack of power supply, at the same time increasing conventional energy the government also pay more attention on the development of renewable energy. Preferable policy and measures are:

- The annual depreciation rate can be calculated as 100% for wind turbine, and allow the owner to take the depreciation fund of wind turbine as cost of other business run by the same owner, to subsidy the owner by the way of setting off income tax;
- The end users of electricity invested wind farm is available to consume their own wind electricity, only to pay power grid company 2% of “wheeling fee”, the surplus wind electricity can be “stored” in power company no longer than 8 months, in case of limited power supply the power will be guaranteed by power company;
- The wind electricity can be sold to the third party, power grid company charge the “wheeling fee”; it also can be sold to power company, the lowest protection feed in tariff were identified in different areas, in the order of 5.8 to 7.4 US cent/kWh.
- In order to encouraging local manufacture, 25% of import duty levied to complete wind turbine, and duty free for the components.

3.1.2.2 Comparison to the results of different incentive policies

Policies and measures were formulated by each country according to local conditions, even though the results of incentive policy are different, but they have the common characteristics as follows:

- Identify the definite target by law;
- The feed in tariff have to be attractive compare to other investment options;
- Power grid companies have to purchase electricity generated by renewable energy;
- Duration of the projects should be long enough to get the return of investment;
- Reduce and stop the subsidies to fossil energy and nuclear energy;
- Internalize the social and environmental costs of polluted energies.

The incentive policies for wind power mainly are RPS, tendering and fixed feed in tariff.

The RPS definite target, in 2001 EU (European Union) Commission and European Parliament set a goal for 2010 that the proportion of renewable energy will be doubled, increasing from 6% to 12%, including hydropower it would be equivalent to 22% of total electricity consumption in Europe, the targets of renewable energy power generation proportion assigned to each member country, some of them see table 1-10.

Tale 3-9 The renewable power proportion in some EU member countries (%)

	Denmark	Germany	Spain	France	Italy	Holland	Sweden	UK
1997	8.7	4.5	19.9	15.0	16.0	3.5	49.1	1.7
2010	29.0	12.5	29.4	21.0	25.0	9.0	60.0	10.0

The implementation of RPS must have a green certificate trade system, make the management more complicate and difficult to operate, currently people still probe into the aspects of this

issue.

Tendering may bring down feed in tariff, however, the funds are limited and low price will not attract investors, the incentive results were not well. For example, UK with the best wind resource in Europe, after more than 10 years of NOFFO, wind power installation only 760MW, equivalent to 25% of Denmark, there is no domestic wind turbine manufacturer as well.

The way of fixed feed in tariff has the difficulty of identifying reasonable price, however, the results are more attractive to investors, facilitate wind market fast growing, stimulate the development and technology improvement of wind turbine industry, consequently bring down the costs of wind power. For example, in 2002 the output of wind turbine was 3100MW in Denmark, accounts for 43.5% of world total, only 530MW were sold in local market, 80% were exported. In 2002 the output of wind turbine was 2060MW in Germany, accounts for 28.6%, and 1210MW in Spain, accounts for 16.9%.

In USA due to the unstable policy, after the expire of PTC whether it would be extent again is uncertain, only one US wind turbine manufacturer left, in 2002 the output was 640MW, accounts for 8.8%, most of them were not produced within the US territory.

3.2 The development of wind power in China

3.2.1 Development of Wind Farm

Demonstration in initial stages: From 1986 to 1993. In this period, demonstration wind farms of small scale were constructed by using loan or donation from abroad. Support from the government was mainly of financing, such as investment to wind farm projects or R&D of wind turbines.

Establishment of industrialization：From the national wind power conference in Shantou in 1993 to present. At that conference, the former Ministry of Electric Power put forward the

industrialization of wind power and the standardization of the early stage work of wind farms' construction. In 1994, it was prescribed that the authority of power grid should allow the wind farm connect to the near grid and purchase all the electricity generated. The tariff of the electricity was decided by a principle that the project should have reasonable profit except the cost and debt repayment. The difference with the average price of the power grid would be shared equally by the whole grid. The benefit of investor was ensured and the construction of wind farms developed rapidly. In this period, some national standards and industry standards were authorized such as "Code on compiling feasibility study report of wind power projects", "Methodology of wind energy resource measurement for wind farm" and "Methodology of wind energy resource assessment for wind farm", and the development of wind power industry was standardized.

Large-scale development and localization: In the future, wind power industry of China will tend toward large-scale development and localization. To make it, the government adopted a series steps. The main object is to enlarge the scale, restrict cost and cut down the power tariff. For example, the former SDPC (State Development and Planning Commission) prescribed that tariff of power generating project should be calculated according to a lifetime mode. The VAT of wind power project is halved to 8.5%. Besides, some local policies were also made to encourage the development of wind power, in which the financing, taxation, land requisition and power to grid are favored.

Since the year of 1986 when the first demonstrating wind farm was constructed in Rongcheng, Shandong province, with efforts over 10 years, wind power development in China has been a great success. The main achievements are as follows:

3.2.1.1 Construction scale enlarged and wind farm management standardized

Till the end of 2003, 40 wind farms have been constructed nationwide except Taiwan province. 1042 wind turbines are installed and the total capacity reach 567MW. The installed capacity positioned at No.10 in the world and No.2 in Asia (less than India). Besides, some

regulations about wind farms' prophase work, construction and operation are worked out, and the management of wind farms to be standardized.

3.2.1.2 Development in large scale is possible with professional team and advanced equipment manufacture

With practicing in years, a specialist team of design, development, construction and operation has been brought up. Local wind turbine manufacture is improved. At end of 2003, cumulative market share of local wind turbines reached to 15.3%. The local made wind turbines account for 33% of newly installed capacity in 2003. So it's possible to develop wind farm in large scale.

3.2.1.3 Electricity cost decrease dramatically and competing ability improved

Along with the establishment and development of wind power industry, cost of construction and operation of wind farms decrease dramatically by technology introduction, wind turbines localization and strengthened management. Initial investment decreased from 12000 Yuan/kW in 1994 to 8000 Yuan/kW presently. Also the tariff of wind power electricity decreased from more than 1.0 Yuan/kWh to about 0.6 Yuan/kWh. The difference between tariff of wind power and coal power reduced gradually and the competing ability improved. In 2003, competing mechanism was introduced into wind power development by the two wind power concession demonstration projects in Rudong of Jiangsu province and Huilai of Guangdong province, that will accelerate the large-scale development of wind power in China.

3.2.2 Wind power equipment manufacture

As R&D projects several grid connected wind turbines were developed in China during 1980's, the rated power were 18kW, 30kW, 55kW and 200kW, due to long period of R&D, it was not able to catch up the demand of market for larger size machines, most of the prototypes had no opportunities for improvement and unable to commercialize. For example,

two prototypes of 200kW wind turbine were developed by national funding, however, when they were not commercialized the main stream products of the market already became 600kW. The turbine costs account for 70% of the total investment of wind farm project, to realize the local manufacturing wind power equipment to reduce project investment is required by the large scale development. At present by the way of introducing, digesting and absorbing foreign matured technology, increasing the proportion of local made components, make the price lower than imported machine in the order of 10% to 20%.

The manufacturing technology of 600kW wind turbine had been introduced by paid technology transfer fee for licensing production, or by joint venture with foreign companies, this size machine already put into batch production in Goldwind of Xinjiang, Xi'an Nordex of Shaanxi and Yituo-MADE of Henan, prototypes were made in Wandian of Beijing and Shenxin of Shanghai.

The MOST (Ministry of Science and Technology) providing the support for localization, by means of national programs for tackle key problems, funding R&D of large size wind turbine. The former SDPC (State Development and Planning Commission) and SETC (State Economy and Trade Commission) provided subsidy or subsided interest loan to the owner of demonstration wind farm, which purchase local made wind turbines, the scale was 80MW in total, gave domestic manufacturers an opportunity to have batch production, and create a market environment to realize commercialization.

The domestic professional component suppliers developed key components of 600kW, according to the requirements of wind turbine manufacturers, such as generator, gearbox and blade, the international famous blade supplier LM set up their solely owned factory in Tianjin, now the local made components of 600kW wind turbine accounts for 90%.

Up to 2003, market share of local turbines was 15.3% Monopolization of imported turbines is broken and the price was held down. It has been an important contribution to wind power industry in China. At the same time, development of local wind turbines provides a strong

technical guarantee to the large scale development of wind power industry in China.

It is planned that the installed capacity of wind turbines will be 1000MW in 2005, which is nearly double of present amount. Moreover, price of imported units keep a high level because the change of international financial market. These are great opportunity to develop local products. Related corporations shall fully prepare and get hold of the opportunity, and advance the progress of national wind power industry.

In development of wind power industry, technical improvements have run parallel with cost reductions and the latter, in turn, have been partly due to advanced technology and partly due to Economies of Scale. Economies of Scale is embodied in follows:

3.2.2.1 Increasing of unit capacity

Modern wind turbines are developing to larger unit capacity. Wind turbines of large unit capacity can produce more electricity with less cost. One of the reasons is that the manufacture cost of large unit does not increase markedly than smaller unit. Furthermore, the number of turbines of a wind farm with certain capacity will decrease by installing larger ones instead of smaller ones. That means the cost of transportation, installation and cable connecting will also decrease.

3.2.2.2 Increasing of production

According to related information, the price of the wind turbines will fall by 15% for each doubling of production. From 1990 to1999, world wind energy doubled every 3 years. This implies, the price of the wind turbines will fall by 15% every 2.5 to 3 years..

3.2.2.3 Increasing of installed capacity of wind farms

It is obviously cheaper to connect many turbines in the same location, rather than just one. A recent German study showed that wind farm costs were lower than “single machine” costs by between 2% and 12%. The reason is, first, large development may attract substantial discounts from wind turbine manufacturers. 100 units may be 20-30% cheaper than 10 units.

Secondly, that enables site infrastructure costs to be spread over a large number of machines, reducing the unit cost. Other reasons are, that enable more effective use of maintenance staff and may secure lower interest loans and financing cost per kW are likely to be lower.

Data from the UK Non Fossil Fuel Obligation (NFFO) clearly suggests that larger projects offer cheaper electricity price. In NFFO3, the average bid price of the “small” NFFO projects that were offered contracts was Sterling 1pence/kWh higher (about 25%) than the “larger” project energy costs.

Therefore, the guidelines of wind power development in China should be advance the industrialization by large-scale development. The main contents are rely on wind projects, advance the industrialization by large-scale development, accelerate the improvement of technology and manufacturing ability by industrialization. That will decrease the construction cost and feed-in-tariff of wind power and the economic benefits and competing ability will be improved.

4 The problems and obstacles of wind power development in China

4.1 System Issues

At present, the wind power developers in China are mainly enterprises directly under the Power Corporations, their subsidiary companies, joint-stork companies charged by Power Corporations or companies tied up with Power Corporations. Few of those are independent wind power developing companies. This actuality has close relationship with the system of the wind electricity tariff. Since the commercially developing of wind power, the price of wind electricity falled continually from RMB 1.0 Yuan/kWh to RMB 0.5-0.6 Yuan/kWh. Even though, the price is still higher than average feed-in-tariff. According the regulation of former Ministry of Electric Power, the difference should be shared over the power grid. But how to share, the range of the grid is the province, district or whole country, there is no clear definition. So this policy is difficult to be put in practice. The result is that the Power

Corporation has to bear the price difference and its profit is lowered. For example, a wind farm of 50MW capacity will generate electricity of 100GWh with the full load hour of 2000. if the price is RMB 0.2 Yuan/kWh higher than average price, then the Power Corporation will loss 20 Million Yuan each year. The more wind electricity, the more loss of Power Corporation.

So it's difficult for investor without a Power Corporation background to develop wind power independently. They are commonly united with the local Power Corporation. With support from Power Corporation, high price will be strived for. The absence of competing holds back the developer from reducing cost and the price. That is harmful to the long term development of wind power in China.

To deal with this problem, competing mechanism shall be introduced and investing from various sources be abstracted. In 2003, NDRC arranged the bidding of the demonstration wind power concession projects for the first time. It was a successful attempt. Investors of different kinds participated in the bidding and the price falled dramatically. In the present system, it is an effective way to introduce competition by bidding of concession projects. But in long views, the key is to settle the problem of shared of the price difference between wind electricity and coal electricity. If the price difference could be shared over a reasonable range and be borne by end users, the benefit of Power Corporation wouldn't be cut down, then capital from various sources would enter the field of wind power without obstacle.

In the draft "Renewable Energy Promotion Law ", it's planed to set a fixed price for renewable energy and the price higher than average price of the power grid will be borne by the users of whole country or subsided by fund of renewable energy. If it is carried out, the problem of the price difference will be settled by law. Furthermore, national policies should be issued to encourage investment to wind industry, advance the competition, introduce various capital and accelerate the commercial development of wind power in China.

4.2 Technical issues

4.2.1. Grid Condition

During the stage of planning, designing and operation of grid-connected wind farms, the gird characteristics should be taken into account seriously. While some international power systems have significant amounts of wind generation, and a good deal of experience with its impact, care needs to be exercised in applying that experience to China due to the interactions of a different power system, market and weather characteristics.

Generally speaking, most technical obstacles for integration wind farm into gird can be eliminated at a cost. However, in order to resolve the possible technical problems, the governmental departments (e.g. National Development and Reform Commission, State Electricity Regulatory Commission), grid corporations, wind farm operators and wind power developers should cooperate closely.

4.2.1.1 Limits for wind power integration

While providing the clean power for gird, wind farms will also bring some unfavorable impacts on power system operation. With the expansion of wind power and the increase of wind power ratio in a local gird, these unfavorable impacts will likely to become the limits for wind power integration. Therefore, investigation on the grid conditions for wind farm integration, and proposals of the measures to overcome the grid-related technical issues for limiting wind power development are necessary.

Based on the research results from home and abroad on the integration of wind farm into grid, the main factors for limiting wind power development are as follows:

- Wind power will decrease the accuracy of load forecasting, and will therefore impact the dispatching and operation of grid.

The term “load” is used to denote the amount of power required to be dispatched by scheduled generation, i.e. the total output of all scheduled generating units detracting network loss. In other words, “load” is the amount of system load detracting the output of wind farms.

Wind power is a kind of intermittent and stochastic power source, which will have an influence on credit of power supply. Therefore, system load forecasting will potentially become less accurate as the amount of wind power generation increases, which reversely has

an influence on power system operation mode and the unit commitment of scheduled generating units. In the case of generation reserve forecasts, this could translate into higher reserve level requirements to cover uncertainties in the availability of wind power generation.

- Wind power has a impact on frequency control of grid

In order to control power system frequency to within defined standards, grid corporations require some power plants to provide frequency control ancillary services. However, as the total amount of wind power generation increases, then variation in its output will have a more significant impact on the frequency, and this will, in turn, require greater amounts of service to be purchased. If the requirement for regulation services was to increase, then the cost to the electricity market would most likely also increase.

Provided the grid corporation is able to source sufficient frequency control ancillary service to meet the expected total frequency variation, this issue does not impose a threat to power system security. However, how to distribute cost of the additional service between the grid corporation and the wind power developer is still a problem.

- Wind power has a impact on voltage regulation of grid

With the increase of wind power installed capacity in distribution networks, the variability of wind power generation causes variability of voltage, particularly if connected to distribution networks originally designed for providing supply to consumers, and distribution networks may not have specifically been designed to cater for the significant and possibly rapid loading variations (compared with normal customer load variation) caused by highly variable wind power generation. Therefore, the regulatory measures are needed to maintain the voltage level in a specified range. However, the variability of wind power generation is not a low probability, this could result in an increased requirement for reactive power ancillary services to manage voltage control.

In order to ensure the voltage quality of power supply, a higher cost of connection may be imposed by the grid corporation to provide additional or upgraded voltage control facilities. Reactive compensation equipment should be installed in the step-up substation of wind farm, which has a fast response characteristic and can be regulated continuously, such as Static Var Compensator and Static Var Generator and so on. In the stage of wind farm planning and designing, the grid corporation should negotiate with the wind farm developer on the integration scheme and determine the technical requirements in the aspects for reactive power compensation and voltage regulation of wind farm.

- Wind power has a impact on power quality of grid

Uncertainty of wind resource and operating characteristic of wind turbine result in the fluctuation of wind turbine output, which may affect power quality of grid. During the continuous operation and switching operation, wind turbine cause voltage variation and flicker, which are main concern of unfavorable influence of wind power generation on power quality of grid. For variable-speed constant-frequency wind turbine, harmonic issue caused by frequency inverter should also be considered.

In order to mitigate voltage variation and flicker caused by wind power generation, both speed control and pitch angle control should be improved so as to minimize the fluctuation of wind turbine's output while maximizing the output of wind turbine. Meanwhile, installation of auxiliary devices in wind farm such as Static Var Compensator and energy storage device can also mitigate voltage variation and flicker, however, it require additional cost of wind farm.

- Wind power has a impact on fault level and stability of grid

Whatever kind of generators are adopted in wind turbines, integration of wind farm will increase the fault level of gird and furthermore affect the relay settings of original protection devices of grid. It is probably necessary to add new protection devices and/or modify the relay settings of original protection devices. Particularly if wind farms are connected into distribution networks, overloading of circuit breakers may occur with the increase of installed capacity of wind farm.

At present, the installed capacity of wind farm is relatively small, which has an insignificant effect on power system transient stability. However, for wind farms connected into the terminal of weak grid, voltage stability problem is still a concern if lack of strong voltage support.

In order to enhance voltage stability of power systems including wind farms, reactive power demand should be compensated locally. As the real and reactive power of wind farms are varied with wind speed, it is suggested that reactive compensation such as Static Var Compensator should be used in wind farm, which can be adjusted continously and quickly. By using Static Var Compensator, power quality and voltage stability related to wind power generation can be improved.

- Other impacts related to wind power generation

As inherent intermittent and fluctuation of wind power, reliability of grid may be reduced while cost of grid operation may be increased. In order to resolve the power quality and reliability problems probably caused by wind power generation, grid corporations may pay cost for research works and additional devices. So, during the promoting development of wind power, other possible problems caused by wind farm integration must be studied and resolved.

4.2.1.2 Integration scheme of wind farm into grid

Now, the costs of integration project of most wind farms are burdened by wind power developers. Two exceptions are the following: one is that the grid corporation is a shareholder of wind farm and burden the part or total cost of integration project according to the results of negotiation with wind farm developer; another is for Wind Concession Projects which are implemented by National Development and Reform Commission of China, provincial grid corporation is required to built the transmission line for wind farm.

Gird corporation should provide convenience for wind farm integration and operation. However, grid corporation, as an enterprise engaged in transmission and distribution business, should take the economic benefit into account when they decide to invest a transmission project. Currently, the policies related to China power industry management system reforming are not well completed, the approach to determine rational price of transmission is still unavailable. After separation of generation from transmission, grid corporations are responsible for the huge tasks of grid construction, upgrading as well as grid security, but they are unable to raise enough money from their whole business. Under this circumstance, grid corporation's benefit can not be guaranteed if grid corporation are asked to construct all integration project for wind farm.

Therefore, the national government should encourage rather than compel grid corporations to invest and construct the integration projects for wind farms.

Based on the current status, the cost of integration project for wind farm can be estimated according to table 1-11.

Table 1-11 Cost of Substation and Transmission Line

Voltage Level (kV)	35	110	220
Substation Cost (RMB yuan/MVA)	40,000	60,000	100,000
Transmission Line Cost (RMB yuan/km)	150,000	400,000	600,000

For example, for a 50MW wind farm connected into 110kV grid through a 30km transmission line, the total capital of integration project is as follows,

$$40{,}000 \times 50 + 400{,}000 \times 30 = 14{,}000{,}000 \quad \text{RMB Yuan}$$

For a 100MW wind farm connected into 220kV grid through a 40km transmission line, the total capital of integration project is as follows,

$$100{,}000 \times 100 + 600{,}000 \times 40 = 34{,}000{,}000 \quad \text{RMB Yuan}$$

4.2.1.3 The duties of grid corporation to support wind power

Grid corporations should support wind power development through the following efforts:

- Study the characteristic of wind farm, evaluate the unfavorable impacts of wind farm on grid operation more accurately, and provide technical support for wind farm integration;
- Enhance the security and reliability of grid operation so as to reduce the outage of wind farm caused by grid fault;
- Under the precondition of ensuring unified dispatch and security operation of grid, grid corporation should purchase total output of wind farms and not limit the output of wind farm as can as possible.
- During arranging scheduled maintenance of wind farm and its connection line, grid corporation should consider the distribution characteristics of wind energy resource in order to minimize the loss of wind farm production.

Grid corporations are responsible for security, reliability and economy of grid operation, among which the grid security is in dominant position. Therefore, grid corporations should have the right to dispatch all power plants including wind farms. It is suggested that grid corporations and other wind power players should jointly establish the specifications for integrating wind farms into grid as regards of planning, designing and operation of wind farm.

4.2.1.4 Summary of grid integration issues

- At present, wind power installed capacity of China only accounts 0.15% of total power installed capacity. According to the long-term plan of power generation, wind power installed capacity will account about 2% (20GW) of total power installed capacity in 2020. Now, the share of wind power capacity in Germany, Denmark and Spain are larger than 10%. So, generally speaking, grid condition will not become bottleneck or limiting factor for wind power development in China.

- As regards whether the size of a specified wind farm will be limited by grid condition, it is necessary to perform calculation and analysis for a given grid characteristic. There are several factors affecting the size of wind farm, including local grid condition, wind turbine type and function of control system of wind farm, etc. Generally speaking, most technical obstacles for integration wind farm into gird can be eliminated, however the additional cost is needed. Therefore, one hand, comparison and analysis among the various schemes for increasing wind farm capacity are necessary; on the other hand, it is also a key issue that which organizations should burden the related cost. In short term, the capital for integration project of wind farm can be treated as a part of provincial grid unified planning and construction program according to the requirements of Wind Concession Projects. And the capital for wind farm integration project should be regarded as part of running cost of provincial grid corporation, it also should be paid by the und user. In long term, it is suggested that the capital for wind farm integration project can be paid by Renewable Energy Fund.

- During the process of drafting the Renewable Energy Promotion Law, the benefit of grid corporations should be taken into account so as to encourage grid corporations to play a more active role in wind power development. It is impractical to ask grid corporations to purchase all output of wind farms without any presuppositions, which is also contrary to the Grid Dispatching and Management Regulation issued by the State Council. However, the conditions should be specified clearly in Power Purchase Agreement under which grid corporations are unable to purchase the output of wind farm. As regards the foreign countries' practice and experience, grid corporations in Germany, Denmark and United Kingdom have issued some technical specifications or grid code on integration of wind farm into grid, in which wind farm are required to be able to control active and reactive power according to the grid status. It means that grid corporations are unable to purchase all output of wind farms without any presuppositions.

4.2.2 Wind power equipment manufacturing

By the end of 2003 there were 85% of installed turbines are imported. The main reasons are

local made wind turbines in small unit capacity and lack of variable pitch constant frequency technology, not able to satisfy the demand from current market. The other reason is lack of certificate schem for wind turbine. In a short period there are part of markets for 600kW fixed pitch wind turbine due to low price compare to imported products, it is the opportunity to further bring down the cost by large scale batch production. At the same time the local manufacturers have to upgrade their products as soon as possible, the government should give strong support to local wind power equipment enterprise in R&D and commercialization, and to establish wind turbine certificate scheme.

4.2.3 Wind resources assessment

4.2.3.1 Problems

Developed countries attach importance to wind resources assessment, wind resources is the most important element of the site selection and construction of a wind farm and it could determine “yes” or “no” of a wind farm project. Those countries that have rapid increase of wind power development attach importance to wind resources survey and assessment work very much. The Department of Energy in USA, European Union and Non-conventional Energy Ministry of India have special funds to compile wind atlas and wind energy database to provide solid data for investors to choose and construct wind farm.

One of the most prominent problem on wind energy development of China is the low level of wind resources proving up and lacking of solid data. So many of the wind farm projects have met many troubles on site selection, planning and design, and finally be forced to get approval first then make the evaluation or even construct directly. This kind of development could bring a great deal of loss. China has not done any detailed survey nationwide, the existing wind and solar atlas was made by Chinese Academy of Meteorological Sciences, based on the data collected from 2000 meteorological stations nationwide. The result shows that the wind energy in China is abundant in macro, but it could not satisfy the requirements of wind farm site selection and wind resources assessment.

China invests only a little to the early stage work and has not enough funds to do such kind of work. The investment that belongs to the government for wind power planning could not find a proper method to employ; and then the early stage work were not sufficient, the reconnaissance, planning and design work also were delayed. The project reserves are also

not sufficient and all these insufficient have brought many difficulties on wind power planning nationwide and each province.

The assessment of the wind energy offshore has not been done in any place. China has a long coastal line and abundant wind energy, considering the coastal areas near the center of power load; the offshore wind energy must take an important role in the future. So it is very important to do the offshore wind energy measurement and assessment.

4.2.3.2 Solution

Standardizing and consummating the early stage work. In the past the quality standard and requirements of early stage work were not clearly defined and this has made the low quality of the early stage work and even some bad influence on wind farm development. Now the National Development and Reform Commission has entrust some certain institutions draw out the regulations on early stage work to make the detailed definitions on site selection, wind energy measurement and assessment, geologic reconnaissance and pre-feasibility study report. And along with the technology improvement of the wind turbine and the experiences on wind farm constructions in China, these regulations should be supplemented and consummated. The investors should entrust qualified institutions to take the early stage work. The design institutions should familiar with all the regulations and follow them strictly to provide a high quality output of early stage work.

Establish a proper channel to allocate the early stage work funds. Because China has insufficient early stage work of wind power and funds, propose the government form a regular method on early stage work and provide some funds every year to organize the governmental works, such as regulation compiling, wind energy survey, wind power planning and management of early stage work. Proving up the effective wind energy, compiling the wind energy atlas nationwide and establishing wind energy database to provide solid foundation on wind power planning. Besides, the early stage work funds could partly be used to do some early design work to increase the project reserves and satisfy the requirements of annual wind power development plan. The funds should be consigned to some certain institutions and only use for wind power.

Introduce market system to the early stage work. Because of the lag of early stage work in China, in addition to the governmental funds the market activity should be introduced to the early stage work, to increase the wind farm project reserves and promote the development of wind power. The funds of early stage work could be a large amount of figure and government should encourage developers and other investors attend such work, and clearly defined that if

the project was made a concession bidding the investor could attend the bidding or get the reasonable compensation on the condition that the early stage work could satisfy the requirements. For other wind farm project the investors who has done the early stage work could has the right to develop the wind farm according to the wind power tariff policy. The investment of early stage work could be listed into cost and make it sustainable. The output of the early stage work could be conveyed.

Strengthen the research work of offshore wind power. China has abundant offshore wind energy and the government should increase the investment on offshore wind energy; measuring the wind energy offshore to select effective wind site; doing the wind energy assessment work to prepare the demonstration offshore wind farm in the near future.

4.3 Economic Issues

4.3.1 Problems

At present, the focus of wind project is electricity price. Besides the environment benefits, the impression of wind power is the high price. Price of wind generated electricity decreased from more than RMB 1.0 Yuan/kWh to about RMB 0.5-0.6 Yuan/kWh since the commercial development of wind power in China. But if the coal generated electricity price is assumed as RMB 0.35 Yuan/kWh, the wind generated electricity is still more expensive by 50%.

The wind electricity price will be analyzed from input and output, or cost and benefit.

4.3.1.1 Relatively high investment is needed by wind power

The cost per kW of wind farm is high. At beginning of wind power development, the cost per kW of wind farm was more than RMB 10000 Yuan/kW. Along with the improvement of manufacture technology, the cost slowly fell down. At present, the newly constructed wind farm cost about RMB 8000 Yuan/kW. Compared with the RMB 5000 Yuan/kW of coal power plant, it is still higher by 60%.

The cost of wind farm has a close relationship with the price of wind turbines. In general, the cost of wind turbines is about 60% to 70% of the total cost of the wind farm. In 1990s, the

price of wind turbines once was as high as USD 900/kW. But along with the increasing of installed capacity and improvement of technology, the price fell gradually. In recent years it has been USD 500/kW and contributed to the decrease of the cost of wind farm. However, since the latest one year, the exchange rate of EURO to USD rise dramatically. As the main suppliers of wind turbines are in Europe, the price of wind turbines in USD also increased. In the latest biddings, the quoted price of the turbines from suppliers has reached USD 630/kW. It must have inevitable negative effects to future wind farms.

The high cost of auxiliary works such as access road and transmission line contributes to the high cost of wind farms. Areas with good wind resources are generally remote and desolate hilly areas, desert or islands, where the road and power transmission line are difficult to reach. So the new road and power transmission lines have to be built. This part of cost is about 10% of the total cost.

Financing conditions are not favorable. The cost of wind farms includes financing cost. The initial cost of wind projects is high and it's difficult to get economic benefit in short time. So the confidence of the financing institute is deficient. For a long time of period, the financing terms are rigorous and long time and favorable loans are lacked. The long-term loans provided by commercial banks are generally of 5 to 8 years. Considering the debt-repayment price, the price will be as high as RMB 0.7-0.8 Yuan/kWh for the short debt repayment period. To restrict the increasing of cost of power generating and reduce the electricity price, the former SPC (now NDRC) modified the method used in calculating the feed-in price. In a document issued in April of 2001, it was prescribed by SPC that the feed-in price of power generating projects should be calculated in a lifetime cycle. In that way, the average prices of wind electricity in the lifetime fell to a certain and were generally RMB 0.6 Yuan/kWh. But along with that, the wind company is hard to get benefit in the paying period for the reason of high pressure of debt repayment. In many cases, short term loans are needed for the necessary of capital turnover. Then the enthusiasm of investors recedes.

If the banks could provide loans of more than 15years, and with a favorable interest, the pressure of debt repayment will be relieved and the cost of financing is decreased. As a result, the feed-in price will decrease.

The tax of wind energy is relatively heavy. The favorable national policy of tax is limited to that half of the VAT (Value Added Tax) in electricity selling is exempted. Namely, the tax rate is 8.5%. Other taxes such as income tax, custom duty and VAT of importing are not abated. In 2003, the custom duty for importing wind turbines is 5% and the VAT of importing is 17%. These two items add up to 23%. This causes the increasing of nearly RMB 1000 Yuan/kW of wind farm's cost. As to the income tax, some individual provinces treat the wind farm as high-tech project and the rate of income tax is abated to 15%. But that is not a national policy.

4.3.1.2 The output of wind project is relatively low

The full load hours of wind farms in China is various now but low in general. The average is about 2000 hours. The highest are nearly 3000 hours and are achieved in such wind farms in Xinjiang. Whereas the worst are merely 1700 hours achieved in Kuocangshan wind farm in Zhejiang province. So, the output electricity of wind farm is only half of the coal power plant with the same installed capacity.

One reason of this fact is the limit of resources. Though wind resources are rich in China, they are centralized in several regions. Restricted by natural condition or power grid, wind energy utilization is expensive in many regions. As a result, the investors turn to where the resources are not so good but it's easy to be exploited. So the full load hours of wind farms are low. Another reason is the absence of effective operation. Experiences in abroad shows that a team of skilled maintenance staff is important to a wind farm, for it can reduce the cost and improve the management of the wind farm. In China almost each wind farm has a small developer and each company has to learn from the start. So the cost is expended in practice and the ability of operation is limited.

In general, wind projects have high cost and limited income, so relative high price is necessary to the running of a wind company.

4.3.2 Measures

The approach to reduce the price of wind-generated electricity is cutting the cost of wind farm construction and operation, improving the operation and gain of more electricity output. But the developers will not do these initiatively and encouraging or restricting policies are necessary. In constituting of these policies, it's essential to sum up and use for reference of experiences of other countries. Among relative policies, NFFO (Non Fossil Fuel Obligation) in UK, fixed price and tax credit in some countries are effective.

4.3.2.1 NFFO (Non Fossil Fuel Obligation)

The main content of controlling the price in NFFO is: invite public bidding for the renewable energy project that intended to be developed. The bidder offers the lowest price will win the bid. The government will provide subsidy to the project and purchase all the electricity output. By public bidding, competition is introduced and the power generating cost of renewable energy falls dramatically. So the market of renewable energy is more competitive and the subsidy from the government is decreased to a large extent.

Since the carried out of NFFO, the price of wind-generated electricity fell dramatically from British Sterling 10.0 pence/kWh in 1990 to 3.8-4.95 pence/kWh in 1997. During the period between NFFO3 and NFFO4, the fall was 31%. It was proved to be effective.

However, some negative effect appeared since NFFO5. Due to the excessively low price in bidding, part of the developer had difficulty in management and the healthy development of wind projects was effected. A new policy act, Renewable energy obligation was issued in July, 1999 to replace NFFO.

In 2003, Chinese government carried out the concession bidding for wind farm projects. That is similar to NFFO in introducing market competition. Due to the competition and the promise of purchasing the electricity output in 30000 full load hours with a fixed price, the feed-in price fell obviously. The success of this bidding built up the confidence of Chinese

government to carry out concession bidding to large wind farm projects. The bidding of the second group of wind concession projects are busy going along in 2004.

When the concession bidding policy is practiced to a certain extend, the reasonable price of local regions will be known. That is a useful reference in approving the middle size and small size wind farms.

4.3.2.2 Fixed price policy

Fixed price policy had important effect in the development of wind energy in German. In 1991, in a law about renewable energy, the electricity generated by renewable energy was regulated to be purchase by a price that was 90% of the average sale price. The price would be set each year on the base of the electricity price two years ago. The nine years implement of that law drove the development of wind industry notablely.

A new law of wind was approved by congress of German in February of 2000 and became effective in March of 2001. The new law defined two prices. The “start price” is a high price that is about RMB 0.8 Yuan/kWh and several years later, it will be replaced by a lower price that is about RMB 0.621 Yuan/kWh. The number of years that the high price is paid will be calculated by the years that the turbines have been installed and the wind characteristic of the site. In a region with strong wind (full load hours of wind turbines about 2500-3000), it is about 5 years. The worse of the wind resource, the longer is the period. Then the enthusiasm of wind developing in the regions where wind resource is poor is protected. That is good for the balance between districts.

China has a vast region and the wind resources and developing conditions are various. There is certain difficulty to carry out fixed price policy. The keys are how to define the fixed price and whether different prices shall be set for different regions.

It cannot be judged only by the absolute number of the price that whether the electricity price of a wind farm is high or low, the marginal cost of the substituted energy shall also be

considered. For example, the wind electricity price in a district is RMB 0.70 Yuan/kWh while the marginal cost of the substituted energy is RMB 0.6 Yuan/kWh (such as in littoral provinces in China), the gap of the two is RMB 0.10 Yuan/kWh; but in another district, wind electricity price is RMB RMB 0.55 Yuan/kWh, while the marginal cost of the substituted energy is RMB 0.35 Yuan/kWh (such as in west provinces in China), the gap of the two is RMB 0.20 Yuan/kWh. Though it seems that the price in the former district is higher, it is more economical to develop wind energy in the former district.

In setting of fixed price, it shall be cautious and precise. The difference of region must be considered. It is unrealistic to set a unique fixed price in the whole country. It may be reasonable to set an incremental price based on the electricity price of conventional energy, such as RMB 0.10-0.20 Yuan/kWh higher than the average selling electricity price.

4.3.2.3 Tax credit

In the countries that wind energy developed rapidly, various policies of tax credit have been adopted and produced obviously effect. In the energy policy in USA, the federal income tax could be discounted at 10% of the capital construction of the project. In Denmark, tax of CO_2 and energy tax (including VAT of energy tax) could be returned to non-power corporation owner of renewable energy. VAT of renewable energy in Netherlands was abated from 17.5% to 6%. Tax credit in India is favored to a large extend that include: imported components of wind turbines were free of the custom duty, income tax of wind projects was exempted for five years, and sale tax of wind projects was exempted in some states. Due to these and other policy, wind capacity in India increased rapidly and ordered No.5 in the world.

In theory, tax abatement or exemption simply reduces the income of local and central government and capital subsidy will not be needed. Moreover, the balance of national revenue will not be broken for renewable energy industry is only a small part of whole at present. So this kind of policy is easy to put into practice.

At present, the taxes affecting the feed-in price of wind energy are mainly custom duty,

income tax and value added tax. It is reasonable to levy the custom duty of imported wind turbines at a relatively high rate for the protection of local manufacture industry. But the custom duty of imported components of wind turbines is advised to be exempted to reduce the cost of wind projects. At the same time, the localization rate of the installed wind turbines should be obligated. That is good to improve the manufacture technology of local suppliers. As to income tax, some individual provinces treat the wind project company as high-tech company and abated it to 15%. But that is not a national policy. Half of the Value Added Tax in wind generated electricity selling is exempted. Namely, the rate of VAT is 8.5%. But considering that there is no discount of equipment and raw material in wind project, this is not much favored compared with coal power project. It has been studied to convert the VAT from production model to consumption model in China. If this conversion will be implemented preferentially in wind projects, it would be propitious to reduce the price of wind-generated electricity.

Yet, most of the taxes are not included in the production cost except the custom duty. So their effects are limited to the sale price of production and economical benefits of the company. As a result, it has no directly effect on improvement of technology and efficiency, and reduction of cost. Considering that now it is the key time of the industrialization of wind energy in China, favorable policies may be carried out first to drive the development of wind industry. When the installed capacity reached a certain extend, the problems of efficiency and cost could be resolved by the function of market and the adjustment of the policies.

5 Policy and recommendations

5.1 The government should support and encourage the development of wind energy

The government should support and encourage the development; the state government and the provincial government should establish a proper financial method for the work of wind energy survey, regulations establishment and wind power planning. Besides, there should be a certain amount of funds every year to support the work of wind resources measurement,

assessment, pre-feasibility study and satisfy the requirement of the annual wind farm development schedule.

5.2 Ensure wind power to feed into the power grid

By clear ordain to allow the wind power feed into the power grid nearby, and purchase all the wind generated electricity under the condition of guarantee the safety of power grid. The power grid company should invest the transmission line and the improvement of substations for the wind power feed into the grid. This kind of investment should be involved in the running costs of provincial power company, and shared by the und user.

5.3 Formulate encouraging mechanism of the wind power tariff

By clear ordain to make sure that the wind power would not participate the tariff competition and the government provide fixed tariff in a long term, the higher part to the average tariff should be apportioned provincially to protect the benefits of the investors. The method to get the fixed tariff could be the following two: according to the wind resources and construct conditions, get the tariff through the concession biddings; or according to the local society and economic conditions and wind resources, define a fixed tariff and the investors could choose good wind farm to develop. The first one could get competition and absord different kind of investors to lower the feed in tariff.

5.4 Improve the localization and promote the development in a large scale.

Accelerate the localization of the wind turbines; by the method of fetch in technology with trade to get the manufacture technology of MW wind turbines on the principle of technique introduction, absorbing and development. Formulate a national examine center of the wind turbine and its components, a quality control system and authentication system to promote the product’s quality, lower the cost and consummate the services.

5.5 Carry out Renewable Energy Portfolio Standard (RPS)

Realize the distribution of wind power between provinces to activate the economic

development of western China. Realize RPS and develop a certain of renewable energy every year by establishing law. Make the development and consuming of renewable energy a responsibility of the whole society to achieve the planning goal. Establish the exchangeable green card index of renewable energy step by step; the government set tariff by market supply and consuming to solve the problem of unbalance of the wind power development in different areas.

Appendix

National and provincial policies for supporting the development of wind power

Documents of National laws and policies

1. Support to the development

Renewable energy and clean energy is encouraged and supported by the government to be utilized. In “Electric Power Law of the People's Republic of China”, “Energy Conservation Law of the People's Republic of China” and “Atmosphere Pollution Prevention and Cure Law of the People's Republic of China”, there are corresponding items. Therefore, government departments in charge such as former SDPC and SETC managed the compiling of industry plan actively. Policy documents such as “Development Compendium of New and Renewable Energy (1996-2010)”, “Agenda of Twenty-first Century of China”, “The Industry Development Plan of New and Renewable Energy” and “The 10th Five-year Plan of Energy Conservation and Resources Comprehensive Utilization” were issued successively. Those provided guides to development of new energy including wind energy.

In 1996, the former SDPC started “The Ride Wind Program” to gain technology by offering market to foreign manufacturers. The technology of wind turbine manufacturing was promoted. In 1999, former SDPC started the “Brightness Project”. The project aimed to provide electricity to 30 million people off-grid by small-size wind turbine and solar home system. The installed capacity of small-size wind turbine in China ranked number one on the world by this project. In 2000, former SETC and SDPC started the “National Debt Wind Power Projects” with a total capacity around 80MW. It was expected to pull the development of domestic wind power equipments manufacture, decrease the cost and buildup the international competing ability of domestic wind power equipments.

To accelerate the development of wind power in China, NDRC issued the document of

“Notice of carrying out the early-stage work of large-scale wind farms in China” in 2003. In the document, the content and result of the work, organization and funding source of the early-stage work of large-scale wind farms were required and deployed.

2. Supported by feed-in tariff and grid-connecting

In the document of “Regulation of operation and management of grid-connected wind farm” issued by the former Ministry of Electric Power, it was regulated that the supervising department of power grid should permit the wind farm to connect to near grid and purchase the total electricity. The feed-in tariff is calculated by the principle that the tariff should cover the cost, debt repayment and reasonable profit. The benefits of investors were insured and the construction of wind farms boomed.

Along with the reform of the socialism market economy system and the transform of the power market, former SDPC adjusted the method of ratifying the feed-in tariff to restrict the increasing of electricity cost and decrease the tariff. In the corresponding document, it was regulated that the tariff should be calculated in a lifetime mode. This regulation could advance the cost controlling of wind power project, reduce the tariff difference with conventional energy, and favor the long-term development of wind power.

3. Supported by taxation

As wind power has no VAT discount of input, the burden was relatively heavy when the VAT rate was 17% and the feed-in tariff of electricity was obviously affected. In 2001, the Ministry of Finance and the State Administration of Taxation issued a document about the VAT policy of part of resource utilization and other productions. In this document, it was clarified that VAT of part of productions would be levied as half of the due ratal since January 1 of 2001. Electricity generated by wind power was included.

Documents of provincial policies

1. Guangdong Province

The Guangdong Development and Planning Committee, and Guangdong Science and Technology Committee issued a document in May of 1999. This document transmitted the notice from SDPC and the Ministry of Science and Technology about more support of renewable energy development. In this document, some measures favored to wind power were put forward combining the practice of Guangdong province. Follows were included:

Land acquisition of wind farm would be implemented as the area occupied by the foundation of wind turbines in principle. The temporary land occupying and land of auxiliary establishment would be approved according to the fact.

Grid connected electricity generating companies of renewable energy that were approved according to the construction process of fixed assets investment projects would be favored in income tax. In the debt repayment period checked by related government agencies, all the income tax would be returned to the companies. The returning would stop when the debt repayment period ended.

Electricity generating projects of renewable energy were permitted to connect to the near power grid with priority. The supervising department of power grid should purchase the total electricity as the grid capacity allowed. In the debt repayment period checked by related government agencies, the tariff higher than the average feed-in tariff should be shared by local power grid.

Government agencies of Guangdong province issued a document about accelerating the wind power development in Guangdong province in July of 2001. The document affirmed the achievements of wind power development in Guangdong province and put forward the follows combining the practice of Guangdong province:

The Government of Guangdong province encouraged developing wind power by financing from various sources. Exploitation of wind resources should be planed as a whole and utilized reasonable. In the period of the 10th Five Year Plan, the newly installed capacity of wind

power would be 300MW in the province.

The supervising department of power grid should permit the wind farm to connect to near grid and purchase the total electricity. The feed-in tariff shouldn't higher than the average sale price of the grid in the province. When the feed-in price bidding was implemented, policy support to wind power would be provided.

Wind power projects should control the cost to within RMB 8000 Yuan/kW at present (including power transmision project). Wind equipments should use local equipments of large capacity as possible and the localization rate should be higher than 40%. The return rate of equity should not higher than 10%. The depreciation period and debt repayment period were both 15years.

Land acquisition of wind farm would be implemented as the area occupied by the foundation of wind turbines. The land occupied by auxiliary establishment would be requisitioned according to the actual area. Wind power could obtain tax credit and other favored policy according to relative regulations.

2. Xinjiang Uigur Autonomous Region

In Feb of 2001, the Land and Resources Department of Xinjiang Uygur Autonomous Region issued a document about the ration standard of land used by wind power project construction. The main contents were:

Land acquisition of wind farm would be implemented as the area occupied by the foundation of wind turbines in principle. The temporary land occupying in real estate construction and land of auxiliary establishment would be approved according to the fact.

The permanent land occupying of wind power project construction should be calculated by different method according to different functions, and the methods were regulated.

In the scope controlled by wind farm, land area except above-mentioned permanent land occupying could be enrolled as protected area of wind farm. The original unit could keep on using the land but the safe operation of wind farm should not be disturbed.

Government departments of Xinjiang Uygur Autonomous Region issued the compendium of research and development of high tech in Xinjiang in Feb of 2003. in the document, the guideline, general goal, main task and preference field of R&D of high tech in Xinjiang were regulated and main measures were put forward.

3. Jilin Province

Government departments of Jilin Province issued a document about support policies of wind power in 1995. The main contents were:

Debt repayment price policy was applied in wind power project. Interests subsidy was provided partly when possible. Income tax paid by wind power company during a certain period would be returned. The VAT would be levied as 6% of the sale income after put into production. Farm land occupying tax of wind farm would be levied according to the area actually occupied by the wind turbines. Land acquisition would be in a planed area. The land would be transferred after approved by regulated procedure.

Chapter 2 Study on Solar PV Development

1 Potentials of PV and Its Strategic Position in Energy Supply

China is one of the countries with immense energy consumption and mainly relies on coal. Under the situation of energy supply in the new century, the energy safety, environmental protection and economic and social sustainable development must be considered by China as an important issue of development strategy. In China or even in the whole world, the conventional energy is limited while the renewable energy is clean, renewable and inexhaustible and will play an important role in energy sustainable supply. Fig.2-1 shows the reserves of conventional energy in the world and China. From the Fig. we can see that the reserve of conventional energy in China is lower than the average level of the World.

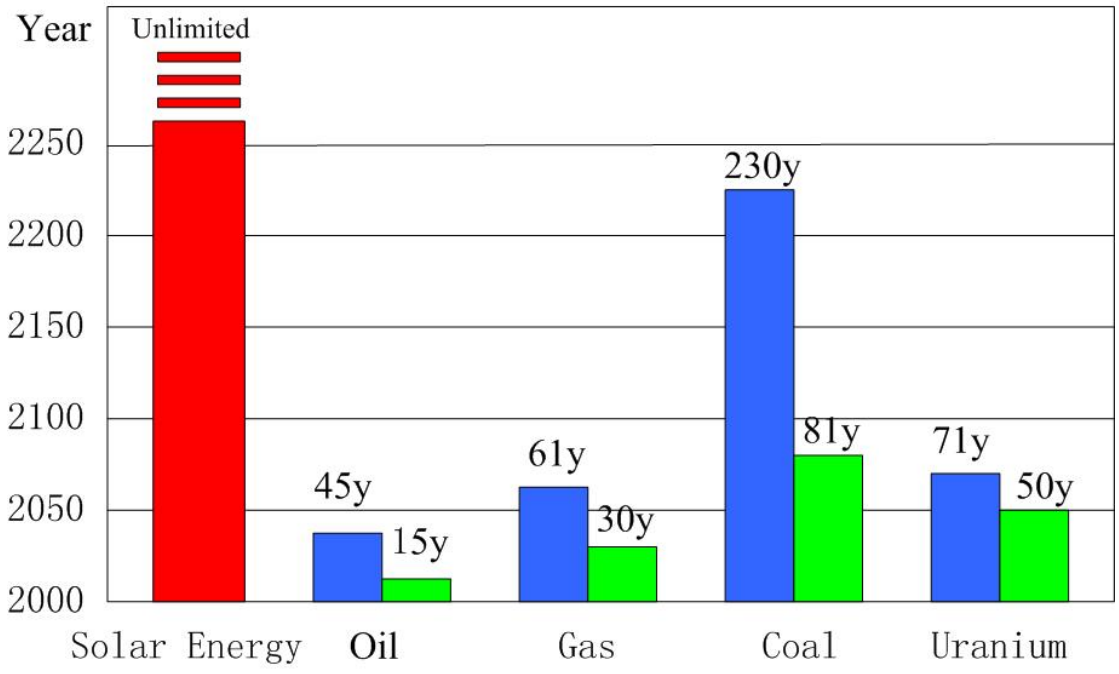


Fig. 2-1 Predictions on Conventional Energy Reserves in the World and China

In the long-term, renewable energy will be the dominant resources of energy for mankind in future. Therefore, most of developed countries and some developing countries attach great

importance to the great effect of renewable energy on the future energy supply. In order to accelerate the development of renewable energy, these countries has increased their input into the study and research of the new techniques in the renewable energy, and has also supported the development and exploitation of renewable energy through legislation and policy making, which in result promoted the booming of the renewable energy. By 2000, the global consumption of renewable energy reaches approximately two billion tons of standard coal, that is, 13.6% of the entire world's primary energy consumption, among which the large hydropower and traditional utilization of biomass energy take 85% and the new types of renewable energy account for 15%.

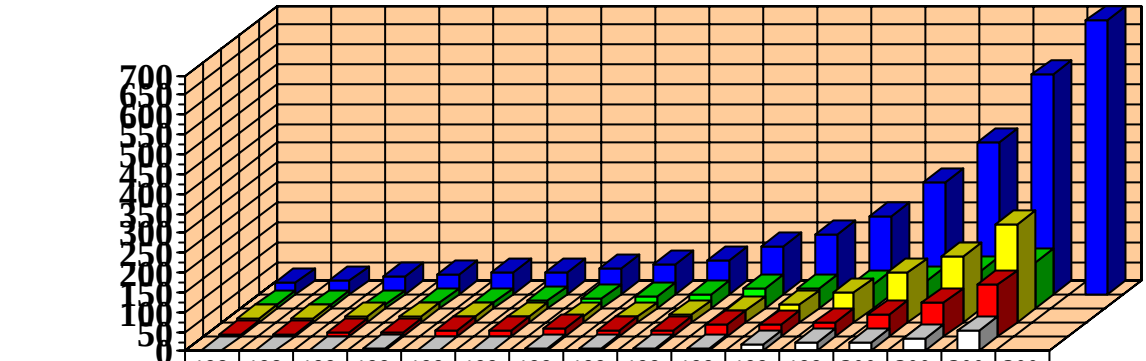
Among the new renewable energy, PV and wind power generation are growing most rapidly, which certainly become the focuses of many countries. These countries, viewing from the point of energy supply security and clean energy, make the commercialized exploitation and utilization of PV as the mainstream of development. EU, Japan and the United States put emphasis of energy supply security on the renewable energy, especially on the solar energy section. It is estimated that by 2030, solar power generation will amount to more than 10% of the world's electric power supply, and by 2050, it will reach above 20%. Exploiting and utilizing solar energy on a large scale is necessary and essential for the solar energy to play an important role in the entire energy supply.

The Chinese government attaches great importance to the development of renewable energy techniques, and takes the PV as a significant issue in several Five-Year Plans. However, due to the limited input, the decentralized management, and the insufficient intensity of development, no complete set of scaled manufacturing chain was formed till now. Therefore, the industrialization level is far behind the international advanced standard and also failed to meet the requirement of the civil economic construction. Hence, in order to exploit and utilize the renewable energy on large scale and increase the ratio of PV power in the total electric power supply, it is necessary to strengthen the support to industrialization, further the development of the techniques for industrialization in great depth and accelerate the perfection of the streamlined techniques so as to enable the scale manufacturing of PV power

in short time.

2 The current situation and trends of PV development

Solar cell is a semiconductor device based on photovoltaic effect of materials, which directly converts solar energy into to electric power. In 1954, the first practical silicon solar cell （η＝6%）, together with the first atomic energy power station emerged in the USA. In 1959, the solar cell has been used in the space discovery and in 1973; solar cell was transferred to ground application on large scale after the energy crisis. In recent years, the production of solar cell has increased dramatically, with 30% increase annually for 7 continuous years. By 2002, it has reached the peak of 561MW. The graph Two gives a description of the world's annual production of solar cell.



	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Rest of World	3	4	4.7	5	4.6	4.4	5.6	6.35	9.75	9.4	18.7	20.5	23.4	32.6	55	
Europe	6.7	7.9	10.2	13.4	16.4	16.6	21.7	20.1	18.8	30.4	33.5	40	60.7	86.4	135	
Japan	12.8	14.2	16.8	19.9	18.8	16.7	16.5	16.4	21.2	35	49	80	129	171	251	
United States	11.1	14.1	14.8	17.1	18.1	22.4	25.6	34.8	38.9	51	53.7	60.8	75	100	120	
Total	33.6	40.2	46.5	55.4	57.9	60.1	69.4	77.6	88.6	126	155	201	288	391	561	700

Graph 2. The World annual Output of Solar Cell (consignment quantity)

The technique of solar cell is progressing rapidly, which is mainly focused on the following aspects: (1) The manufacturing scale of commercial solar cells has been enlarged rapidly, that is, the annul production of a single factory can reach 250MW. (2) The manufacturing devices have become more automatic and intelligent (3) Many new types of batteries are practical and

highly efficient. For example, the efficiency of crystalline silicon solar cell package has increased very fast（η＝20％）. The film solar cell has been put into practical use. (The production line with an annul production of 15MW is being operated by the US AP company; the production line of annul production of 40MW has commenced operation by the Japanese Zhongyuan company.(4) The cost for the solar cells is declining rapidly(the price of monomer solar battery is 1.6 $/ W, the price of a package is 2.6 $/W). By the year 2010, the cost of the solar cell can be reduced to 1.0$/W hopefully. The cost of the PV power generation system will decrease below 2 $/W, and the cost of clean PV power generation can come down to 6 – 10 cent /kWh.

To protect the environment and meet the requirement of sustainable development, many nations in the world have set up their magnificent plan for the development of PV cell one after another:

The new energy plan of Japanese government ： 2010－5 GWp；

The white papers of renewable energy of EU: 2010－3 GWp；

PV plan of the US: 2010－4.7GWp；

Gregorian calendar	2000	2005	2010	2020
Annul output of solar cell （GWp）	0.26	0.91	3.2	30
The accumulative total solar cell installation （GWp）	1.26	4.19	15	150
The price of solar cell （US$/Wp）	3.5	2.8	2.0	1.0
The price of PV system（US$/Wp）	7.0	4.68	3.12	1.52
The cost of power generation （US$/KWh）	0.246	0.164	0.11	0.053

Australia: 2010－0.75 GWp；

Developing countries ～10％	2010－1.5 GWp；
The World’s accumulative total PV installation	2010－15 GWp；
In the next 10 years, the average increase rate is approximately	28.5%

With the decrease in the cost of solar cell, rapid development will be made in grid-connected PV power generation system. The table below gives the prediction of the world’s solar cell prices and the cost of power generation (the data is roughly consistent with the situation in China):

Study on solar cell was started in 1958 and first applied on the Dongfanghong II satellite in China. In 1973, solar cells were applied on the ground use. The PV industry of China was at the primary stage before 1980s, during which, the annul production of PV had always been below 10KW while the price was very high. As confined by the high price and low output, the market of solar cell was developing very slowly. Except for applied on power supply of satellites, the solar cell was limited to a very small range of low power system on the ground, such as beacons, railway signal system, the power supply for the equipments in weather stations on the high mountains, electric enclosure, black light lamp, direct current daylight lamp, the power of which are generally several watt to dozens of watt.

During the period of the Sixth Five-Year Plan and the Seventh Five-Year Plan, supports were given to the development of the PV market and industry in China. Both the central government and the local governments input some funds into the field of PV, which consolidate the rather weak Chinese solar cell industry and carry out demonstrations in several application areas, such as microwave relay station, military communication system, water gate, cathode protection of oil pipeline, carrier telephone system in countryside, mini-type household system and village power supply system. Meanwhile, during the Seventh Five Year Plan, China has introduced several foreign solar cell production lines, amongst which one was amorphous silicon cell production line of 1MW and others were single crystal silicon cell production lines. This enabled the productive capacity of China increase to 4.5MWp/year abruptly. At the same time, the price fell to around 40 ￥/Wp comparing with

80￥/Wp or so at the beginning of the Seventh Five Year Plan. This exerted positive effect on the exploitation of PV market. Now solar cell is no longer applied only in the small power supply system, but also extends to a broad range including communication, traffic, petrol, electrification of rural areas, civil product and so on. PV power generation has not only been listed in the nation's key projects, but also in the nation's electric power construction plan. Moreover, it has been applied in some critical projects, including "The bright project " of the National Development and Reform Commission, the construction project for the towns without electricity supply in Tibet initiated by the Ministry of Electric Power, the Ahli photoelectric project in Tibet, the forest fire control communication system project initiated by the Department of Forestry, optical cable project of Ministry of Post and Telecommunication, Cathode protection of oil pipe line of Department of Oil, the "Available in every village" project initiated by the Department of TV and Broadcasting, etc. In 2001, the annual output of solar cells reached 4.5MWp in China and the accumulative amount of consumption reached 20MWp.

In 2002, the National Development and Reform Commission initiated "Power Supply Plan for the villages without electricity in west region". The objective of the project is to solve the problem of power supply in 780 villages without electricity supply in the seven provinces in west regions of China (Tibet, Xinjiang, Qinghai, Gansu, Inner Mongolian, Shannxi and Sichuan) and to reach 16.5MWP for PV use. This project stimulated the PV industry greatly. Several solar cell packaging line have been built up, which lead to a dramatic climb in the solar cell with annul production to 100MWP/year (the production of the year 2002 was 20MWp). By the end of the year 2003, the accumulative total installation of solar cell in China has reached 50MWp.

3 The major barriers for developing PV power generation in China

As known to all, China has very rich resources of sunlight and a large potential market. After 20 years' efforts, a solid foundation has been established for the further development of PV power generation and larger scale application. However, in order to achieve the complete

commercialization, and further enlarging the market, it is necessary to clear the barriers, which block the development of the market including the cost of production, criterion of construction, funds, policy and exploitation of market.

3.1 The obstacles of the industry

The PV industry in China has been developed in an unbalanced way and out of line in each links.

The international PV industry is basically balanced in all the sectors. Generally speaking, the supply and demand is in a harmonious state and the output of each sector is essentially determined by the market. The coordination among each sector can guarantee the industry of PV to develop rapidly and soundly, and the cost to drop sharply.

Due to various factors, each sector on the manufacture chain of the Chinese PV industry was developed in an inconsistent and unbalanced state. The pattern of the manufacturing chain is like a horn with each sector weak to different extents and dependent on the import from the abroad. Especially for the solar silicon material, silicon ingot/ silicon wafer and device which are very essential parts of the PV industry, the manufacturing capacity is really low. This phenomenon reflects the weak basis and congenital deficiency of the PV industry. The weak basis and the unbalanced and inharmonious development are responsible for the high cost of the products and the low competitive capacity.

- Solar silicon raw materials

At present, most of the silicon material for the solar monocrystal silicon and polysilicon ingot depends on the importing. It is still a blank in the field of trial-producing the solar silicon materials.

- Silicon ingot and silicon wafer

The production of silicon ingot and silicon wafer used for solar cell mainly includes the manufacturing of CZ monocrystal silicon and polysilicon ingot and slicing. Now, the total manufacturing capacity of monocrystal silicon ingot and silicon wafer is about 37MW, in

which Ningjin of Hebei province contributes about 30MW, the 605 factory in Beijing takes 2MW, Ningbo, Yunnan and Qinhuangdao altogether produce the other 5MW. Because of the small scale of manufacturing and high cost, it is even more worthwhile to purchase silicon. Generally, the contradiction between demand and supply in china is not very significant.

At present, annul production capacity of polysilicon ingot/ silicon wafer is only around 10 MWp, which falls far behind the domestic demand and claims the weak sector of the development and production of polysilicon cell in the future.

- Cell-manufacturing

By the end of 2003, China has put into production of crystal silicon cell, with the production capacity of 50MW(of which, Shangde of Wuxi City possesses 25MW, Ningbo, Yunnan, Qinhuangdao, Shanghai 811 and Guofei take the other half). The share doesn't reach 1/100 of the world's total production capacity (in the year 2003, the total yield of the world was 700MWp). Due to the small scale, the drawback in techniques and many other factors, the cost is higher than that of the world's market. Therefore, in 2002, when "Sending electricity to every town" project took shape in a short time, the market show the lack of capacity of handling contingency and the capability of competition. Therefore, for this 20MW PV project, the cells made in China took up less than 10%.

- Module production

At present, China has a 50MW production line of PV modules. By the end of year 2003, it reached 100MW, which largely exceeded the production capacity of the cell. Consequently, most of the packaging lines use the imported silicon wafer.

All in all, except that Japan stock-control company exports and sells back single crystal silicon ingot and silicon wafer, every section in the manufacture chain of Chinese PV industry has the same problem that the production capacity is smaller upstream and larger downstream. The mismatch and inharmonic situation between upstream and downstream (larger in downstream and smaller in upstream) are two essential factors resulting in the high cost of Chinese PV industry

Small scale and low automatic level

The production scale awfully affects the cost of the products. According to the experience curve (or the learning curve), for most of the industries in the world, the cost declines 10% to 30% with the doubling of the production scale. As the cases of PV, the statistic outcome is 20%. The method included of the concept that the level of technology and the scale of the manufacture progresses shoulder to shoulder. Using this method to calculate the cost of every section in the solar cell production, we have gained a graph , which can illustrate us the fact that increase in production scale results in the reduce of the cost. The graph Three shows relationship lying between silicon wafer and the production scale (the red line stands for the selling price, the blue line stands for the cost, assuming that the price is 1.3 times of the cost).In the other sections, for example, cell production and package enclosure, show the similar relationship.

One issue to be addressed is that the Chinese enterprisers do like to enlarge the production scale. However, the case is that the Chinese PV market is very small and rather instable. Without the corresponding policies and laws, the huge rise is the largest barrier for the enlarging of the production scale.

The specific material and productive device in the manufacture of the cell and the package

The quality of the supporting specific raw material for cell production needs improvement.
The manufacturing of productive devise and testing equipment is rather lagging behind.

The industry does not associate tightly with the study and the invention.

China devotes so little into the projects showing strong association with PV industry. The supporting technology of industrial department is very weak and the development of technology is progressing in very relatively slow paces.

3.2 Technical Barriers

For the off-grid power generation system, including village power supply system, household power supply system, communication signal power supply and other types of solar products, the technology is rather mature in china without barriers. For the crucial component parts of the PV power generation system consisting of solar module, storage batteries, controller, and inverter etc, the technological standard has been established rather completely. The technological level of the product shows a little distance between the international standard.

As in the case of grid connection, China is now at the preliminary stage. The Ministry of Science and Technology initiated the technological development and experimental unit demonstration study of roof PV power generation system in “the Ninth Five” and “the Tenth Five”. Very encouragingly, progresses have been achieved in these projects. Synchronize and close PV power generation systems of different powers from 5KWp to 50KWp have been built up. In the fields of inverter and controller in grid power generation system, the interface technology of synchronize and close PV power generation system and electric grid, distribution system , computation and detection, data collection and system monitoring, some successful experience have been gained. These progresses indicate that China has elementally obtain the critical technology of grid PV power generation system, including VCT, PWM maximum power following-up control technique, grid connection inverter technique, the data acquisition of the system and data transmission techniques. China now is capable of designing, constructing and applying grid PV power generation system of certain scale without any negative effects. The safety of the system can be under thoroughly guaranty. The application of PV technology, generally speaking, is not regionally restricted. It also enjoys the unique advantages such as safe and reliable, zero noise, zero pollution, null requirement of fuel, able to supply power on the spot without power transmission line and short construction cycle. All these factors are out of reaches of the conventional power generation system and other power generation techniques. In addition, the broad application of grid PV power generation system can also enjoys the following direct benefits:

- Power generated on every roof on the spot, used by every own house, dispersed power station, no space being occupied；
- Peaking regulation electric network ；
- The twig of the electric grid merges into the system can help with the improvement of power supply quality on the twig of the electric grid.
- Power factor compensation

Now technical standard of grid-connected PV power generation system is under establishment in China. By the end of this year, it can be submitted for final approval. The issuance and application of the technical standard can further regulate grid-connected condition, ensuring good performance and safety.

3.3 The market development

Currently, the major market in China is on the communication/ signaling areas, other industry fields and application in the remote farming and pastoral area, which is very obvious from the two graphs above.

- Before 2002, the annual production (the domestic market) contributes only 1% of the world's yearly yield;
- In 2002, the Chinese government start up the SDDS program, shed light on the market, bringing it up to 20MWp, which is nearly 4 of the world's yearly output;
- It had been estimated that by the year of 2003 the Chinese solar installation would not exceed 10MWp;
- Currently, the annul export of solar module is not less than 10WMp.

The commercialized market

At the present, the commercialized market in China is generally in the field of communication/ signaling, other industry areas, commercialized solar products(solar garden light, solar road light, solar watch and calculator) and the application in the remote farming and pastoral zones,. The market of communication signal and industry area is rather limited, the annul demand of which is very stable (about 10MWp); the commercialized power supply

usage per year is approximately 20MW; the pure commercialized solar energy household power supply market in the farming and pastoral area will not exceed the point of 10MWp as well.

National village electrification project

In China, the PV power generation system is playing an important role in providing electricity to some remote regions, and will be playing the same important role for another 10 years. The market in this area is of great potential. China has already initiated "SDDX" program, in which with the help of PV systems, 800 towns without electricity has been powered on. There are still about 28,000 villages without electricity and 7 million households without electricity longing for PV electricity (the potential market is about 1500MWp). However, there are some problems as following lying in the way.

For the power station that already been built up：

- The construction of the power station is invested by the government. But who takes control afterwards? Who should be responsible for charging?
- The problem of maintenance and management after the completion of the construction of the PV power station.
- The charging standard and the ability to pay；
- If the collected electric charge is insufficient to maintain the operation of the power station and the replacing of storage battery, after several years, who will be responsible for the price gap?

For the village electrization PV projects in the future:

- The source of investment and the mode of financing;
- What types of sustainable development policy and commercialized mode of operation should be adopted?
- The other problems are the same ones mentioned above.

Grid connected PV program

Grid connected PV power generation is the necessary result of PV power generation entering the area of the large scale application of electric power , and also the largest market of PV power generation in the future. However, the market in china has not yet been launched, which is largely depending on the policy support from the Chinese government. If the Chinese government intend to initiate this project, the following problems are required to be solved：

- The technical standard;

- The admittance of electric grid;
- The planned ratio and the goals to achieve in power generation (Peak regulation? Emergency measure? Reduce the release of greenhouse gas?)
- Promoting policy and the electricity grid price;
- The development and production of components(Solar cell unit, invert and control equipments)

The development of super scale PV power generation and long term PV power generation area

PV power generation and the long term application generally include the following items:

- power station on the desert;
- Large scale of photoelectric production of hydrogen;
- Large scale of PV water rising power station;
- The application of PV power generation in the area of electric automobile;
- Power generation in the space.

In this area, it is still empty for China.

3.4 The overseas stimulating policy and law

Frankly speaking, the largest gap lying between China and the world's leading countries in the field of PV power generation is the confirmation of the government's developing aims and the stimulating policy and laws established corresponding to the aims.

The Japanese government asset forth the developing aims of renewable energy (including hydroelectricity and geothermal energy0, which states by the year of 2010 the renewable energy should contribute 3.1% of the total amount pf primary energy supply (or 19 million tons of oil equivalents). In 2000, the ratio is 1.2%. In this aim, PV power generation occupied 4,820 MW.

In order to fulfill this purpose, the Japanese government established the corresponding plan of study and development, demonstration project and subsidy policy. In the study and development of 2001 to 2005, it includes the exploitation of solar cell of new generation,

large surface amorphous silicon and polycrystalline film cell, the development of public application technology and long term solar cell (such as millimicron cell, coloring matter cell, spherule crystalline silicon cell). The demonstration projects included: BIPV project demonstration, PV house centralized synchronize and close demonstration (200 houses of 3KWMp PV centralized in a region conducting synchronize and close system), PV house promoting plan (during the period between 1994 to 2001 80,000 set of the systems had been installed), local new energy promoting plan and enterprises new energy grant-aid plan and so on.

The concrete subsidy policy is that, the subsidy is provided during the installation of the PV power generation system, which decreases evenly every year. From the 50% subsidy in the very beginning, through 10 years' gradual decline, by the tenth year, the subsidy is null. Besides the installation subsidy of the PV system, the system is allowed to supply electricity "back - flow" to the electric grid. And the buyers can purchase the electric power at the same electricity price, which is very similar to " the net deficiency meter measurement " in USA.

Most amazing actions of German government are the 100,000 PV roof project and the new energy electric power law issued in 2002(Further editing has been carried out in 2002, making the law more favorable to the wide spread of PV power generation).

"The law of renewable energy" in Germany states that the electric power corporations should purchase the PV electric power on the grid at the price of 0.99 Germany mark. In 2004, some changes have been made in the law, according to different power classes and different mode of installations. The new edition of law is as follows:

The American president Clinton announced the million roofs projects in the year of 1997, which states by the year 2010 PV power generation system and photo-thermal heat system should be installed on 1 million roofs. In USA, 30 states have passed "the net deficiency meter measurement" specific for PV. The electricity generated by the PV system is allowed to go into the electric grid and the amount of the back-flow is measured. The electric charge should be conduct according to the net reading of the meter. The meter is allowed to run

backwards. When electricity provided by the PV is greater than the electricity consumed, the electric power corporation should pay at the retailed electricity price. In the California, the "Boy Down" policy provides subsidy directly on the purchase of electricity from the solar cell power generation system, about 4 American cents per Watt.

Grid System	**Price [Cent/kWh]**		
2004	**Initially 30 kW**	**30 to 100 kW**	**Exceeding 100 kW**
Building / sonic barrier	57,4	54,6	54,0
vertical wall of building	62,4	59,6	59,0
Broad field in countryside		45,7	

In Span, the new "Electric Power Law" encourages synchronize and close PV power generation system. The electric power corporations should purchase the electricity from solar energy at higher price. As to the system below 5KWp, the price of the solar energy electricity is 0.38 Euro per kilowatt. For the system larger than 5KWp, the price of the solar energy electricity is 0.28 Euro per kilowatt. On the contrary, the conventional electricity price is only 0.03 Euro per kilowatt.

3.5 The corresponding policies and laws in China and the implementing effects

In China, there are no favorable policies and subsidy policy that can be operated practically. As for grid connected PV power generation, the National Development and Reform Commission and the Ministry of Science and Technology had jointly announced the document (Ji-jichu 1999 NO.40), which was a notification about further supporting of the

renewable energy development. It claimed clearly that for the grid connection power generation project adapting the renewable energy, under the allowance of the capacity of the electric grid, the managerial department should allow connection to grid in the near site and purchase all the electric output on the grid. However, there are no detailed practical electricity price policy and the standard of subsidy. The electric power department has not cleanly approved the parallel in of the PV power generation. As for the grid connection PV power generation system already built up, the electric power departments provide permission to every single project respectively. Moreover, the electricity generated by the PV system is either consumed on the spot by the local user or parallel in the grid free of expense. The electric power departments do not spend money on the purchase of solar energy electric power. In the conclusion, although the country in principal regard the PV grid connection power generation as positive and tend to be supportive, the further soundness of the policy is required to popularize it in large scale.

As for the off-grid PV power generation system, the corresponding laws and policies are still empty. But there are a number of projects enjoying subsidy directly from the nation, such as: the construction of no electricity supply town project of the National Electric Power Corporation, the send electricity to every single town project of the State of Development and Reformation Formation, the bringing broadcast and television to every village of the Department of Broadcast and Television. These projects are funded by the corresponding national departments, but commercialized promoting projects. The appropriate fund is for specific project, and does not possess the sustainable feature. This type of national appropriative fund project cannot be generalized, for there is no commercialized market, resulting in the problem of maintain and management after the completion of power station. Therefore, in order to popularize the off- grid PV power generation system, the policies and laws with aim of promoting the market should be set up.

3.5 The input of fund and financing

The Chinese government devotes very little in the PV power generation, compared to the developed countries.

EU:

The five year financial support of EU ：

Structural finance

300 million Euros

The study and development (The fourth framework plan) 400 million Euro.

The investment from EU member countries 1.6 billion Euro

(Amongst which 38% are ants and subsidy, 62% is indirect support)

Private investment 1.3 billion Eruo；

The “take off movement” of EU

Investment on PV 2.85 billion Euro.

Britain：

The British government issued the “the law of renewable energy”, which become effective in the beginning of 2002. This law commands that the entire licensed electric power supplier must employ renewable energy to supply 3% of the total electric force within 3 years (March, 2003). By 2010, the electric power generated by renewable energy should contribute 10.4% of the total electric force. In addition, it set forth the 1 billion pounds specifically for the development the technology of renewable energy (PVIR, Vol.XX No. 9, p4).

Italy：

Italy launched the PV roof project in 2001. The government provided 28 million US dollars and the subsidy rate reached 75%. System 1 –50 kW, is connected to the grid. The electricity price is the same as the conventional electricity price.

China

“The tenth five-year plan”:

The money devoted into PV R § D: “973” + “863” + “tackle key problem” ~ 100 million

4 The basis and necessity of supporting PV power generation by law

The successful cases abroad

Viewing from the experiences of developed countries in the world, the law plays a very critical role in the development of PV power generation. The 100,000 roofs project in Germany is a best example, which was initiated in 1999 and completed in 2003. In 2000, law on renewable energy power was issued in Germany. By the end of 2001, the installation of PV power generation in Germany was 230% of that of 2000. The German government considered the 100,000 roofs project as an absolute success. The contents of the 100,000 roof project and its achievement are as follows:

The major contents of the PV part the German renewable energy law on

- The electirc network corparations have the responsibilty to purchase the electricity from renewable energy, and pay for the compensate electricity price on the electric grid;
- In the fixed period of time, enjoy the stable electricity price on the grid
- The electricity price of the newly built power station declines every (PV: 5%/a);
- The law should be put into action on April, 2000;
- The cost is chared equally: the portion higher than the regular electricity price is shared equally within the country;
- PV: the electricity price on the grid in the beginning is 50,6 Cent/kWh, by the year 2003, it was brought down to 45,7 Cent/kWh;

The success can be seen in the following aspects:

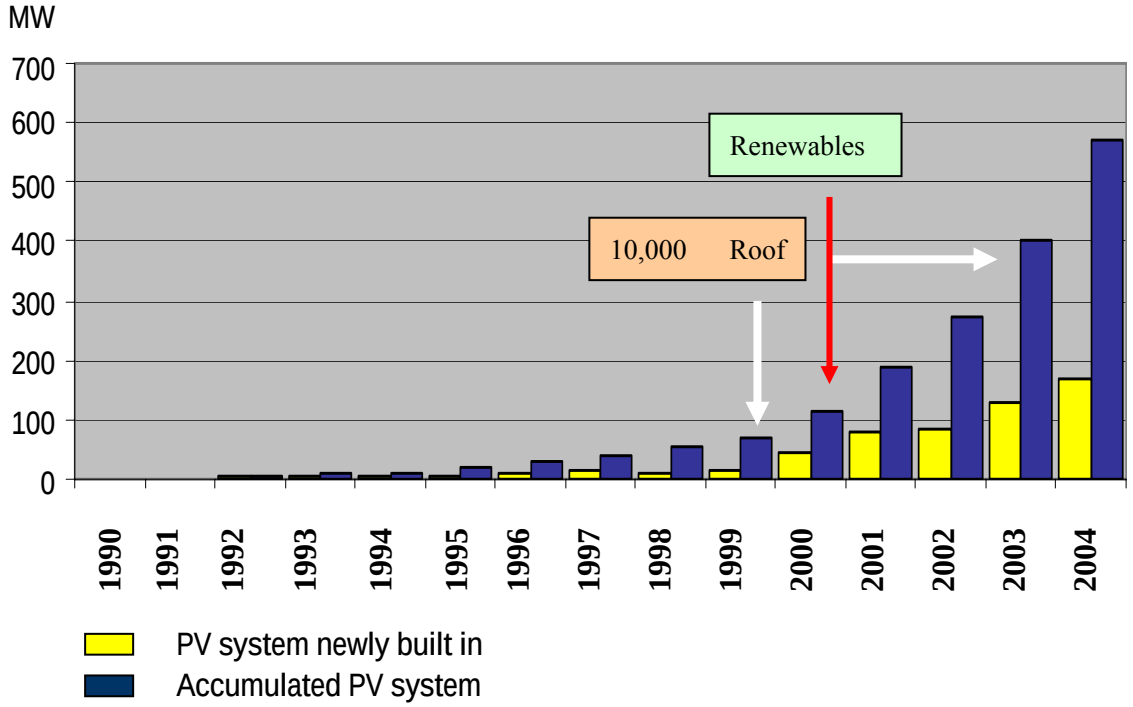
- not entirely relay on the national fiancial promoting system;
- The income of green eletricity is used to purchase the long price green electricity;
- The successful progressing of 100, 000 roofs project;
- The installation of PV system exceeds the expected 300MWp (the actual intallation is 350MWp);
- The adjustment of prices: send the PV into real market;
- The loan form the banks has been recovered completely;
- Thousands of job opportunities brought by renewable energy;
- The price of the PV system has declined 8% from 1999 to 2000. This tendence will contiue in the following years;
- The similar mechanisms are under operation in other countries.

What is called “green electricity purchase green electricity” is that the citizens are voluntary to buy green electric power, which is more expensive than the regular electric power (around 10 Euro cents per kilowatt) for 2 to 3 Euro cents. The electric power corporations spend the income from selling green electric power on the purchasing of high price green electric power (around 45.7 – 50.6 Euro cents per kilowatt).

Benefited from such laws, the user of PV power station gains interest by selling the expensive

green electric power to the electric power corporations. The bank loan can be recovered. The factory producing PV can earn money from selling solar cell. The government fulfils the aim of promoting clean energy. The electric power corporations purchase the high price green electricity with the markon of selling green electricity. In this way, there is no lost for the corporations (just like a Chinese old saying: gain from the people and spend on the people). At the same time, the duty of reduce the amount of release is also accomplished. Through the promotion by media, those people buying the green electric power are very happy to be informed that they have made contribution to the development of energy and electric power, the living environment and the nation as a whole, by paying only small amount of green electricity markon. Although the 100,000 roofs project has been finished in 2003, yet the construction of PV roof in Germany have never halted for a mount. The following graph is the development coordination of German PV roof construction (including the forecast for 2004):

The development coordination of German PV roof construction



The law and the operational mode in Germany can be used as reference. The critical point of the German policy is that for all the electric output conduct markon to green electric power and purchase green electric power at high price, meanwhile coupling with low interest loan policy. In china, the quantity of power station is 1650TWh in 2002. If we rise the electricity price per kilowatts for 1 cent, then the green electricity markon through out the country will be 16.5 billion yuan. If the price is increased by 2 cents, there will be 33 billion yuan. For every household, it only cost 15 Yuan every year, which is a small number even for the family with less than 500-Yuanmonthly income. On the other hand, 33 billion Yuanis large enough to conduct the assorting subsidy for Chinese renewable energy power generation electricity price.

The necessity of lawmaking on PV power generation in China

The cost of PV power generation is relatively high at present (for the grid connection PV power generation without storage battery, the cost is approximately 50,000 Yuan per kilowatt, the one with storage battery is around 80,000 Yuan per kilowatt, the household power supply system is about 70 Yuan per watt and the communication power supply system is 70,000 Yuan per kilowatts), Assuming that the average solar cell generates 1500KWh per kilowatts every year, and it will be 300,000KWh for 20 years. If 3 Yuan is charged per KWh, 60,000Yuan can be recovered in 20 years. If 3 Yuan is charged per KWh, 90,000 Yuan can be returned 20 years later. Thus, it can be calculated that the cost of the PV power generation is about 5-8 times of that of the conventional thermal power.

At present, PV power generation is not capable of competing with the conventional electric power. Therefore, certain amount of subsidy is necessary for its development. There are various subsidies including one lump-sum subsidy on devices ("Construction project of towns without power supply" and "Sending electricity to every town" are in this category), electricity price subsidy (such as wind power and the case in Germany) etc. The most feasible method is to conduct the electricity price subsidy. The electric output of grid connection PV power generation should not be lass than 3 Yuan/KWh, and the electric output of the off-grid village centralized power supply should not be lower than 4 Yuan /KWh. In this way, it can be guaranteed that the power generation company that conducted the installation can gain sufficient money from selling the electricity to maintain and manage the solar energy power station and replace the storage battery. In this way, the power station can be taking good care of and run normally. In addition, it is critical to ensure that the power generation companies can gain profit from this, so that they are willing and active to set up the solar power station and afford to run the stations regularly.

In the case of PV household power supply system, the best subsidy measure is to give the one lump-sum subsidy (such as the actions in the project of World's Bank / GEF), bringing down the price to the level that can be afforded by the public since the electric output measurement cannot be conducted and it is also not possible to collect electric charge house by house.

If the electricity price subsidy has been conducted, the off-grid centralized PV village power supply system will be free of the problems of maintenance and management for the reason that the company that built up the PV power generation system has to ensure the normal operation of the power station, to gain profit from the selling the electric output. Otherwise, the cost of construction cannot be recovered.

In order to support the electricity price subsidy, the policy of no interest loan or with discount should be adopted for 20 more years or even longer to reduce the great initial investment for PV power generation.

5 Other supportive methods for PV power generation

In this section, there are some other issues that need to be illustrated. These are important issues but may not be supported through legislation. So, the issues are put forward to the government to solve the problems through other measures.

3.6 Tax policy

1) Product value added tax

As PV power generation manufacturing enterprises do not consume much fuel, there is almost no equivalent deduction from the fuel value added tax. Therefore, in the cost of unit energy supply, the ratio of value added tax is higher than the conventional energy enterprises, which increases the cost of the production. It is recommended that the value added tax be collected referring to that of small hydro-power, i.e. 6%. This will be very favorable for the development of the manufacturing enterprises.

2) Import and export tax

The import tax for the solar cells has been avoided. The value added tax of the import is 17%. In order to stimulate the enterprises in China, higher importing tax for the whole sets of panels should be imposed. However, as for the silicon wafer, solar cell chips, and packaging material, which are short in China, the customs should be reduced or avoided.

As to the export of new energy and renewable energy product, China has already announced and adopted a series of policies promoting export.

3) Income tax

At present, the government has listed new energy and renewable energy as high and new-technology industries, which provides some taxation privilege to the new energy and renewable energy enterprises. For example, referring to the high and new- technology industries income tax action or the foreign funded- enterprise tax action, income tax of those enterprises should be reduced or avoided. Alternatively, according to the energy saving law, the PV power generation and renewable energy product are in the category of energy saving products, and enjoys the corresponding policy and privilege for energy-saving product.

3.7 Credit and investment policy

The government supports the idea of raising funds in various channels, especially stimulates the enterprises to develop PV power generation and renewable energy as dominating force of the industry and takes the advantage of the international pressures on environment protection to attract international organizations and developed countries to take part in the development of PV power generation and renewable energy in China.

1）In the pastureland and remote areas faraway from the power grid and with small load, it is an ideal way to utilize the local renewable energy to solve the problem of power supply. However, most of these regions are very poor. It is not practical to ask the local government and the people to buy the renewable energy power systems themselves. The Ministry of Electric Power shall conduct general survey on the resources, population, economy, and load of the areas without power supply and according to which short-term, mid- term, and long -term electric power construction plans should be made, including programs utilizing renewable energy to solve the problem. In this way, the renewable energy power will be listed in the regular electric power construction.

2）Strive for the specific loan and loan with discount for the development of national new energy and renewable energy. The main measure is to list the PV power generation project in the policy loan category through loan with low interest (discount) policy and bestow discount loan to the PV power generation key project with basic construction loan. The specific fund administration organization can be set up to be in charge of running the fund (or managed by the related bank)

3）Strive to build up specific foundation for the development and construction of new energy and renewable energy. The source of foundation comes from the national financial plan or certain amounts of taxes imposed on fossil energy.

4）Solve the problem of loan guarantee for the PV power generation and renewable energy enterprises. Provide common loan for the PV power generation and renewable energy enterprises through effective methods.

5）Strive for the favor loan from the foreign governments and the international financial organization, overseas grant, the aid foundation and investment fund from the international

organizations (such as UNDP, WB, GEF, etc.). Strive for the intergovernmental cooperative programs on PV power generation, renewable energy, and global climate changes.

Low discount loan or the interest-free loan can bring down the high initial investment in the PV power generation system effectively, and so to reduce the financial pressure of power generation enterprises when investing in the construction of PV power station.

3.8 The price policy

In order to promote the large scale development of grid connected power generation of new energy and renewable energy, the corresponding policies on grid connected power generation and fixed price should be issued. In 1994, former Ministry of Electric Power publicized the policy that the wind power is permitted to connect to the nearest grid and all the electricity output is to be purchased. The on-grid price is set according to the cost of the power generation plus the original payment of interest and the reasonable profits. The differential price with the average electricity price on the grid is shared by the entire grid, which are purchased and conducted by the electric power corporation. This policy was further confirmed in 1999 in "The notification about further support to the development of new energy and renewable energy issued by National Development and Reform Commission and the Ministry of Science and Technology"

There is no clear purchase policy on the electricity price of the grid connected PV power generation by far. To promote the development of PV power generation, we should cooperate with the corresponding departments to stipulate the on-grid policy for PV power generation based on the wind power gird connection policy mentioned above. For example, the principle of "repay capital with interest combined with reasonable profit" can also be used in stipulating the on-grid price of new and renewable energy power, and shall continue for some years. The differential price with the thermal power can be shared on electric grid of a larger region, so as to avoid that the sharing among the provincial level of electric grid results in less enthusiasm of developing new energy and renewable energy, which is a general problem at

present. The experience of Germany can also be adopted which is to purchase the green power by some enterprises with high pollution on a compulsory basis as well as through the publicity of media. The income from the differential price of green electric power is taken care of by the electric power departments, specially used in subsidy for PV power generation and for differential price of other clean energy power.

3.9 The subsidy policy

The government will consider various types of subsidy policy, such as, the direct subsidy on the investment for PV power generation construction programmes, or discount interest loan, and subsidy on the electricity differential price of PV power generation and renewable energy etc.

As for developing PV power generation and renewable energy system with the purpose of providing electricity to the remote and undeveloped region, the central and local government should supply part of the fund directly, as subsidy for the high cost of the PV power generation system and renewable energy system. The scope of subsidy can be determined based on the actual situation. During “the Eighth Five-Year Plan” and “the Ninth Five-Year Plan”, 7 PV power stations were built up in Tibet with the support from electric power construction foundation, which was 439kW in total and solved the problem of electricity supply for 7 towns without electricity previously. In 1995, the National Development and Reform Commission used 3 million Yuan coupling with the German PV aid programme. In 1996, the Ministry of Agriculture provided 1.2 million Yuan to couple with the American PV aid programme. In 2002, the National Development and Reform Commission brought the project of “sending electricity to every town” into action.

The subsidy policy requires large amounts of money. However, China is short of fund, it is difficult to spend much money on the subsidy. Therefore, it is comparatively feasible to form the foundation for PV power generation and development of renewable energy.

In principle, no direct subsidy will be provided to the project investment (except for the national key construction projects that are required to be finished in a period of time). The subsidy for the electricity differential price can be very effective in mobilizing the mechanism of the market and free of problems of maintenance and management after construction (The power generation enterprises gain profit only by selling electricity, and there will be no electricity generated without good maintenance and no profit in result).

For some PV household power generation systems, the electricity output can not be measured and the electricity charge can not be collected. In that case, it can be promoted through market behavior. The lump-sum sale subsidy to products can also promote the development of the market.

Chapter 3 Study on Solar Thermal Application and Development

1 Resource Evaluation

China is one of the countries that have richest solar energy resources. In China, the average annual amount of radiation per unit area (i.e. intensity) ranges from 335 to 837 KJ/cm²/year, with a mean of 586 KJ/cm²/year. It is indicated in Table 2-1.

Table 2-1 Solar Energy Resource and Distribution in China

Type	Region	Annual Sunshine Hours (/h)	Total Annual Amount of Radiation (/MJ.m^2)	Solar Energy Resource
1	West of Tibet, East-south of Xinjiang, West of Qinghai and West of Gansu	2800 - 3300	6680 - 8400	Richest
2	Eastsouth of Xizang, South of Xinjiang, East of Qinghai, South of Ningxia, Middle of Gansu, Inner Mongolia, North of Shanxi and West-north of Hebei	3000 - 3200	5850 - 6680	Good
3	North of Xinjiang, East-south of Gansu, South of Shanxi, North of Shaanxi, East-south of Hebei, Shandong, Henan, Jilin, Liaoning, Yunnan, South of Guangdong, South of Fujian, North of Jiangsu and North of Anhui	2200 - 3000	5000 - 5850	Moderate
4	Hunan, Guangxi, Jiangxi, Zhejiang, Hubei, North of Fujian, North of Guangdong, South of Shaanxi, South of Jiangsu, South of Anhui and Heilongjiang	1400- 2200	4200 - 5000	Poor
5	Sichuan and Guizhou	1000 - 1400	3350 - 4200	Poorest

What we can learn from Table 2-1 is 2/3 of total area in China has more than 2000 hours annual sunshine, which provides a better condition for solar energy application. Except basin

of Sichuan province, solar energy for most of the area in China exceeds or equals to that of other countries in the same latitude, which is much better than that of Europe and Japan etc.

2 Methods of Solar Thermal Application

Solar thermal application includes solar hot water, solar building, solar stove, solar air conditioning, solar heating, solar drying and sea water desalination, solar thermal power generation and other applications in industry and agriculture.

The main application for low temperature solar thermal is solar water heater that provides hot water for bath in residential and heating in swimming pool. At present, vacuum tube, flat-plate and combined storage are the major three types of solar water heater. Most of flat-plate solar water heaters are copper-aluminum composite and all copper. Flat-plated solar water heater is easy to install and convenient to integrate with building, which is the dominated product in world market. There are two major vacuum tube solar water heaters: all-glass vacuum tube solar water heater and thermal tube vacuum tube solar water heater. Combined storage solar water heater is solar collector combined with tank, the structure of which is simple, easy to be installed and cost low, but life of combined storage solar water heater is short and mainly used in rural area.

Compared with traditional air conditioning, solar energy air conditioning saves energy and doesn't emit pollution such as Freon, which can be called green air conditioning.

There are a variety types of solar drying equipments: glasshouse, heat collector, glasshouse and heat collector combined, entire integrated and solar concentration, etc.

Solar thermal power generation is using thermal-electricity affect to generate power, which is applied in industry and agriculture.

3 Necessity of Solar Thermal Application Development for China

3.1 Corresponding with China's Sustainable Development Strategy

In 1992, the State Council in China issued the White Paper "China 21 century Agenda" with aim to make the strategy and countermeasure on sustainable development in 1994. It is stated in the paper, "put the development of renewable energy in the priority status of the national energy development strategy…" and "strengthen the development of techniques of the direct and indirect utilization of solar energy".

Program of Action for Sustainable Development in China in the Early 21st pointed out issues such as "improve energy structure" and " improve energy efficiency", which suggests renewable energy should be greatly developed, biogas, energy-efficient stove, solar energy and wind energy should be applied in suitable region, and rural energy structure should be improved.

Solar energy is renewable, which keeps the environmental sustainable development. Solar thermal application has developed to a scaled industry, which creates social benefit and economic benefit, reduces the consumption of conventional energy, and meets the China's

sustainable development strategy.

3.2 Importance of Accessing Better-off Life in China

In recent years, the growth rate of GDP in China is around 7% to 8%. Building industry keeps increasing, the total annual area of new residential is increased by 1.6 billion to 1.9 billion square meters, and living condition is improved.

Hot water for living is an important norm for better-off life. The varieties of solar water heater meet the different requirements of different people, from household system to big scale hot water supply project for hotel and entertainment places. Because solar water heater can meet the requirement of rural area very well, it improves the rural energy structure. The total annual hot water requirement by 2020 is 20 billion ton, assuming the consumption of per person per day is 40kg. If the application area of solar water heater for per hundred people by 2020 could be 30 square meters, which equals that current in Europe, the total installed capacity of solar water heater in China could be 0.5 billion square meters, which could provide 22 billion ton hot water.

3.3 Cost Efficiency

Since solar energy is the energy source for solar thermal application product, the operation and using fee is relatively much lower than other products. The comparison of costs of solar water heater, gas water heater and electric water heater is in Table 2-2

Table 2-2 Comparison of Costs of the Three Types of Water Heaters in China

Items	Solar water heater	Gas water heater	Electric water heater
Water consumption (tons/day)	8t/d	8t/d	8t/d
Equipment scale 200 liters/unit	40	80	80
Equipment investment (RMB)	150,000	96,000	80,000
Annual operating cost （RMB）	6,600	58,400	52,560
Service life（years）	10	7	8
Average total investment used (RMB)	15,660	72,114	62,560

3.4 Great Effect in Energy Efficiency and Environmental Protection

Solar energy building is an important part of energy efficient buildings

The percentage of building energy consumption in the total energy consumption of China is increased from 10% in 1978 to 27.45% at present that is one to two times higher than advanced countries, which has become an outstanding problem for China's sustainable development. Energy consumption of heating and air conditioning is 65% of the total building energy consumption. In 2020, hot water requirement for living will reach 20 billion ton in China. The integration of solar energy air conditioning and heating and solar water heater with building is a effective and environment protection way to reduce building energy consumption for sustainable development. If the total capacity of solar water heater in 2020 is 0.5 billion square meters, 0.15 billion kWh power could be saved.

Reduce green house gas emission

Building energy consumption results serious pollution in China. The green house gas (GHG) emission from building energy consumption is 1/4 of the total GHG emission in China. With the further integration between solar thermal application product with building, GHG emission will reduce in large with the benefit from solar energy heating and air conditioning system taking the place of traditional system. Taking solar water heater for example, the CO_2 emission reductions in five types of solar energy resource area that showed in Table 2-1 are 306, 252, 180 and 144kg/m^2 respectively.

Reduce industry energy consumption

With development of technology, solar water heater not only provides hot water for living, but also provides medium and high temperature hot water for industry and agriculture, which expands the application of solar water heater. It is estimated that in 1990 the energy consumption in the world is $3.09*10^{20}$ J, among which, industry energy consumption is $1.36*10^{20}$, and 20% of industry energy consumption is for drying. The energy of glasshouse solar energy dryer that is natural air is 100% coming from sun and drying by heating. The power consumption of the fan in the glasshouse dryer that enforces airflow is only 5% of the total energy consumption. The dryer that heating by solar energy and conventional energy together can save 20% to 40% of energy consumption.

3.5 Well Commercialized

Solar water heater industry is the first commercialized renewable energy industry

Solar water heater is the most widely applied and rapidly industrialized solar energy application. The technology, manufacturing technical and production scale of all-glass vacuum tube solar water heater that independently developed and produced by China are in international advanced, which has good international competition ability since its low price. At present, China is the No.1 in solar water heater consumption and manufacture country.

Most of companies are private companies that meets market economic

Private company, stockholding company and state-owned company are the three types of company of solar water heater industry, and private company and stockholding company are majority. Among eight large-scale enterprises with sales of over RMB 100 million in 2002, two of them are state-owned or state stockholding companies; among twenty seven

large-scale enterprises with sales of over RMB 50 million, only eight of them are state-owned or state stockholding companies, the portion of which is only 29.6%.

Solar water heater industry increases job opportunities and promote development of related industries

In statistics, the increase rate of annual production and application volume of Chinese solar water heater is 20% in recent years. The number of employee is over 250 thousand, with annual sale over RMB 12 billion. Industry structure has been preliminary established, which includes raw material process, product development and manufacturing, project design and after service, which has become a fast growing new industry and promote the development of related industries, such as glass, metal, heat preservation material and vacuum equipment, etc.

4 Possibility of Solar Thermal Application Development in China

4.1 History

The research on solar collector was started since fifties in 20 century in China. Some research have been made on high temperature solar collector and medium temperature solar collector as well as their application technology, but the technology of low temperature solar collector and its application technology is most developed, in which, solar water heater has a certain scale and is the largest industry in renewable energy. Solar dryer and passive solar technology is becoming near developed and has a certain application.

4.1.1 Technology Development

a) Solar water heater

The core component of solar water heater application technology is solar collector. With the help of technology R&D from *Seventh Five Year Plan* to *Tenth Five Year Plan*, a great deal of research have turned into production, such as copper-aluminum composite flat-plate solar collector, all-glass vacuum tube solar collector and solar water heater. Especially the successful development of Al-N/Al all-glass vacuum tube solar collector greatly promoted the industrialization process of Chinese solar water heater. Solar water heater enterprises, especially the large-scale key enterprises in the sector, have also been actively developing new technologies (and associated products) that can be integrated into buildings. Examples include solar water heaters with separated parts, solar water heaters that can be hung from balconies and modular solar collectors.

All-glass vacuum tube solar collector could be used in cold area in whole year, which can also be used in heating in industry, drying, air conditioning and sea water desalination. Heat pipe vacuum tube solar water heater combines heat pipe and vacuum tube technology, which can produce 400 ^{o}C temperature to generate power and the key technology research is still in laboratory phrase.

b) Solar energy floor heating

Solar energy floor heating is new building heating method in recent years in China. The water

temperature for heating is relatively low, and the heat exchange between floor and house is mainly by radiation, which makes humidity in normal and room comfortable. Heat collecting and heating circulation are two separate systems, and the system has accessory electricity heating system. Normally, if the area of solar collector is adequate, the electricity heating can be postponed after twenty-three o'clock in a day, when the electricity price is at the lowest of a day, which is cost efficiency. Because the advantages of solar energy floor heating, it has been listed to building energy efficiency technology policy of Ministry of Construction (MOC) and *Tenth Five Year Plan* and *Plan through 2010 on Building Energy Conservation*.

c) Solar air conditioning

After decades of development, the technology of solar air conditioning has come into application. The development of solar air conditioning was put into nine-fifth plan and has made achievements. Guangzhou Energy Research Institution of Chinese Academy of Sciences (CAS) successfully developed practical solar air conditioning at Jiangmen city, Guangzhou, in January 1998. Water temperature for refrigerating is 65 ^{o}C to 75 ^{o}C, and water temperature for living is 55 ^{o}C to 60 ^{o}C. A 100kW refrigerator that is absorbing heat from two polar could provide 600 square meters air conditioning. Beijing Solar Energy Research Institute developed a 100kW solar air conditioning in Rushan, Shandong province, which used thermal tube vacuum tube solar collector and refrigerator that is absorbing heat from one polar and operates in medium temperature.

The main obstacle for commercialization of solar air conditioning is cost, only by reducing the cost of solar collector refrigerator could help.

d) Solar drying

The technology of solar drying is matured in all. Since solar drying has high technicality requirement especially in drying technique, it is still not in commercialization scale. Because of lack of finance and structure reform, some research institutes stopped development and promotion of solar drying. Since users are mainly in rural area where is lack of technical support, users can't use solar drying technology well.

In the national western development strategy, solar drying technology has the most opportunity to be first fully developed in western region where has adequate sunshine.

e) Solar thermal power generation and solar sea water desalination

Solar thermal power generation and solar sea water desalination is still in laboratory development period in China, which is five to twenty years behind advanced countries.

4.1.2 Solar Energy Building Trend

Table 2-3 Application Volume of Solar Thermal of China in 2002

	Application area (thousand square meters)	**Energy saved**	**Equals to standard coal (thousand ton)**
Solar water heater	40000	100kg standard coal/m2	4000
Passive solar house 200 liters/unit	15000	24kg standard coal/m2	360
Solar stove	500	500 kg standard coal/per unit/per year	250

a) Technologies already in commercialization development:

Main product is independent household solar water heater system, which can't meet the requirement of integration with building. Over 30% of the area in China could use solar energy technology for heating and air conditioning.

At present, the integration of solar water heater with building in China is still in preliminary phrase. Because of the difference of economic, technology and building style, the design scheme of advanced countries can't fully suit Chinese building integrated with solar water heater. Another reason is technology of Chinese solar water heater system has not matured yet and advanced technology has not been widely applied. Therefore, the market share of users that collectively install the water heaters is relatively low compared with volume of household install, which is only 20%. Because solar water heater system has bigger profit, it will has a better future and be the main increase of future industry development.

b) Technologies in early commercialization and need support from government:

Solar energy heating and solar air conditioning

c) Technologies in demonstration:

Solar dryer and solar energy integrated with building

4.1.3 Government Support

4.1.3.1 Technology Support

Technology support include supporting technology R&D project, research and research institutions

Since the seven-fifth national R&D plan, seven-fifth, eight-fifth, nine-fifth and ten-fifth national R&D plan, “863” national R&D plan and Natural Scientific Fund etc have put solar thermal application into their R&D project. The successful development of all-glass vacuum tube solar collector and Al-N/Al technique are benefited from above projects.

All-glass vacuum tube solar collector has become a new industry with annual production volume of 10 million square meters, the production and installed capacity of which are both internationally advanced.

4.1.3.2 Financial support

Financial support include provide finance for technology R&D project, national interest discount loan and national project.

a) Bank loan

In 1987, Energy Conservation Office under National Council granted RMB 60 million loans from China Industrial and Commercial Bank and China Agriculture Bank (50% reprehensively) to promote and apply renewable energy technology including solar water heater.

Output: The loan increased to RMB 120 million in 1996, and state revenue provides interest discount to the loan, which is subsiding 50% of the interest to enterprise to support its technology R&D. Solar water heater enterprises, such as Jiangsu Huayang, Zhejiang Meida, Anhui Lijiang and Hebei Sanhuan etc., have benefit from the loan and become the backbone enterprises in the industry.

RMB 120 million loan with half interest discount was provided to solar thermal industry every year from 1987 to 1997.

In 2002, former SETC provided RMB 150 million loan with full interest discount from national debt to support technology R&D of three main backbone enterprises. Among these, Shangdong Himen Solar Energy Ltd. Co. received RMB 120 million loans to reform automatic producing line for tank; Jiangsu Huihuang Solar Energy Ltd. Co. received RMB 30 million loans to establish producing line for porcelain enamel tank; Anhui Liguang received support also. All these provide basis for the commercialization development of solar water heater.

b) Innovation Fund for Small Technology Based Firms

Innovation Fund for Small Technology Based Firms that is established in February 1999 by State Council for special focus has total of RMB 1 billion, the support of which include providing finance for free and discount interest. The financial support targets are energy efficiency and new energy. 1000 projects are approved in 1999 with RMB 0.85 billion budget

support, and RMB 0.46 billion has been provided, which resulted in RMB 0.85 billion of local counterpart funding and RMB 3.75 billion of bank loan.

Output: Two solar energy enterprises have received RMB 2 million and RMB 0.8 million respectively for free. Small scale renewable energy enterprises have benefited from this.

c) Industry University Research Program

Former SETC and Beijing Municipal establish Industry University Research Program.

Output: this program supported All-glass vacuum tube thermal tube industrialization project of Tsinghua Solar Energy Ltd. Co.

4.1.3.3 Policy Support

At present, the Government of China has already published and implemented a number of policies to provide guidance for development of the industry. These policies are beneficial in promoting use of solar energy and the development of the solar water heater market. Specifically, these policies include:

- ***10th Five Year Plan on Resources Conservation and Comprehensive Utilization*** **(former SETC), including a focus on the development of energy efficient buildings and buildings using solar energy.**
- ***Plan for Rural Small-Scale Production Facilities and Ecological Households*** **(Ministry of Agriculture), including an emphasis on houses using solar energy, solar stoves and solar water heaters.**
- ***10th Five Year Plan on the Development of the New and Renewable Energy Industry*** **(former SETC), including emphasis on use of solar thermal energy.**
- ***10th Five Year Plan for Development of the Environmental Protection Industry*** **(State Environmental Protection Administration (SEPA)), including an emphasis in the comprehensive use of resources on the research and promotion of solar energy.**
- ***9th Five year Plan and Plan through 2010 on Building Energy Conservation*** **(Ministry of Construction), including introduction of solar water heaters into successful dissemination projects.**
- ***Green Residential Building Standards*** **(Ministry of Construction), including solar water heaters as a construction item.**
- ***Key Points and Technical Guiding Principles for the Construction of Green Ecological Residential Complexes*** **(Ministry of Construction, May 2001). It indicates that the use of solar energy and other green energy sources is appropriate in environmental control systems, such as space heating, air conditioning and hot water supply. It also points out that the use of solar water heaters in residential buildings is currently one of the key, commonly used green/ecological technologies.**

Local governments have issued their own policies to promote solar thermal application, which

will have further influence on solar water heater market. For example, “Key application points of household solar water heater system for multi floor building” issued by Office of Construction, Jiangsu province, and “Design, install and check of solar water heater integrated with residential building” in developing of Anhui.

Laws and regulations issued:

a) Electricity Law of People’s Republic of China (issued at December 28, 1995)

In Article 5 of Chapter I General Provisions, “The construction, production, supply and utilization of electric power shall protect the environment according to law, adopt new technologies, minimize discharge of poisonous waste, and prevent pollution and other public hazards. The State encourages and supports electricity generation by using renewable and clean energy resources.”

In Article 48 of Chapter V Electricity Price and Electricity Fee, “The State advocates the exploitation of rural hydropower resources, the construction of medium and small size hydropower stations to promote rural electrification. The State encourages and supports rural areas to utilize solar energy, wind energy, geothermal energy, biomass energy, and other energy resources to develop rural electric power sources and to increase the rural power supply.”

Comments: Electricity law has certain promotion and encouragement to development and application of renewable energy, but lack of concrete and quantizing measurements, which results in weak affection and promotion to renewable energy development.

b) Energy Conservation Law of People’s Republic of China (issued at November 1, 1997)

In Article 5 of Chapter I General Provisions, “State advocates development and utilization of new energy and renewable energy”.

In Article 38 of Chapter IV Energy Conservation Technology Improvement, “Governments of all levels should stress on rural energy development to develop and utilize renewable energy and new energy such as biogas, solar energy, wind energy, hydro and geothermal etc., the principal of which is to achieve comprehensive and effectively utilization according to different scenarios.”

Comments: The expression is similar to Electricity Law as well as its effects.

c) Construction Law of People’s Republic of China (issued at November 1, 1997, implemented at March 1, 1998)

In Article 4 of Chapter I General Provisions, “State advocates building technology research, raising building design content and standard, encourage energy conservation and environmental protection, and promote application of advanced technology, advanced equipment, advanced technique, new building material and modern management”.

Comments: Building developer should consider solar water heater as hot water supply to building in project design, design check and final acceptance. If solar water heater is not

adopted, expert should make illustration. Solar water heater is the key technology promoted by MOC. But the cost of building adopted advanced energy conservation technology such as renewable energy is higher than that of normal building. Therefore, developer and design institutes don't have much intention to apply solar water heater without related incentive measurements.

d) Catalog of Encouraged Industry, Product and Technology Fields by State (revised version 2000) (issued at September 1, 2000)

In this catalog, it says "Encouraged industry, product and technology fields by State include hydro resource protection and development (hydro generation), renewable energy power generation (solar energy, geothermal energy, ocean energy, biomass energy and wind energy), building energy conservation technology, disposal and comprehensive utilization of urban trash and other solid waste, forest resource comprehensive utilization, wasted comprehensive utilization and big-scale waste water project."

SDPC, SETC and Ministry of Foreign Economic and Trade (MOFET) issued Industry Guideline for Foreign Investment under the approval of Stated Council at March 11, 2002, which started implementation at April 1,2002. Encouraged invest fields in Industry Guideline for Foreign Investment includes: Establishment and operation of new energy power plant (solar energy, wind energy, geothermal energy and tide energy); energy conservation technology and renewable resources and their comprehensive utilization technology. Since the implementation of this guideline, project invested will benefit from favorable policies such as free importation tax for equipment and importation VAT.

4.2 Current Status and Developing Trend of Solar Thermal Energy Utilization in China

4.2.1 Current Status

Solar water heater is one solar thermal energy utilization technology that is already commercialized.

The solar water heater industry experienced a rapid growth in 1990s. The production capacity and installed capacity of solar water heaters in 1998 and 2002 is showed in the following table 2-4.

Table 2-4 Sales Volume of Solar Water Heaters in 1998～2002

Year	Sales Volume / Million m2	Increase over previous year / %	Sales Revenue / Billion Yuan	Increase over previous year / %
1998	3.40	-	2.50	-
1999	4.18	41.0	4.00	60.0
2000	6.10	27.0	6.00	50.0
2001	7.80	27.8	9.38	56.7
2002	9.60	23.1	10.56	12.3

The total production of solar water heaters in 2002 was 10 million m^2 , of which vacuum tube solar water heaters was 8.55 million m^2 , representing 85.1% of the total volume. Flat plate solar water heaters was 1.35 million m^2 , covering 13.4% of the total volume; and combined storage tank solar water heater was 0.15 million m^2.

4.2.2 Economic and Social Benefit

According to survey and calculation, FIRR and EIRR of a new modern vacuum tube solar water heater production line with annual production capacity of 45 million m2 is 16% and 29% respectively. Accordingly the investment recycling period is 5.5 years, which provides an evidence that it is economically feasible to establish a solar water heater manufacture factory. In 2002, the total production value was 11 billion RMB, the total sales volume was 9.60 million m2 with sales value of 10.65 billion RMB. Total tax was 0.4 billion RMB.

The solar water heaters in China is competitive in the international market with low price and improved quality. In 2000, the export value of solar water heaters was 6.40 million US$. The export value in 2001 was 10 million US$, increase 56%. And the export value in 2002 was a little bit bigger than that in 2001. The target regions include more than 30 countries or regions in Europe, Africa and South-east Asia.

Among the solar water heater producers, there are 8 producers whose sales value exceeds 0.1 billion RMB and 19 producers exceeding 50 million RMB.

4.2.3 Market Expectation

It is expected that China will establish a modern-equipped solar water heater industry by the end of 2020. And the production capacity is expected to reach 26-30 million m^2 by 2010 and 70-100 million m^2 . The export will cover 20-30% of the international market. Final, it is expected to support 5-10 large enterprises with annual production capacity of 1-2 million m^2 .

5 Problems in the Utilization of Solar Thermal Energy

5.1 Technical Barriers

The production and processing technology of solar water heater system is behind the international level

The solar water heater technology is behind the international level without design software. At present, 80% of the solar water heaters are either natural cycling vacuum or natural cycling flat plate. The solar water heater can only meet the demand for bathing and technology is low. Besides, the quality of the products doesn't meet the international requirements.

The basic material technology for solar water heater is behind the international advanced level. For instance, the low transparency of the glass leads to the low efficiency of flat-plate solar water heater by 5-8% compared to the international level.

The Solar Thermal Energy (high temperature) Utilization Technology is 15-20 years behind that of developed countries.

5.2 Financial Barriers

Except a small number of large leading enterprises, few companies invest their profit in R&D. Most of the solar thermal energy utilization products including solar water heaters are developed via state investment.

Little R&D program

Since late 1990s, the government assumed that solar water heater industry was already mature and stopped investing in R&D, which severely constrain the technology improvement. Further, there was no national research center involved in solar thermal energy utilization, which slows down the upgrading of solar water heaters. And the industry repeated low technical development. Although some companies owned patents, the technology is low and easy to duplicated. Besides no enough attention was attached to the protection of the patent. These factors all limited the investment from the companies. The result is that China's production was 4 times that of Europe, however the income was only 1/3, which showed that the value of China' s solar water heater was only 1/12 of that of Europe.

Insufficient state subsidy and international loans

UNDP and GEF support to establish 3 solar water heater monitor and certification center;UNDP invest 1.8324 million US$ to establish a 100 thousand m^2 pilot project of integration of solar water heater into building. A solar building program supported by Dutch government was undertaken. Moreover Shandong Lino Group received German fund and technology.However, international fund and program is not sufficient.

5.3 Market Barriers

There is no standard for production and installation

Till now, there are 14 national standards made and revised by National Energy Standard

Committee. Besides there are 3 industry standards.

However, there is a big range in the size, type and installation sites of solar water heaters produced by different producers, which caused disorder installation, unfixed tuber, insufficient protection from wind and lightning. Those factors bring negative effects on the visual feature and building safety. The governments of Dalian, Dongying, Tongliao request upgrading or dismantling the solar water heaters on the building roofs to some extend. The integration of solar water heaters into buildings is the main developing trend, which results in the great demand for the technical standard and installation standard.

Large number of small scale producers with an irregular price system

There are a large number of small scale solar water heater producers. Without price monitoring system, a lot of solar water heaters in the market are of low quality and unreasonable price become dominant, which not only affect the good development of solar water heater industry but also affect the reputation.

Poor management

Most of the solar water heater producers are private companies with family management system. This system is out-of-date. Moreover the administrative people are not well or professionally educated.

5.4 Insufficient Administration System

Insufficient protection on patents.

Vacuum tube solar water heaters, which have a 85% market share, are characterized as simple structure, easy manufacture, low technology and less requirements for market entrance. Although the material and process procedure varies in every companies, the basic structure is the same. And publication is serious, which stirs the market.

Inefficient management and control system

Insufficient National Quality Test and Certification Center

Although China has issued 17 national and industry standards, the national product quality and testing center is not established yet. The quality management and control is not enough and some products in the market are of poor quality.

Local protectionism

The existing local protectionism free the local testing lab from supervision. Some labs even issue the certification without testing.

5.5 Insufficient Incentives

There are indeed some good tax policies for new energy products, for example, the VAT for hydro power products is 6%. However, the VAT for solar water heaters is as the same as conventional energy products, i.e. 17%, although solar water heaters are energy-saving.

1) In “State Power Law”(passed on Dec.28,1995), “State Energy Conservation Law”(passed

on Nov.1, 1997) and "State Construction Law"(passed on Nov.1, 1997 and issued on Mar.1, 1998), it is highlighted that the development and utilization of renewable energy should be supported and encouraged. However the policies are not specific and hard to implement, which contribute little to the development of renewable energy. Although solar water heaters are priority energy conservation program promoted by MOC, the cost for the integration of solar water heaters into buildings are more than conventional buildings. Without correspond incentive policies, the real estate developers and building designers are reluctant to invest in this area.

2) It is written in "Recommendation Catalog of Investment Industries for Foreign Investors"(implemented April 1,2002): Establishment and Management of New Energy Power Factory(solar energy, wind, geo-thermal, tide) ;energy conservation, recycling and comprehensive utilization technology.

Since the implementation of the new catalog, the foreign investors will benefit from the policies such as: without import tax for the equipment used in new energy projects and without VAT

6 Current Status of Solar Thermal Energy Utilization in Developed Countries

6.1 Solar Thermal Energy Utilization Technology

A 7 thousand m^2 pilot solar tank was established in 1979 in America, which was used to provide heat to a 150 KW power generator.

Russia developed new solar tank with combined solar water spray promoter and cold spray promoter with solar tank. The new tank can meet the annual electricity demand of a 100 m^2 house with 6-8 people. Another institute put forward the concept of comprehensive solar tank station, i.e. make comprehensive use of solar energy, geothermal, housing heat via heat bumper and heat tube, which can reduce the cost of solar tank electricity and become competitive with fire electricity in north Caucasia. This new technology is available through the whole year, supplying cool air in summer and heat in winter.

Flat-plate solar water heaters are dominant in the international market. And vacuum tube solar water heaters cover a small portion. The advantages of flat-plate solar water heaters are high efficiency, easy integration into buildings. Along with the development of copper soldering technology, low iron grass and improved technique, china has grown up to a flat-plate solar water heater processing base for international market. Moreover, the market share of flat-plate solar water heaters in national market is also increased.

The integration of solar water heaters into building is the main way of solar thermal energy utilization technology adopted by developed countries. At present, the integrated buildings abroad are mainly independent or rowed small houses. The developing mechanism is as following: the customers pay the cost of the integrated roof; Solar water heater producers or dealers invest in the manufacture and maintenance; the manufacture of solar water heaters and integration should be completed by one company to issuer safety and quality. the company

can charge the customers when it is finished.

6.2 Solar Thermal Energy Utilization Market

See table 2-5.

Table 2-5 The Installed Solar Water Heaters in 15 EU Countries in 2001

Country	Accumulated installed capacity/ million m^2	Market share/%	Average capacity per thousand people/m^2
German	3.705	31	4.5
Greece	2.976	25	28.3
Austria	2.340	20	28.9
France	0.550	5	0.93
Spain	0.450	4	6.6
Denmark	0.320	3	6.0
Italy	0.311	3	0.55
Switzerland	0.260	2	3.6
Portugal	0.250	2	2.5
Netherlands	0.213	2	0.14
Sweden	0.213	2	0.24
UK	0.206	2	0.35
Finland	0.032	2	0.59
Belgium	0.024	0	0.24
Irland	0.003	0	0.08
Total	11.854	100%	

There are three categories of solar water heaters in American market: low temperature (less than 43℃),medium temperature(60~82℃) and high temperature(more than 82℃). The vacuum tube solar water heaters belong to medium temperature category. In 2001, the total consumption of solar water heaters was 0.96 million m2 . By the end of 2001, the total installed capacity was 11.1 million m2 , of which 10.1 million m2 was low temperature products and 25 thousand m2 was medium temperature products and the rest were high temperature products.

In America, the solar water heater is mainly used for heating the swimming poor and only a

small number is used for household heat water and heat water program.

Israel is the country with a highest solar water heater utilization per capita. In 2002, the production of flat-plate solar water heater was 450 thousand m^2 , export was 60 thousand m^2 and import was 4.22 million m^2. The accumulative total volume was 3.5 million m2 with average 5.8 million m^2 per thousand people.

The solar water heaters installed in Japan are mainly produced in Japan. By 2001, the total installed capacity was 7.36 million m^2s, of which flat-plate solar water heaters was 7.22 million m^2fand vacuum tube solar water heaters were 140 thousand m^2.

It is estimated that the installed solar water heater will grow with a rate of 35% from 2003-2010 in 15 EU countries. And at that time, the total installed solar water heaters will be 81.55-100 million m^2 .

6.3 Government Actions in Utilization of Solar Thermal Energy in Developed Countries

6.3.1 Legislation

The solar water heater law of Israel is composed of national standard and some solar water heater utilization ruled or regulations. The main part of the law "Design and Construction Law" requires that solar water heaters should be integrated into newly-built buildings. And "the Land Law" is involved in the integration of solar water heaters into existing buildings. Furthermore, "Commodity Control and Service Law" guarantees the quality of solar water heaters.

Barcelona Parliament requires that solar water heaters should be integrated into newly-built and upgraded buildings. And more than 60% households should be heated by solar water heaters.

6.3.2 Incentives

America expects to finish a sustainable development plan in 2010—millions of roof plan with solar thermal energy utilization.

In many European countries, solar water heaters are one benchmark for real estate development and building upgrading. The mass installation not only reduced sale and installation cost in a great deal but also make it easy to maintain. Therefore they are welcomed by customers. The typical programs need 500-1000 solar water heaters. During 1997 to 1998, 5000 units solar water heaters were installed via this way.

Many European countries provide subsidy to solar water heater industry with average 20-50% of the cost. In German, the subsidy can even reach 60% of the cost. In UK, a fixed subsidy, 500 pounds for each system is adopted.

Australia also adopts subsidy policy. For instance, in Victoria, the customers of solar water heaters will get 1/3 of the sales price as subsidy.

6.3.3 Standard and Regulations

The governments of America, Japan, UK, France already made products standards, integrated building standards and certification systems to control and assess the quality of solar water heaters and after-sale service, which contribute to the improved performance, service and reputation of solar water heaters as well as extend the market.

7 Suggestions and Recommendations

7.1 Legislation

7.1.1 Standardization and Certification

The building administrative units under State Council should work together with other departments to make technical specifications and standards for production, quality control and installation of solar water heaters. Apart from this, national quality testing and certification center should be built.

7.1.2 Integration of Solar Water Heaters into Buildings by Force.

a) Installation Guarantee

The utilization technology of solar water heaters into buildings less than 10 floors is mature now. And many pilot projects were initiated. In this case, in the regions with annual sunshine over 1500 hours, either solar water heaters should be integrated into buildings less than 10 floors such as hotel, restaurant, hospital, school and etc by force or the installation space should be saved.

Solar water heaters should be integrated by force to office buildings, schools and symbol buildings sponsored by government.

The building administrative departments in the regions over county level should take specific measures combined with urban and rural construction plan to promote the utilization of solar water heaters.

Real estate developers and service suppliers should provide convenience for installation of solar water heaters.

b) Punishment

Make punishment regulations, based on which, the departments breaking the rules will be punished.

The projects implementing companies will be charged less than 500 thousands RMB by energy administrative department of government over county level if they don’t integrate solar water heaters into buildings or reserve the installation space.

The real estate developers and service suppliers will be warned by energy administrative department of government over county level if they interfere with the installation of solar water heaters. They will be charged less than 100 thousands RMB if they insist.

7.1.3 Encourage Local Regulation

According to the past experience, local legislation is normally more specific, practical and simple than central legislation.

7.1.4 Incentives

Favorable tax policy should be given to commodity buildings with integrated solar water heaters, to encourage people to use solar thermal energy products.

a) Establish special fund for subsidizing pilot programs.

The government should subsidize or provide discount loan to encourage and promote development of solar water heaters.

b) Discount tax for solar thermal energy utilization products.

Solar thermal energy utilization products are energy saving with 300kWh/m2 per year. Compared with the hydro power tax, favorable tax rate 6% and 30% return rate should be given to solar thermal energy utilization products to support R&D.

7.2 Other Measures Beyond Legislation

Establish uniform administration agency and strengthen government control

Establish efficient financing channel to promote commercialization

Make reasonable pricing system and avoid vicious competition.

Enlarge investment in solar heating, sea desalt and drying technology.

Solar heating, cooling and seawater desalting technology are in preliminary stage. In terms of technology, commercialization is possible. Some pilot programs were already carried out by some institutes. In the long run, large scale commercialization is possible and will improve china's energy structure. In this case, more investment should be given to these areas and establish special funds to promote R&D and commercialization of these technology.

Upgrade flat-plate solar water heaters, develop integration technology of vacuum tube solar water heaters into buildings.

Flat-plate solar water heaters is dominate the international market because of the advantage in integration into buildings. However, vacuum tube solar water heaters share 85% of the market in China. Therefore, it is a key issue to improve flat-plate solar water heater technology and develop integration technology of vacuum tube solar water heaters into buildings so as to extend and strengthen the solar water heater market.

8 Prospective After the Legislation

It is anticipated that a well-off society will be built in 2020. At that time, average daily use hot water per capita will be increased to 40kg, i.e. 20 billion tons of hot water all over the country each year. At present, the average solar water heater capacity per capita is low. According to "2000-2015 Development Plan of New Energy and Renewable Energy Industry, total installed capacity of solar water heaters will reach 230 million m2 in 2015 with 8.39 billion tons of hot water. The total installed capacity of solar water heaters in 2020 will be 500 million m2 with 22 billion tons of hot water. The analysis mentioned above shows that the present solar water heaters can meet the demand of 1/4 households in China in 2020. If solar water heater is replacing electricity water heater, 300 kWh/(m2•a) energy saving will be gained and 0.4 kW load burden will be released. Entering 2020, if 500 million m2 solar water heaters are installed, 150 million kW electricity will be saved. And the electricity load peak will be decreased. And the energy structure will be improved.

With the legislation, solar heating, cooling, drying and seawater desalting technology will experience rapid development. And utilization of those technologies will make great contribution to the energy restructure.

Chapter 4 Study on Small Hydropower Development

1 Small Hydropower Resources of China

1.1 The Gross Potential and Distribution of Small Hydropower Resources

1) Small hydropower station refers to those not more than 50MW.

2) Technical exploreable potential of small hydropower is approximately 128GW，ranking the first place of the world.

3) Small hydropower resources of each river basin and each province please found in the attached table 4-1 and table 4-2.

1.2 The Resources Characteristics of Small Hydropower of China

1) **Distribute extensively.** There are over 2400 counties (cities、districts) in China, while more than 1600 of which is rich in small hydropower resources.

2) **Complement the big grid greatly.** The small hydropower resources are mainly located in the remote mountain areas and minority areas where the people live sparsely and the energy demand is separate. It costs highly to **transmit** the electricity from far away since the electricity loss is considerable. The small hydropower can be developed separately. The grid can be formed and the electricity can be supplied on the spot with the low cost of power generation and transmission. Small hydropower is the natural and rewarding complement of the big grid.

3) **Falls into the scope of the clean renewable energy.** Electricity generated by small hydropower does not emit the poisonous gas and exerts the positive influence on the environment. The development of the **s**mall hydropower will not change the natural distribution of water, destroy the natural balance, result in the change of the biosphere in some areas, or cause the earthquake or climate change, and there are also few resettlement and submersion. The small hydropower resources are mainly located in the upper stream of Yangtze River, middle and upper stream of Yellow River. Most of those are natural forest protection or the ecological protection areas, zones of transforming the farmland into woodland and grassland, and main areas of water and soil erosion. To develop the small hydropower and implement the project of substituting small hydropower for bavin in those areas is the important way to improve the ecology and protect the environment.

4) **Provide with regional and comparative advantages.** The distribution of the hydropower accords basically with that of poor areas in China. Small hydropower concentrates mainly in poor, mountain and border areas. It is the first resource choice that can transform the resources advantage into the comparative advantage when the issues of "agriculture、country、farmer" are addressed. Small hydropower provides with the outstanding regional and comparative advantages.

5) **Suitable for the separate development.** It doesn't take too much investment to build up the small hydropower station. The construction period is short and the cost returns fast. The small hydropower resources scatter extensively. It is easy to mobilize all parties' initiatives, no matter the country, enterprises or individuals, to develop the small hydropower.

2 The Brief Introduction of the Foreign Small Hydropower Development

1) Over 100 countries have developed or are developing small hydropower.

2) The total installed capacity of the global small hydropower is around 60GW. Because many countries lack the statistic data of small hydropower, at present it is hard to find the completed statistic data of the installed capacity of the global small hydropower. The attached table 4-3 makes the list of the installed capacity of small hydropower in some countries.

3) The developed countries explore the small hydro on the purpose that shp is the clean renewable energy asserting no impact on the environment. The developing countries explore the small hydropower with more considerations on addressing the power shortage in the remote areas and rural areas, as well as promoting the economic development and protecting the environment.

4) Many countries have worked out the new planning of the small hydropower development. For example, EU has passed the plan that the electricity generated by the renewable energy will account for 22.1% of total electricity amount up to 2010, while 6000MW is generated by small hydropower. Vietnam is going to build up 19 small hydropower stations before 2005, increasing the capacity of 57MW，and has confirmed 3000 mini-hydropower station sites. Guinea of Africa have confirmed 150 small and mini hydro station sites while Nigeria plans to construct 236 small hydropower stations with the total capacity of 700MW，Ecuador builds up small hydropower stations and raise the living standard of local household in the remote areas with the revenue of power generation. Iran has constructed 8 small hydropower projects, and there are 9 shp stations under construction, 300 stations under the planning，Indonesian government is going to help 18600 villages to have access to power by developing small hydropower and mini hydropower. Latvia in recent years has built up 91 small hydropower stations，and there are 74 shp projects under the approval. Norway plans to construct 400 small hydropower stations. Laos, Bengal, India, Ethiopia, Tanzania, Uganda and other countries have also the plan to build up the small hydropower stations. According to the estimates of International Hydropower Association, up to 2010, the electricity generated by shp will reach 220TW·h，increasing twice than 115TW·h of 1995.

5) In order to promote the development of small hydropower，each country programs a series of policies, mainly including:

- **Small hydropower is the renewable energy，enjoying the renewable**

energy policies concerned. EU、USA、Australia has formulated the renewable energy promotion policy, small hydropower will duly enjoy that policy. Taiwan of China has made clear that small hydropower is the renewable energy.

- **Formulate the preferential policies.** Philippines republic order No. 7156 provides the preferential policies for the investment on small hydropower, including: the special favored tax rate is only 2% of the gross revenue of the electricity distribution、7 years after the contract is signed, the imported and exported mechanical equipment and materials are tax-free、the equipments purchased by the domestic fund are derated 100%、the special tax of the fixed asset levied on the mechanical equipment is only 2.5%、value-added tax is free、the income tax is free etc. The federal government of India unveils a series of the motivation mechanism and arranges some fund to attract many IPP to invest in small hydropower，such as the license is valid 30 years in the first application period and 20 years in the continuous period (at present 20 years and 10 years respectively)、allow the investment return rate is 5% (2% before) higher than the libor、the special appropriation for debts alleviation、ensure the return rate of the foreign investment to be 16%、the new project is tax free for 5 years etc. Many countries have the similar preferential policies as Philippines or India do (entirely or partially).

- **Consider the development of the small hydropower as the important way of promoting the rural electrification.** For example, Malaysia、Indonesia and other countries have made clear that small hydropower is the important way to realize the rural electrification and formulated the specific implementation articles.

3 The Basic Development Status and Prospect of Small Hydropower of China

3.1 The Development Course

The first hydropower station in China is Tortoise Hill Hydropower Station located in Taiwan, with the installed capacity of 500kW，which was built in 1904. In 1912，the mainland built the first hydropower station——Shilongba Hydropower station，lying around Kunming of Yunnan with the installed capacity of 480kW，up to 1949，the total capacity of hydropower stations, no matter what size, amountrd to 360MW in China，and the annual electricity was 1.2 billion kW·h.

From the foundation of new China till the end of the 1970s，the main goal of exploring small hydropower is to deal with the power shortage in the broad rural areas. During such a period of time，the rural people have no access to power. In order to address the problem, the central government sticks to the course of “walking on two legs”, and gives the national and local initiatives and creativity into full play. It works out a series of policies and calls on all places to combine with the construction of the irrigation works to develop the small hydropower. During that time，small hydropower was developed from the single station operation, transmitting the low voltage electricity, supplying the power to customers on the

spot for illumination in the 1950s and 1960s，into in the 1970s the integrated power generation and supply, and the small hydropower realized grid incorporation. Small hydropower has formed many county grids of "self power generation, self power supply" and over-county grids，and started to feed the electricity into the big grid gradually. Before the 1980s over half Chinese counties are supplied the electricity by small hydropower for processing, irrigation, meeting the power demand of the township enterprises and the economic and social development from originally addressing the household's illumination only.

From the 1980s to the end of the 20th century，linking rigidly to the rural electrification, small hydropower becomes the main approach to promoting the rural economic development, increasing the revenue of the local government and helping farmers get rich when it satisfies the power demand of rural areas. In the year of 1983、1990、1996, the state council has approved Ministry of Water Resources organizing the construction of 100 preliminary electrification counties in the 7th five-year plan, 200 counties in the 8th five-year plan and 300 counties in the 9th five-year plan. Till the end of 2000，there are 653 preliminary electrification counties completed by developing the small hydropower. Small hydropower supplies the electricity for almost 800 counties. In that period of time，reservoirs were built in the cascade hydropower station of the upper stream of the river and raised the regulation capacity. Over 95％of stations have fed the electricity into the county grid for the unified dispatching，while the definition of small hydropower increases from 25MW to 50MW；with the gradual expansion of the local grid，110kV transmission line formed the backbone framework of the local grid.

Entering the new century，small hydropower not only continues the function in helping farmers get rich and promoting the development of local economy, linking rigidly to the national strategy of the sustainable development，it also gives full play in improving the ecology, protecting the environment and promoting the rural modernization in rural areas. In 2003，the country has implemented the pilot project of substituting small hydropower for fuel on the purpose of meeting the living energy demand of household in mountain areas to reduce the forest cutting and consolidate the fruit achieved by the project of transforming farmland into woodland，which indicates the new landmark of the small hydropower.

The installed capacity and electricity of small hydropower of China in past years could be found in the attached table 4-4.

3.2 The Achievements

1) Till the end of 2003，48000 small hydropower stations have been built，with the total capacity of 30832.99MW and annual electricity of 97.916 billion kW·h。

2) There are about 1600 counties (city、district) of total 2400 that have explored the small hydropower. The small hydropower scatters in 30 provinces (metropolis、autonomous region). Installed capacity and energy of small hydropower of each province (autonomous Region、metropolis) at the end of 2003 can be found in the attached table 4-5.

3) There are about 800 counties mainly depending on the electricity by small hydropower，while almost 1/2 territory、1/3 counties、1/4 population are mainly provided with energy by small hydropower.

4) Small hydropower has accumulatively helped 500 million people to have access to power.

5) 653 preliminary electrification counties has been completed, involving 252 million people and 2.74 million km^2.

6) 400 hydropower and rural electrification counties are under the construction, covering 200 million people and 2 million km^2. After the project is completed in 2005，the annual electricity consumption quantity per capita will be raised from 360kW·h in 2000 to more than 600kW·h，the annual living electricity consumption quantity per household will be elevated from 322kW·h in the year of 2000 to over 550kW·h.

7) The project of substituting small hydropower for fuel is under the implementation.

3.3 The Influence

1) **The development of small hydropower improves the ecology，protect the environment，promote the transformation from farmland into the woodland as well as the ecological building and the sustainable development.** In 2003，the electricity generated by small hydropower in China is 97.916 billion kW·h. It reduces the emission of 50 million tons of CO_2 and other poisonous gas. There are 20 million household using in some depth the electricity for cooking, which annually reduces the deforestation of 130,000 hectares and saves the timber about 9 million m^3 in the areas that are supplied power by small hydropower. The bestrowing rate of the forest in 653 preliminary electrification counties is grown 9.88% averagely in last 15 years，5.4% more than the average rate of the whole country.

2) **Small hydropower has become the important way of realizing the electrification at large.** With the help of developing small hydropower and building up the electrification counties，accumulative 500 million people have access to power. The rate of the electrified household increases enormously after the electrification county is completed. The rate of the electrified household in the first batch of the preliminary electrification counties has been raised from 69.1% into 97.9%，while in the second batch is from 76.5% to 96.6%，and the third batch is from 82% to 96%.

3) **The development of small hydropower accelerates the economic development of the poor areas, minority areas, and quickens the people's step of getting rich.** The 82% of the 653 completed preliminary electrification counties are located in the middle and west part of China，more than 200 counties are minority counties，over 100 counties lie in the border areas of China. Although the resources and social economic conditions of those counties are different, the development of the electrification counties helps them to increase the GDP、financial revenue、net

income of farmers per capita、the electricity consumption quantity per capita twice more than that of 5 years ago or quadruple in 10 years. The growing speed is higher than the average level of the whole country in evidence.

4) **The electrification brings along the industrialization and urbanization, and promote the reshuffle of the economic framework.** In the past 15 years of building up the electrification，the rate of the industrial production value over the industrial and agricultural value is basically growing 10% in every 5 years, while that national rate only increases 10.9% from 1985 to 1994. Xingshan county of Hubei province forms the industrial chain with the lead of the small and medium hydropower, and the percent of the industrial production value increases from 30% to 80%. 20 million rural surplus labors have been transformed into the 2^{nd} and 3^{rd} industry of 3 batches of the preliminary electrification counties, which picks up the advancement of the urbanization.

5) **Quicken the step of the comprehensive governance and development of small and medium rivers，and improve the agricultural production and farmers' living condition.** The water governance has been linked to the power generation. A large batch of the multi-purposed water conservancy projects were completed and the reservoir capacity is increased more than 100 billion m^3 accumulatively. Tens of thousand of small and medium sized rivers have been fathered and the capacity of controlling the flood is raised. In the past 15 years of the electrification construction，it adds the net irrigation areas of 1.68 million km^2，foodstuff 30 billion kg，and addresses the drinking problems of over 64 million people and 47 million livestock.

6) **Expand the external exchange，and open up the new way of the international cooperation.** The practice of developing small hydropower，building up the rural electrification with the Chinese characteristics, protecting the environment to improve the ecology and realize the sustainable development is highly appraised and extensively acknowledged by the international community. At present every country is developing small hydropower. Many countries visit China to investigate and find out the development of small hydropower. The small hydropower research sector has provided the feasibility study, project design and the integrated equipment for tens of the developing countries.

3.4 The Role of Small Hydropower of China

1) **Small hydropower is the principal part of the renewable energy in China.** Presently, the electricity generated by small hydropower accounts for more than 95% of the total renewable energy of China，and such a situation won't change in several years. Small hydropower has taken the lead in promoting the development of the renewable energy.

2) **Small hydropower composes the important part of the rural energy in China.** In 2002，the installed capacity of small hydropower accounts for 55% of the total by all means of the electricity generating equipment in and below the county level of

China.

3) **Small hydropower composes the important part of power sector of China.** In 2002，the installed capacity and annual energy of small hydropower of China occupy the 33% and 34% of the total of the whole hydropower, while 8% and 5.7% of the total national power. There are 7 provinces where the installed capacity of small hydropower accounts for over 50% of the whole hydropower in the province, and there are 9 provinces where it accounts for more than 30%，and other 7 provinces more than 20%.

4) **The small hydropower market is the main field of honor in global small hydropower market.** The installed capacity of China takes about half of the total capacity in the world. In view of the extensive influence of small hydropower of China, the headquarter of International Network on Small Hydropower is located in Hangzhou, China. The organization consists of over 60 country members, 150 governmental members and other international agencies members. In 2000, UNIDO establishes the IC-SHP in China. Since 1981，China has run international small hydropower training course for 36 terms, and 615 trainees from 70 countries attended the training course.

3.5 The Experiences Achieved by Small Hydropower of China

1) **The country works out a series of the course and law to promote the development of small hydropower.** It provides in《Electricity Law of People's Republic of China》: "The State advocates the exploitation of rural hydropower resources, the construction of medium and small size hydropower stations to promote rural electrification."

Before the 1960s，the country provided that, small hydropower project as one of the infrastruvture projects in each part of China, should be ensured the sufficient supply of the construction materials, and trio investment structure and the policy of "feed power with power" were put into the practice; from the 1970s, the local capital gave the priority with the appropriate subsidy from the central government in building up the small hydropower projects. The assistance from the central government accounts for 20—60% of the total investment and the equipment is supplied according to the plan. It carried out the policy of "Who builds、who manages、who owns"，protected small hydropower to sell the big grid the surplus electricity，and required the big grid to support small hydropower to feed the surplus electricity into the grid, the ownership of the small hydropower station remained unchanged. If the grid purchases the energy by small hydropower, the purchase purpose should not be profitable.

After the 1980s，the country worked out"small hydropower should have its own power supply areas"、"Generally speaking，the power tariff of small hydropower should be close to that of the big grid"、"self builds、self manages、self uses"、"feed power with power"、"the electricity sold to the grid by small hydropower stations should offset, month by month, the electricity that small hydropower stations purchases from the grid"、"The selling price of small hydropower to the grid is treated as the price out of the plan and participates the market

regulation under the control of local government" and other policies. The special loan for small hydropower is established. The national government each year administers some subsidy and sets up the rural hydropower development fund in local government. Each kWh levies RMB 0.02 Yuan. Small hydropower enterprises pay for 6% value-added tax at and below the level of the county after the tax reform only.

Under the guidance of the integrated policies of the national government, each province (metropolis、autonomous region) brings forward the according policy in line with the local situation. For example, Jilin unveils《Management Ordinance on Rural Hydropower》, Guangdong Provincial People's Congress passes《Decision to Give More Support to the Development of Rural Small Hydropower》, Guangdong provincial government publicizes the document，making clear the provincial government offers each kW of small hydropower RMB 500 Yuan、the small hydropower enterprises may deliver the electricity to the customer directly、the purchase price the big grid offers small hydropower should be treated as the lowest protection price according to the general average purchasing price of the provincial grid、it is the preferential to purchase the electricity delivered by small hydropower etc.

2) **Central government attaches the great importance to the development of small hydropower.** The leaders such as Mao Zedong、Deng Xiaoping、Hu Jintao、Li Peng、Zhu Rongji、Wen Jiabao have many times made the instructions on the developing small hydropower、building up electrification counties and other important issues of small hydropower. They pointed out that rural hydropower should stick to the direction of serving the agriculture、rural areas、farmers，rigidly linking to the economic development、governance of the rivers、ecological protection and poverty alleviation to contribute more to the social and economic development. In the documents regarding the agriculture and rural areas issued by central government and state council in 2002、2003、2004，rural hydropower has been many times listed into the rural small-scaled infrastructure projects. It demands to expanding the investment scale and enrich the building content. It calls on the start-up of the pilot project of substituting small hydropower for fuel to consolidate the fruit of the project of transforming the farmland into the woodland. The high attention from the central government provides with a sound environment for the rapid development of small hydropower.

3) **It is rigidly liking the development of small hydropower to the promotion of rural economic development and rural electrification.** When it helps rural people to have access to power, small hydropower forms the rural productivity，transforms the resources advantages into the economic advantages, alleviates the rural poverty and realizes the double wins of the economic and social benefits. It is the strong dynamic energy for the development of small hydropower to increase the local income，raise the power consumption level，improve the farmers' production and living condition，realize the rural electrification.

4) **It is rigidly linking to the improvement and the protection of the environment.** It actively encourages farmers to promote the project of substituting small hydropower for fuel to protect the forest. In the areas of transforming farmland into woodland, areas of protecting the natural forests and other key ecological

construction areas, it is implementing the project of substituting small hydropower for fuel to address the farmers' fuel and rural energy issues and consolidate the ecological construction fruit and realize the double wins of economic and ecological benefits.

5) **Stick to the reform direction of the independent power distribution company.** The distribution status of small hydropower resources determines that it is suitable for the separate development，forming the grid on the spot，supplying the electricity in close vicinity，self power generation and self power supply，feeding the electricity into the grid. To establish the independent power distribution company conforms to the rural productivity development level and the reform direction of the power sector.

3.6 The Development Prospect of Small Hydropower of China

1) Development Goal

- By the end of 2005，the total installed capacity of small hydropower will reach 37939MW，while 400 counties achieve the hydropower and rural electrification level.
- Up to the end of 2010，the total installed capacity of small hydropower will reach 54389MW and another 400 hydropower and rural electrification counties will be accomplished.
- By the end of 2015，the total installed capacity of small hydropower will reach 73253MW.
- Up to 2020，the total installed capacity of small hydropower will reach 936.89GW，with the annual energy of 356.5 billion kW·h.

2) Development Emphases

- It is preferential to develop the rich small hydropower resources in the western areas to address the power supply issues from the west to the east. In the western part of China, the increased installed capacity of small hydropower will account for 65% of the total in 2003—2020.
- It will select those areas with the rich small hydropower resources and good exploring condition to carry out the exploration in a concentrative and successive scale. It will give the resources advantages into full play and accomplish a batch of provinces where the installed capacity of small hydropower amounts to 4GW and a batch of bases with the installed capacity of over 1GW.
- Zhejiang, Fujian, Guangdong and other areas where the small hydropower resources concentrate, the electricity demand increases fastly, as well as those north areas where small hydropower accounts for a low share of the grid but the situation of selling the grid the electricity is favourable, should try to realize

over 80% developing rate of small hydropower before 2010.

- Those areas that are mainly depending on the electricity by small hydropower should reinforce the construction of the reservoir hydropower station with the strong regulation capacity to raise the quality of the power supply.

3) The Overall Development Arrangement

- By the end of 2020，it will increase the installed capacity in western part of China of 42401MW，while the total capacity reaches 54982MW，taking on 65%、58.7% of the whole country respectively; increase 14491MW capacity in middle part of China，the total capacity reaches 19733MW，taking on 22.2%、21.1% of the whole country respectively; increase 8307MW capacity in eastern part of China, the total installed capacity amounts to 18972MW，taking on 12.8%、20.2% of the whole country respectively.

- By 2020，there will be 12 provinces where the installed capacity of small hydropower reaches more than 4GW in China. From 2003 to 2020，it will increase 51962MW installed capacity of small hydropower in those 12 provinces. Up to the end of 2020, the total capacity of 12 provinces will amount to 75525MW，taking on 79.7%、80.6% of the whole country respectively.

- By the year of 2020，it will accomplish 42 small hydropower bases, and the installed capacity of each base is more than 1GW.

4 Main Problems in the Development of Small Hydropower of China

1) **The country lacks the law to encourage the development of the renewable energy.** The developed countries have widely implemented “Renewables Portfolio System” and other compulsive market share system. They set up the development fund for the renewable energy to encourage the development of the renewables. However, the legal vacancy exists in that part in our country，so small hydropower as one part of the renewable energy is affected accordingly.

2) **The policy taken by the country to promote the development of small hydropower is not effectively fulfilled.** The long-term practice has proved that “small hydropower should have its own power supply area”、“self power generation、self management、self utilization” and other series of policies have not been effectively fulfilled although those policies not only conform to the situation of China but also promote the development of small hydropower. Particularly the national grid transfers the property of small hydropower supply areas without any return, and forcibly manages the small hydropower grid to snatch the power supply market of small hydropower. Such behaviors heavily blow the rural productivity and the initiatives of developing small hydropower.

3) **It is obviously unfair for small hydropower to sell the grid the**

electricity. Mainly **reflected** in:

- Due to the impacts of the power sector, "power price of small hydropower should be close to that of the big grid"、"the electricity sold to the grid by small hydropower stations should offset, month by month, the electricity that small hydropower stations purchases from the grid" and other policies have not been effectively put into the practice. The newly built small hydropower station can not implement the price for the repayment of capital and interest, which imposes the big pressure for the newly built small hydropower station to repay the loan and results in the difficulties of the rolling development.

- Some small hydropower stations are restricted to sell the grid the electricity and have to discharge a great deal of water. Some even discharge more than 50% water for nothing，meanwhile the fire plants causing the severe pollutions, however, can generate the electricity fully and its electricity can be accepted by the grid at a high price. Even in 2003 when the electricity is in urgent need, some small hydropower stations still had to discharge water a great deal and the electricity generated by the discharged water can reach 4.3 billion kW·h.

- The monopoly of the grid has not been broken. The power stations under the management of the national grid enterprises（or its other affiliated enterprises）can sell the electricity at a high price without any limitation, and the grid offers them power fee month by month，while small hydropower stations have to sell its electricity at a low price and with the selling quota. The obvious unfairness still exists in the electricity market.

- There is a wide gap between the purchase price the grid offers the small hydropower supply areas and the purchase price the small hydropower supply areas have to pay the grid，which goes against the development of the small hydropower supply areas and small hydropower. For example, the buying price that small hydropower supply areas have to pay the grid is RMB 0.318/ kW·h，while the purchase price the grid offers the small hydropower stations is only RMB 0.15/ kW·h averagely in Guizhou province. Many small hydropower stations can only sell the energy at the price of RMB0.12/ kW·h to the grid，and have to leave the profit to the national power supply sectors.

4) **The decrease of the financial support.** The reason that the central government offers the subsidy is attributed to the public, social and ecological features of small hydropower and its functions in the protection of the environment and alleviation of the poverty. However, the subsidy from the central government in the 1st batch、2nd batch、3rd batch of the electrification counties only accounts for 30%、9%、3.2% of the total investment respectively. As the central investment is decreasing gradually, local financial support is reducing accordingly.

5) **Taxes that small hydropower has to pay is so heavy that it has affected the rolling development of small hydropower.** According to the survey and calculation of the sector concerned，when the tax system was reformed in 1994 the

taxes that hydropower station pays increase over 3 times than before the reform. Because there are no incoming items that can be deducted, the real tax is very close to 17% and reaches 16.5% usually, while the fire plant can deduct its incoming tax, so real tax they pay is only 6%—10%，and about 9% at average，that is to say, small hydropower pays nearly twice as much as the tax fire plants pay. Although the country provides that the small hydropower stations can enjoy 6% value-added tax at and below the level of the county, because the downstream grid enterprises implement the 17% value-added tax，in fact due to the lacks of the counterpart measures，if the grid enterprises make out the invoice of 6% value-added tax to small hydropower stations，there will be a 11% gap that the grid enterprises can not offset，which causes the un-fulfillment of such policies in many places.

5 Necessity and Feasibility of Continuing Accelerating the Development of Small Hydropower

5.1 Necessity of accelerating the development of small hydropower

Small hydropower is the clean renewable energy and rigidly linking to the promotion of the rural economic development. It provides with the twoness. The development of small hydropower will realize the unification of ecological, social and economic benefits.

1) **Small hydropower is the clean renewable energy to contribute to the protection and improvement of the environment.**

- **Can reduce the emission of GHG.** The emission by GHG in our country accounts for nearly half part of the total emission by all developing countries，ranking the 2nd place of the world and just following USA. Among all the emission of CO_2，energy activity occupies 96%. With the gradual growth of the energy consumption，the GHG emission of our country will inevitably increase in a large extent. In September of 2002，our government declared the formal ratification of《Kyoto Protocol》. The active development of small hydropower can reduce the energy generated by the fossil fuel, therefore, reduce the GHG emission and contribute to the global environment. According to the planning，by the year of 2020，the electricity generated by China small hydropower will amount to 356.5 billion kW·h，each year reduce the emission of 180 million tons of CO_2，so as to contribute a lot to the protection of the environment.

- **Can consolidate the fruit of transforming farmland into woodland, protecting the natural forests and promoting the implementation of other ecological protection projects.** At present, firewood and bavin are still the main living fuel in the key ecological construction areas. In 2001 the disafforestation quota approved by state council during the 10th Five-Year plan is 223 million m^3 each year, and the firewood limitation that farmers are allowed to cut and burn is 64 million m^3. however, according to the estimates，the real firewood quantity consumed by farmers is about 228 million m^3. Unless the farmers' living fuel problems can not be addressed from

fundementally, it would be hard to consolidate the fruit of transforming the farmland into the woodland and protect the natural forests. The active development of small hydropower and implementation of the project of substituting small hydropower for fuel can address the farmers' living fuel problems and prevent the forest, the grassland and the vegetation from destroying.

- **Conduce to the reshuffle of the power sector of our country.** In 2003 the electricity generated by the fire plants accounted for 83%，and the renewable electricity including small hydropower is only taking on 6%. Plenty of coal power causes the severe pollution on the environment and the discontentment of other countries. It is to improve the power structure and increase the renewable electricity that plays an important role for the reshuffle of the power sector of our country, and small hydropower can bring on the important functions as well.

2) **It is one of the most effective ways to develop small hydropower to address the rural energy problems.**

- **Can increase the power supply for the rural areas.** Farmers live separately in our mountain areas and locate in the end of the grid，if the small hydropower could be developed on the spot, it would increase the power supply to rural mountain areas. Power is in a very bad need everywhere recently，in 2003 there are 21 provinces limiting the use of power to some degree，rural areas lying in the end of the grid are also in bad need of the power, and such a power shortage will not be alleviated in a few years. Small hydropower station can be completed in a short period of time, and the investment returns rapidly. Most of the small hydropower stations can be operated in 1-3 years. These years there are 2GW small hydropower capacity putting into the operation per year, which corresponds to building up several big hydro stations every year，moreover, all electricity generated by small hydropower are consumed by rural areas，which alleviates the power shortage of rural areas, particularly those areas that mainly depend on small hydropower to supply the electricity.

- **Meet the impending demand for power in the mountain areas abroad.** In 2002, the power consumption amount at and below the county level is only 628kWh，taking on only 49% of the national level. There are 1065 counties where the power consumption per capital annually is lower than 300kWh，less than 1/4 of that of national level, accounting for 43% counties of the total. The electricity consumption in our rural areas is still very low, meanwhile more than 60% counties are rich in the abundant small hydropower resources. Development of small hydropower resources in those counties and the construction of the small hydropower electrification may promote the harmonious development among power supply, grid and power load, and raise the power consumption of those areas.

- **One of the most important ways for the country to realize the prevalent**

power services. By the end of 2002，there are 608 countries, 9303 villages，4.58 million household，17.43 million people that still have no access to power. The un-electrified people are concentrating in the remote areas where the big grid is **hard** to cover, however, those areas are rich in the abundant small hydropower resources. For example, un-electrified people in south west part of China account for 62% of total un-electrified population in the whole country. In China it is almost possible to develop small hydropower everywhere. It is effective to develop small hydropower in line with the local situation to address the power shortage problems and shed the intellectual light on each stockaded village.

3) **Small hydropower is the superior resource that the poor mountainous areas can develop, it is also the specific measure to address the problems of rural areas, agriculture and farmers. The development of small hydropower is conducive to promoting the productivity of the poor areas and helping farmers get rich.** The practices in the last decades show that small hydropower has played the irreplaceable role in promoting the local economic development，increasing the financial revenues and helping people to cast off poverty and get rich. In 2001 the country formulated the new program of poverty alleviation, brought forward the principle of alleviating the poverty in the development form and by exploring the local resources. 80% of 592 poor counties considered as the key counties that will alleviate the poverty by the way of the development have the abundant small hydropower resources. If small hydropower could be developed, it would bring the dynamic force for those areas, bring along the rural industrialization and urbanization, promote the upgrading of the industry and help to transfer the surplus labors and the reshuffle of the rural economic structure.

5.2 Feasibility of continuing accelerating the development of small hydropower

1) **There are still plenty of small hydropower resources that are not explored so far.** The developing rate of small hydropower of our country is only 24% and there are still 90GW small hydropower potential which is not developed. The plentiful renewable and clean energy are wasting for nothing. The development potential is still considerable.

2) **Our country has the successful experience in exploring small hydropower.** The development practice in the last decades accumulates the rich **experiences** for the future development.

3) **Local government and rural people support the development of small hydropower highly.** The **development** of small hydropower can realize the unification of the economic, social and environmental benefits, which are warmly welcomed by the government and the local people.

4) **The development of small hydropower is provided with the favourable technical foundation.** Although the manufacturing craft of small hydropower equipment still has the distance from that of the developed country in some depth,

and some turbines can not be produced in China, generally speaking, we have been provided with the comparatively self-contained technical specification and regulation, which covers each step of the planning, design, construction, operation and management，and realized the systematization and formed the template of small hydropower equipment, brought up the experienced staff, enriched the management organization, and supported the technical guarantee to the development of small hydropower.

6 Policy Suggestions to Renewable Energy Promotion Law of People's Republic of China

1) **The grid enterprises should purchase all the renewable electricity including small hydropower and in full amount.**

2) **Formulate the clear principle of fixing the price for the renewable energy to sell the grid the electricity:**

- **The renewable energy including small hydropower should implement the green power price when selling the grid the electricity, and the principle of fixing the price should be renewable power generation cost + proceeds + the price of the environment protection.** Only by doing this way can the advantages of the green power be reflected..

- **Before the implementation of the green power price，according to the principle of reckoning in the appropriate compensation of the cost、the reasonable proceeds、the legal tax，it should accelerate the realization of the appropriate power price at which small hydropower sells the grid the electricity to ensure the rolling development.**

3) **The surplus electricity from the small hydropower distribution grid in small hydropower supply areas should be sold to the grid equally as small hydropower stations directly sell the grid the electricity. The small hydropower distribution grid in small hydropower supply areas and the big grid should supply the electricity mutually, at the ownership dividing point, the electricity should be offset month by month, while the offset electricity should be balanced at the respective power price.**

The surplus electricity from the small hydropower supply areas is the renewable electricity too. Since those small hydropower stations are feeding the electricity into the distributed grid，and exchange the electricity with the big grid via the distribution grid only, the renewable feature of small hydropower distribution grid in small hydropower supply areas remains unchanged.

4) **The country encourages and supports the distribution power supply in rural areas，calls for the separated development，power supply on the spot，self generation and self power supply，feeding the electricity into the grid，mutual exchange of the surplus and the scarce electricity.** All above are the unique advantages of small hydropower of all renewable energies.

5) **Continue the implementation of the policy "small hydropower should have its own power supply areas", while the power distribution enterprises in self generation and self supply counties shall stick to the direction of being the independent distribution company.**

The blue print of the reform on power sector has made clear that the power transmission should be divided from power distribution to supply the electricity competitively. The power distribution enterprises in self-generation and self power supply counties have already been the independent legal person and provided with the rudiment of the independent power distributed company, therefore, it is conforming to the direction of the reform of power sector. "Small hydropower should have its own power supply areas" and the system of self generation and self power supply in fact ensures the market of small hydropower, which has the commons with the concept of RPS in some depth, conformed with the situation of China and conduced to the development of small hydropower, should be continued in《Renewable Energy Law》.

6) **The country carries out the RPS for the renewable electricity, and builds up the electricity trading market for the green energy. And clarify the specific schedule.**

7) **Levy 3% value-added tax on all small hydropower enterprises, and make out the invoice of value-added tax at 3%, the VAT the grid enterprises pay is also 3% when the grid buys the electricity from small hydropower.** (It is also putting in another way that if the grid enterprises buy the small electricity but can not deduct the VAT partially, it can be levied first and then returned, or as the factors brought into the consideration when adjusting the power price).

At present the VAT small hydropower enterprises pay is 6% at and below the county level. Due to the multi-channel investment in small hydropower, it is hard to determine what is at or below the county level. The expansion of this policy to all small hydropower enterprises will conduce to the concrete operation and make all small hydropower enterprises stand on the same scratch line. Meanwhile, the original policy has not clarified how the downstream grid enterprises deduct, that is to say, they still have to pay 17% VAT and can not deduct 11% VAT, which causes the policy not to be fulfilled entirely. According to the survey and calculation of the petroleum processing and the coal gas production and supply, both industries only pay VAT 3.2%、3.8% respectively. As the clean renewable energy, it would be helpful to decrease the VAT rate to promote the development of the renewable resources and protect the environment.

8) **Allow the small hydropower generation enterprises to supply the electricity to the customers directly, which conforms to the reform direction of power sector of the country.** There are practical experiences that small hydropower provides the electricity for customers directly, particularly in the rain season, such direct supply can make the best use of electricity generated by small hydropower.

9) **Clarify that the loan return period can be extended to 20 or 25 years for small hydropower.**

Because the cost of small hydropower is mainly once and for all, if the loan return period is 10 years as it provides now, small hydropower has to enjoy the higher power price than now. Through the survey and calculation，we found that，if other conditions remain unchanged and only extend the loan return period from 10 year into 20 years，the power price for repaying the loan can be lowered RMB 0.1/kW·h approximately，the decreasing extent is considerable. From the aspect of practical operation，at present the state council approves the loan return period for the project of upgrading the rural grid extending to 20 years. In the implementation opinions regarding the development of western part of China on several policies circulated by Office of General Affairs of state council, hydropower projects of western part of China can enjoy the loan return period of 25 years. Therefore, there are the precedents for extending the loan return period and it is feasible too.

10) **Central government, local finance and the renewable fund offer the subsidy for the development of small hydropower and other rural public infrastructure.**

11) **Central finance offers the 20—50% capital fund of the total investment for small hydropower station substituting for fuel; small hydropower station substituting for fuel borrows the grid to transmit the electricity, the grid enterprises only charge the practical operation cost for the borrowing and can not sell such the electricity at an added price; In the dry season the grid enterprises should adjust and store up the small hydropower station substituting for fuel, supplement the scarce electricity in some depth; the electricity sold to the grid or bought from the grid from small hydropower station substituting for fuel is offset year by year or season by season; the surplus electricity from small hydropower station substituting for fuel enjoys the same renewable power generation policy.**

The project of substituting small hydropower for fuel is the effective way to address the fuel problems of farmers in mountainous areas. The project can conscientiously protect the fruit of the project of transforming farmland into woodland and of natural forests protection. It is also the important measure to improve the ecology and protect the environment. The farmers' affordability plays the key role in determining whether such a project can be implemented smoothly or not. It is most important to decrease the power price of substituting for fuel conscientiously. According to the survey and calculation of the typical rural household，when the power price is lowered to RMB 0.20/kW·h in the west part of China、RMB 0.25/kW·h in the middle part of China、less than RMB 0.30/kW·h in the eastern part of China，farmers may afford and would like to use the electric cooking. On the basis of the planning，in order to decrease the power price to the goal as above, it is necessary for the country to offer the hydropower station the subsidy，according to the different affordability of all places, the subsidy standard is around 20—50%，west part of China will get the highest subsidy，east part comparatively low. Meanwhile，if the power supply enterprises do not raise the price for the electricity substituting for fuel, the farmer's burden can be alleviated more, their initiatives of using the electric cooking can be elevated. Considering the small hydropower stations are affected by the natural condition，the electricity substituting for fuel may be insufficient during some period of time. If the grid enterprises can supplement the lacking electricity appropriately and offset year by year or season by season, it could ensure people's life not to

be affected.

12) **The active development of small hydropower can help people living in the remote areas have access to power while the country offers the development outlay and operation fund.** This is also the important way to fulfill the electricity service at large.

13) **Apportion the investment on the multi-purposed hydropower project appropriately.**

The multi-purposed hydropower project shall apportion the investment of the flood control、ecology、irrigation and water supply properly，sticking to “who benefits，who shares in”. The investment mainly coming from the flood control and ecology, with the priority on the social benefits, shall be shared by central government or the local finance benefiting from the project, and the investment on the irrigation and water supply having economic benefits, in some depth, shall be shared by the beneficiaries.

14) **Build up the R&D system with the enterprises as the main body gradually. The country provides the proper subsidy for the technical innovation, new technology and the equipment transfer of small hydropower.**

During the decades of development, the small hydropower manufacturing industry of our country has shaped into the considerable scale. There are more than 80 turbine and generator manufacturers，and the manufacturing capacity each year is about 6GW. A series of standard has also been formulated and an integrated set of experiences with the Chinese characteristics has been accumulated. However, as it is said ahead, the function of small hydropower equipment in our country still has the distance from the developed country. We can not produce some type of turbine now, and the capacity of R&D of small hydropower enterprises is poor. The support on small hydropower equipment manufacturing industry should mainly concentrate on the self-development, introduction of the type that can not be produced in China, and the efficiency upgrading of turbine. Such research should depend on the enterprises mainly with the proper subsidy from the country.

7 Other Problems

7.1 Policy support on the independent operated small hydropower stations

Policy: (1) Finance offers the independent operated small hydropower stations the investment subsidy; (2) Actively encourage the independent operated small hydropower stations to form the grid and supply the electricity on the spot, while several small hydropower stations can operate and connect to each other; (3) The independent operated small station executes the power price provided to the household by the administration region, if the power fee is not enough to offset the operation cost, the local finance should offer the subsidy; (4) It advocates the social investors developing small hydropower stations, forming the grid and supplying the electricity on the spot，and the country provides the proper assistance for the investment and operation cost of the station. After the big grid extends to the small hydropower grid, small hydropower supply areas can continue be mutually

supplementary in each other's needs.

The small hydropower stations operated independently are mainly built up in the areas where the grid is hard to extend to. Such small hydropower stations can form the network and supply the electricity on the spot to alleviate the power consumption difficulties in production and daily life. The small hydropower may operated solely and only provide the electricity for one or several villages. It is also possible for several small hydropower stations to connect with each other and supply the electricity for one or several towns. In Sichuan province、Qinghai province and other places，there are still some isolated county grid (referring to the country grid that has no physical connection with the other grid). The whole county depends on small hydropower to supply the electricity. In those places small hydropower is in fact responsible for helping people have access to power and fulfilling the prevalent electrical service, in such a circumstance, small hydropower reflects more social benefits and public interests rather than the economic benefits. However，from the aspect of supporting agriculture, rural areas and farmers, the independent small hydropower needs the support. In view of the public feature of small hydropower，the country or the local government should become the main investors and offer the subsidy for the part that the operation cost exceeds the power fee to keep the normal operation and management of the shp station. Meanwhile, the country encourages social capital to develop small hydropower in areas where people have no access to power, and provides the subsidy to mobilize the initiatives of the whole society.

7.2 Special policy support and reasons for the development of small hydropower in western part of China

Special policy: (1) If the local state-owned enterprises develop the small hydropower in west part of China, the finance offers those enterprises 10% assistance of capital fund; (2) The finance pays the discount when cashing the promissory note for the development of all small hydropower stations in western part of China.

No matter in western part or south east part of China, the regions that are rich in the abundant small hydropower resources belong to the poor areas of that province (metropolis and autonomous region). Therefore, as far as the development of small hydropower is concerned, both western part and eastern part are in need of the policy support. Those policies have been mentioned as above. Considering that the integrated economic development level lags behind, the local enterprises have the poor strength and lack the capital fund to develop the small hydropower in western part of China, in order to promote the development of those enterprises and raise their dynamic energy, we suggest the central finance offer about 10% assistance of capital fund through transfer payment when the local state-owned enterprises develop the small hydropower in west part of China. With the growth of the developing scale, the exploring cost of small hydropower will be higher and higher. In view of the low power price in the western part of China，it is conducive to reducing the burden of returning the loan if the finance pays the discount when cashing the promissory note for the development of all small hydropower stations of western part of China. According to the survey and calculation，if other conditions remain unchanged and only the lending interest is decreased a half，the small hydropower operation cost within the loan return period will be lowered about RMB

0.1/kW·h，therefore, tax rate plays an important role in influencing the operation cost of small hydropower. If the finance could pay the discount when cashing the promissory note for small hydropower of western part of China，it would raise the economic benefits and the capacity of returning the bank loan of small enterprises in west region.

7.3 Problems of Mini-hydro

Foreign countries strongly support the mini-hydro. The mini-hydro built up by farmers can feed the power into the grid and the electricity purchased by or sold to the grid by mini-hydro are offset and balanced at the same time. At present，the mini-hydro is mainly supplying the electricity to one household or several household for the illumination，if the capacity of the mini-hydro is large enough, it may supply the electricity to a whole village for the illumination or some agricultural products processing. The support policies mainly include: (1) offer farmers the subsidy for buying the mini-hydro; (2) set up the maintenance station in those areas where there are many mini-hydro，serve the farmer, the cost of the maintenance station comes from the finance or renewable energy fund; (3) offer mini-hydro manufacturers the preferential tax rate.

Appendix

National and Local Policies Concerned to Promote the Development of Small Hydropower

I、The provisions of the present《Electricity Law of the People's Republic of China》

2nd Paragraph of Article 5: The State encourages and supports electricity generation by using renewable and clean energy resources.

2nd Paragraph of Article 12: The local people's governments shall adopt diversified measures in line with local conditions to develop power sources and promote power construction on the basis of the electric power development planning.

1st Paragraph of Article 22: The State advocates parallel operation between power production enterprises and power networks or among networks. Requests by power production enterprises with the qualifications of an independent legal entity to feed its electricity generated into a power network shall be accepted by the network operation enterprises.

2nd and 3rd Paragraph of Article 38: For the power purchase price of an independent power network, a proposal shall be made through consultation by the enterprises engaged in power production and power network operation, and shall be examined and approved by the authorized pricing administrative department.

For the power produced by locally funded power production enterprises, if forming an independent power network within different regions of the province or generated for local use, the price may be under the control of the people's governments of the province, autonomous region or municipality directly under the Central Government.

Article 47: The State adopts preferential policies for rural electrification, and provides special support to rural power construction in minority nationality areas, frontier and remote areas, and poverty-stricken areas.

1st Paragraph of Article 48: The State advocates the exploitation of rural hydropower resources, the construction of medium and small size hydropower stations to promote rural electrification.

Some provisions of Electricity Law of People’ s Republic of China as above aim at small hydropower，while some of them have the close relationship with the development of small hydropower although they are not concerning small hydropower directly. All the texts play a good role in promoting the development of small hydropower from different sides，and ensure the development of small hydropower to be advocated and supported legally.

II、The document circulated by CCPCC and state council regarding the agriculture and rural work in the year of 2002、2003、2004 requests to accelerating the development of small hydropower.

Opinions of Several Policies regarding Increasing Farmers' Income Circulated by CCPCC and State Council（Zhongfa［2004］No.1）requests: water-saving irrigation、water drinking for people and domestic animals、village way、rural methane、rural hydropower、pasture and fence and other "Six Small-Scaled Projects" are giving the active play in the improving farmers' production and living condition、bringing along the increase of farmers' employment、increasing the farmer's income, and those projects should be expanded the investment scale and construction range, and enriched the building content,.

Opinions regarding the Agricultural and Rural Areas Work Circulated by CCPCC and State Council in 2003（Zhongfa［2003］No.3）requests: The national agricultural infrastructure capital and the finance of supporting farmers should be around water-saving irrigation、water drinking for people and domestic animals、village way、rural methane、rural hydropower、pasture and fence and other "Six Small-Scaled Projects". Those projects should be expanded the investment scale and enriched the building content. The rural energy construction shall give the important support for rural methane and the project of substituting small hydropower for fuel in the areas that implement the transformation from farmland into woodland to consolidate the fruit of the transformation.

Opinions regarding the Agricultural and Rural Areas Work Circulated by CCPCC and State Council in 2002（Zhongfa［2002］No.2） requests: Attach the more importance to the rural small-scaled infrastructure, mainly support water-saving irrigation、water drinking for people and domestic animals、village way、rural methane、rural hydropower、pasture and fence and other projects.

CCPCC and state council have for 3 years consecutively clarified in the documents regarding the agriculture and rural areas work that it should accelerate the development of small hydropower to address the rural energy problems and help farmers get rich. The document also clarifies the role and function of small hydropower in the development of rural energy and rural economy，which is to link the small hydropower to improving the ecology and protecting the environment, creating the good policy and social environment for the development of small hydropower. Meanwhile，according to the request of CCPCC and state council，all places have carefully worked out the planning of the project of substituting small hydropower for fuel. 886 counties have completed the planning of 25 provinces（metropolis、autonomous region）. It is planned that by the year of 2020 the project of substituting small hydropower for fuel will address the living energy problems of 28.3 million household、104 million people，each year reduce the consumption of bavin for 149 million m^3，corresponding to protecting 23 million hectares of forests. Comparing with the fire plant, it may reduce the emission of CO_2 200 million tons、SO_2 920000 tons，therefore, the ecological benefits are very obvious. Presently，according to the national approval, the pilot project of substituting small hydropower for fuel has been carried out in 5 provinces（autonomous regions），including 26 projects. The whole project will be implemented after the pilot project is completed at the end of this year.

III、State council has consecutively approved Ministry of Water Resources building up the rural electrification and formulated a series of policies to promote the development of small hydropower.

In 1983，《State Council Approves and Pass on the Notice to the Report by Ministry of Water and Electricity regarding the Active Development of Small Hydropower and Building up the Chinese Rural Electrification Pilot Counties》（Guofa [1983] No.190）worked out the following policies:

（1）The small hydropower above the county level should be listed into the infrastructure plan to ensure the necessary supply of the material、stuff and the equipment. The investment on small hydropower from the collective ownership does not have to list into the national planned channel. If farmers build up and manage the small hydropower stations by themselves and for self use, their investment doesn't list into the channel either.

（2）The construction of small hydropower relies on the local strength to collect the capital while the country provides the necessary support. From the year of 1985，each year RMB 100 million yuan has been drawn from the power construction investment to provide some counties for building up the small hydropower.

（3）Fulfill the policy of "feed power with power". The profits from the newly built small hydropower stations will not be brought into the local financial budget, neither does the profits that are produced by the grid and sold to the county wholesale. All the profits will be used for developing small hydropower and the local small hydropower grid, except for those part for the production cost and the loan return according to the plan. From the aspect of tax paying，according to the provisions concerned，if the small hydropower enterprises have difficulties in paying the income tax, within a fixed period of time the tax payment can be decreased.

（4）Continue providing the loan with the low interest for small hydropower. The loan used for the new purchase of small hydropower equipment is provided the preferential agricultural loan at the lowest lending interest. The loan return period can be extended from 3 ~ 5 years to 10 years when necessary.

（5）The small hydropower supply price in line with the local condition is under the checking and ratification of the hydropower sector of the county according to the national provisions concerned, or executes the floating power price in accordance with power supply and utilization condition.

（6）Small hydropower and small hydropower grid built up by local community are constructed, managed and maintained by the people of local community. The county that mainly relies on the small hydropower supply can combine the water with the electricity to establish the integrated management entity at the county level of "power generation, power supply and power consumption". The entity will take the whole responsibility of the electrification work.

The small hydropower grid and small hydropower supply areas are under the integrated control of the county. It advocates small hydropower grid feeding the electricity into the big grid when the condition is provided with. In the rain season both big and small grid shall endeavor to carry out the seasonal electricity consumption, while in the dry season the big grid shall supply the electricity to the small hydropower grid according to the planned indicator. The contradiction between the big grid and small grid should be dealt with well on

the basis of the document provisions concerned.

（7）Under the condition of unified planning，if economic factors of the project are reasonable，the prefecture and county can build up the hydropower station with the capacity over 12000MW; The voltage degree of small hydropower transmission and transformation project should be within the extent of the power supply, if necessary, can be higher than 35kV.

In 1991，《State Council Approves and Pass on the Notice to the Application by Ministry of Water Resources regarding Building up the 2nd Batch of Preliminary Rural Hydropower Electrification Counties》（Guofa [1991] No.17）worked out the following policies:

（1）Continue the implementation of the policies in the document Guofa［1983］No.190 to promote the construction and management of small hydropower.

（2）The construction of small hydropower relies on the local capital while the country provides the necessary support. During the "8th Five-Year Plan"，the country arranges 200 million loan transferred from appropriation each year to support the rural electrification. The planning, agriculture, bank and other sector concerned at each level shall give the further support. "Give people work in place of relief subsidies"、development fund for the poverty alleviation and other capital can also be used for rural hydropower and electrification as well as rural hydropower grid construction。

（3）If the electricity by small hydropower is out of the plan, the power price is controlled locally and the electricity can enter into the market. In order to raise the capacity of returning the loan to realize the self-development, the appropriate power price elevation is accepted. Generally speaking，the power price of small hydropower should be close to the average power price of the big grid.

（4）The rural hydropower supply areas can follow the policy provided by the country for the big grid，increase RMB 0.02/kWh as the electric power construction fund, such a fund together with the "feed power with power" fund and the special fund for small hydropower construction in past years can be used to establish the rural hydropower development fund to realize the pay use and the rolling development.

（5）The small hydropower will continue the management guidance of "self-construction、self-management、self-consumption" and "small hydropower should have its own power supply areas" to form the trinity of "power generation, power supply and power consumption" and establish the integrated management system. Continue the policy that the big grid should support the small hydropower and give some interests away. The national grid should not transfer directly or in disguised form the rural hydropower grid and its power supply areas built and managed locally without any return.

（6）Under the integrated planning，the province、prefecture、county may build up the hydropower station with the capacity over 25MW, and the transmission and transformation project with the voltage degree higher than 35kV. And the project executes the policy of "The one who constructs and manages benefits from it".

（7）Formulate the planning of the grid and power supply construction, in line with the local economic development and the comprehensive governance of rivers. It should give the

priority to those stations with the multi-purposed use and the regulation capacity, and should combine the medium-sized hydropower stations with the small ones. It should make the best use of the seasonal energy generated in the rain season to develop the local economy. Where the condition is provided with, it advocates the network connection among counties, and feeding the electricity into the big grid. After the electricity is fed into the big grid, the small hydropower grid delivers the electricity to the big grid while the latter distributes the electricity.

In 1996，《Notice on Several Issues from State Council regarding Building up the 3rd Batch of Preliminary Rural Hydropower Electrification Counties》（Guobantong [1996] No.2）approves the Ministry of Water Resources continuing the organization of the 3rd batch of preliminary rural electrification counties and clarifies that:

（1）The construction of small hydropower relies on the local capital while the country provides the proper support. The assistance of central government in accordance with the standard of the 2nd batch is elevated in a comparatively big extent.

（2）It approves the rural hydropower and grid enterprises continuing executing VAT 6%.

（3）Continue the implementation of the provisions concerned regarding building up the 2nd batch of preliminary rural hydropower and electrification counties.

In 2001，state council again approved building up the 4th batch of rural hydropower electrification counties in the 10th Five-Year plan. The central government continues arranging some assistances and implementing the provisions regarding building up the rural electrification.

Since 1983，the country have arranged the work of small hydropower and electrification in 4 consecutive Five-Year plan, and formulated a series of policies, covering small hydropower planning、project approval、capital、management system、construction of the power supply areas、selling price to the grid、tax、the preferential bank loan and other aspects. The policies link the development of small hydropower to the development of the poor areas and poverty alleviation. Under the support of those policies，the upsurge of developing small hydropower is lifted all places and makes the great achievements. The development of small hydropower has helped hundreds of million people to have access to power. There are accumulative 653 counties completing the preliminary rural electrification. The electrified household rate reaches over 96% and exceeding the national average level. With the help of electrification, the GDP, financial revenue, farmers' net income per capita, power consumption per capita of those electrification counties have basically increased twice as much as those of 5 years ago or quadrupled in 10 years，and the development speed is obviously higher than the national average level. Under the support of those policies，small hydropower development has walked ahead of the world. The experience in developing small hydropower to build up rural electrification, and helping people in remote areas to have access to power and alleviating the poverty has been unanimously attached importance to and acknowledged by the international community. The headquarter of IN-SHP consisting of more than 60 countries and regions、over 150 government and international agencies is located in Hangzhou, China. In 2000 the UNIDO established the IC-SHP. Meanwhile at the early 1980s when China was carrying out

the planned economic system, many policies to promote the development of small hydropower have been provided with the market economic features, which makes small hydropower take the lead in coming into the market competition among the whole power sector and promotes strongly its own development.

IV Notice of State Council regarding the Circulation of〈Development Program of Chinese Agriculture in the 1990s〉（Guofa［1983］No.80）provides，by the end of 2000，it increases hydropower capacity 15000MW，among which the large-sized hydro 2800MW，medium-sized 630MW，small-scaled 6000MW. There are 500 rural preliminary electrification counties that will be completed.

Development Program of Chinese Agriculture in the 1990sbrings forward the clear development goal for small hydropower and electrification，which drives polices at each level to attaching importance to the small hydropower development. By the end of 2000, the task of developing small hydropower and building up the electrification has been over-fulfilled.

V The power price small hydropower executes is fixed by the market

In 1986，National Economy and Trade Commission、Ministry of Water and Electricity、National Price Bureau provided in《Notice on Several Provisions regarding the Small Hydropower Price》（［86］ShuidianCaizi No.119）:

（1） Small hydropower should execute the principle of "self construction、self management、self consumption". If the electricity generated by small hydropower is out of the plan, it can be adjusted by the market.

（2）Small hydropower station operated solely or small hydropower grid feeding the electricity into the big grid supply, if they supply the electricity to their own power supply areas, may not execute the national integrated power price，but the local price sector should determine the electricity distribution price in line with the local practice and according to the principle that the interest is reasonable.

（3）Every small hydropower station feeding the electricity into the big grid should obey the uniform dispatch of the grid. If the customer subscribes for the small hydropower electricity, the power sector should sell the electricity on a commission basis. The power price sold to the grid by shp station should be determined as average electricity generation cost at the medium degree plus generation tax and the reasonable interest, but such a price should not be lower than RMB 0.05/kWh. The electricity sold by the grid on the commission basis may not implement the national uniform price but executes the selling price sold to the grid plus average electricity supply cost by that provincial power bureau, plus the line loss, the tax for the electricity supply and the average interest in supplying the electricity. The selling price to the grid and electricity distribution price should be implemented after checked and ratified by provincial price bureau, power bureau and department of water and electricity. The price should be also submitted to National Price Bureau and Ministry of Water and Electricity to put on records.

（4）The selling price to the grid and electricity distribution price should be at the different prices in the rain season and dry season and be divided into the peak and valley price

at different time.

（5）In order to support the development of small hydropower, the big grid and small hydropower grid should supply the electricity mutually. At the same computation point in the same month（The meter is installed at the dividing line of the ownership）, the transferred electricity mutually offset each other according to the peak and valley period of time. After the electricity is offset，if the electricity by small hydropower sold to the grid has the surplus, the excessive electricity should be sold at the power purchase price the big grid offers when the big grid needs and the customers subscribe for; If the big grid provides more electricity for small hydropower supply areas, the power price of the excessive electricity defers to the small grid price.

The documents above has elaborated the selling price by small hydropower to the big grid、the distribution price of the small hydropower grid, the electricity exchange between the big grid and the small grid and the according price. Although in the 1980s our country was still within the planned economic system, those provisions, however, have had the market economic elements. The small hydropower price is the first price outside of the national uniform pricing but determined locally，which leads small hydropower to walk into the market at the earliest and promotes its development strongly. Meanwhile，the document also clarifies the lowest purchase power price standard the grid offers the small hydropower enterprises. Although it looks very low at present, the standard protects the benefits of small hydropower well. Besides, it also provides small hydropower development with the good condition in mutually offsetting the electricity of the big and small grid. In fact many texts of this document are still applicable nowadays.

VI Execute the Value-Added Tax 6％

Ministry of Finance and State Administration of Taxation make clear in the documentNotice on Adjusting the VAT Rate of Agricultural Products & Avoiding the VAT of Several Items（Caishuizi［94］No. 004）: The small-scaled hydropower entity pays 6% VAT according to the simplified procedure below the county level, and makes out the special invoice accordingly by itself.

It is conducive to mobilizing the initiative of developing small hydropower, raising the development benefits and reducing the burden of small hydropower enterprises when small hydropower entity pays for only 6％ VAT.

VII Provide the Preferential Loan for Small Hydropower

In 1986，Notice on Adjusting the Lending Rate and Paying the Discount When Cashing for the Promissory Note by Ministry of Water and Electricity、Ministry of Finance、People's Bank of China（［86］Shuishuinongdian No. 5）clarified，since 1986，People's Bank of China each year arranges the small hydropower special loan in some banks concerned and requests the local government all places to pay the discount when cashing the promissory note for the small hydropower special loan.

The establishment of small hydropower special loan increases the support strength of the financing sector on developing small hydropower. In the 1990s the small hydropower special

loan reaches RMB 2 billion，and it is easy for the development of small hydropower to be provided with the loan. The small hydropower special loan was called off gradually at the end of the 1990s when the banks are commercialized.

VIII Guangdong Provincial People's Congress and Government actively support the development of small hydropower

Guangdong Provincial People's Congress makes the decision on continuing the support on the development of rural small hydropower，and the provincial government formulates the specific implementation measures under the decision, and circulates "Implementation Measures on Supporting the Mountain Areas to Develop Small Hydropower"（Yuefuban［2002］No.86）, which covers:

（1） Increase 500MW small hydropower capacity from 2003-2007 in 50 mountainous counties of the whole province.

（2）Province continues the assistance of RMB500／kW for small hydropower station，each year it will support 100MW newly increased small hydropower capacity.

（3）The small hydropower enterprises built by the county or town are allowed to supplying power to the customer enterprises, but the supplied electricity should be consumed within the county.

（4）The electricity purchase price that the big grid offers small hydropower entities is the average comprehensive purchase price of the provincial grid, which is also the lowest protection price for small hydropower.

（5）The grid entity should give the priority in purchasing the surplus electricity generated by small hydropower and the purchased electricity from small hydropower should be offset month by month.

The Guangdong provincial policies clarify the provisions in investment, management system, power generation and electricity price sold to the grid etc, and bring forward the explicit development goal and investment policies. Several policies mentioned by the document address the main issues that affect the development of small hydropower and promote the small hydropower development greatly. In 2002 the total increased small hydropower capacity is 390MW in Guangdong，another 497MW is increased in 2003，this development speed is twice over that several years ago. At present， the installed capacity of small hydropower in Guangdong province has reached 4600MW，ranking the 1st place of the country. The rapid development of small hydropower in Guangdong province is inseparable with the feasible policies.

IX Yunan、Hunan、Shanxi and Other Provinces Formulate the Decision on Accelerating the Development of Small Hydropower

Yunan provincial government provides in the document Decision regarding Accelerating the Development of Small and Medium Hydropower（Yunzhengfa［2003］No. 138）:

（1）From 2003 to 2010，it should ensure 3000MW small and medium hydropower to be operated，and try to put 4000 MW into the operation，which is twice as much as that of 2002.

By the year of 2020 it will break through 10000 MW, form the transmission and distribution grid with the voltage degree of 110kV at the county level，basically form the main framework of the grid among the prefectures, promote the network connection of the whole province; Under the supervision of the government establish the open, fair-play, orderly, healthy electricity market system dividing the administration from the enterprise.

（2）It sticks to the following basic principles to reach the goal as above:

Insist on taking the reform and opening-up as the promotion force of the development. To open up the development market of small and medium scaled hydropower, expand the cooperation and exchange from home and abroad, introduce the domestic and foreign capital, modern technology and operation management to continuously enrich the scale and raise the developing level, and develop the hydropower as the backbone industry of the power sector.

It sticks to making the overall planning and optimizing the resources allocation.

It sticks to the market oriented and orderly competition.

It sticks to who constructs, who owns, who manages, who benefits from, and who shares the risks.

It sticks to the principle that rural hydropower should serve the agriculture, rural areas and farmers.

It sticks to the sustainable development.

（3）It has worked out the development planning on rural hydropower of the whole province，actively boosted “hydropower and rural electrification”、“upgrading of the grid”、“project of substituting small hydropower for fuel”、“alleviate poverty with the help of the electricity”. By the year of 2005, it will complete the construction of 46 hydropower and rural electrification counties，start and boost the project of substituting small hydropower for fuel，and help all people have the access to power. By the year of 2010，it will continue the implementation and completion of the project of substituting small hydropower for fuel，and build up 80 hydropower and rural electrification counties.

（4）The policy measures to accelerate the development of small and medium scaled hydropower

Strengthen the macro regulation. Bring the construction of small and medium scaled hydropower into the development plan of the power sector as well as national development overall planning. The responsible sector should strengthen the overall planning, management and the exploration steering on the hydraulic resources of small and medium scaled hydropower. Around the development goal to develop the hydropower as the backbone industry of the power sector, it should bring the features and advantages of small and medium scaled hydropower into full play to increase the investment and make the overall arrangement. It should tackle opportunity, give the prominence to the key projects, implement step by step, with the harmonious development to provide with the stable electricity for local economic development.

Pay attention to the prophase work. The local government at each level should invest more in

the prophase work and make the arrangement beforehand，trying to reserve a batch of projects、start working on a batch、and put a batch into the operation，to boost the development of small and medium scaled hydropower. It should also make the water-basin planning on the 1st, 2nd and 3rd step tributary and collect the fund from many channels to accelerate the schedule of the prophase. The provincial planning and reform commission will since 2004 each year arrange RMB 10 million Yuan on the prophase work of small and medium scaled hydropower consecutively to establish the use rolling system.

Put more investment on small and medium scaled hydropower.

Reshuffle the power capital.

Speed up the advancement of “tie in the electricity with the mine”. According to the national provisions that the power generation entity directly transmits the electricity to the large electricity consumers，it should explore the method of such a direct electricity transmission, and grid entity should also give the support.

Establish the canonical electricity market. It will use the price lever to adjust the interest allocation among local power generation, transmission, distribution and sale, and stick to the principle “appropriate compensation for the cost，proper determination of the proceeds，legal calculation of the tax，insistence on the fair share”, accelerate the formulation on the guidance of the electricity dispatch and the power price at which the small and medium scaled hydropower sells to the grid.

Improve the support and protection policy. Carefully fulfill the preferential policy of west development and the provincial policy regarding the expansion of the private investment to develop non-public sector of economy. The foreign investors who invest the development of small and medium scaled hydropower will be treated equally by national territory department, resettlement sector, forestry bureau and taxation sector when the construction of small and medium scaled hydropower covers the land, submersion of wood, resettlement or taxation. It will carry out the preferential policies to levy the farmland compensation fee、resettlement compensation fee、farmland reclamation fee and occupation tax, income tax and VAT，and continue the policy of “feed power with power” and 6％ VAT payment by shp enterprises，meanwhile it will stick to the policy of export tax rebate on the electricity generated by small and medium scaled hydropower. It advocates the development of reservoir hydropower station and compensates for the land occupation more favorably. The development company of water basin can use the fixed asset, depreciation fee and the whole proceeds of water resources of the operated hydropower station as the capital fund to realize the rolling development.

Increase the support on building up rural hydropower. The local government at each level should arrange the counterpart fund on rural electrification construction and on the project of substituting small hydropower for fuel. It should also allocate the special fund for helping people to have access to power, and supporting the rural hydropower construction by the government paying the discount when cashing the promissory note and using the poverty alleviation loan. Each year the provincial government pays the discount when cashing the promissory note for the newly built small hydropower station, particularly for the those in the

remote, minority and poor areas. It will continue implement the policy of "self-construction、self-management、self-consumption"、"who constructs、who owns、who manages、who benefits from"、"small hydropower should have its own electricity supply areas"; when the surplus electricity of rural hydropower station is sold to the provincial grid, the provincial grid should give the support to ensure the surplus electricity to be first sold competitively to the grid; it encourages and leads the each economic entity to invest in rural hydropower no matter it is individual and collective, it also works out the policy and regulation on advocating the development of rural hydropower and other renewable energy to explore the rural electricity consumption market. The income tax paid by small hydropower enterprises and left to the local will continue implementing the preferential policy of "feed power with power".

Hunan Provincial Government provides in the document of Notice that Office of General Services of Hunan Provincial Government Transmits the Opinions by Provincial Planning and Reform Commission on Accelerating the Development of Rural Hydropower (Xiangzhengbanfa [2003] No. 29):

(1) During the "10th Five-Year Plan", it will invest 5 billion Yuan to increase the 700 MW hydropower capacity. By 2005, the total hydropower capacity of the whole province will reach 3700 MW, and 500000 household will use small hydropower instead of fuel to meet the daily energy requirement. Establish the large scaled rural hydropower base in Huaihua、Chenzhou、Shaoyang and Xiangxi autonomous prefecture. During "11th Five-Year Plan", it is planned to invest 6 billion Yuan to increase 1000 MW capacity. By the year of 2010, the total hydropower capacity of the whole province will reach 4700 MW, and 1.7 million household will use small hydropower instead of fuel to meet the daily energy requirement. Turn Huaihua, Chenzhou, Yongzhou and Zhangjiajie city into the oversized rural hydropower bases of the whole country, while turn Hunan province into the strong hydropower province.

(2) Simplify the project approval procedures and publicize the market admittance condition.

(3) Deepen the reform on local grid and develop the competitive and orderly electric market.

(4) Strengthen the policy support and build up the good external environment.

Rural hydropower project will continue enjoying the preferential policies and protection policies in order to support the development of rural hydropower. The sector concerned in the government at each level should create the good external environment and condition for the employers. The financial sector should support the development of rural hydropower. The poverty alleviation fund can be used as the capital fund to develop rural hydropower. The equity participant will be the poor village and they get the gains according to the size of the share put in. The proceeds belong to the poor village collection. The assistance to the development of hydropower in Xiangxi autonomous prefecture will continue according to the document Xiangbanfa [2001] No.10 provided by the office of general affairs of provincial party committee and provincial government. It also offers the proper assistance for the development of hydropower in other poor areas and minority areas, but depends on the real financial capacity. Rural hydropower station and grid enterprises less than 50 MW will pay the VAT 6% in the simplified way and make out the special invoice accordingly.

Shanxi Provincial Governemnt provides in the document of《Notice on Some Sectors

Strengthen the Small Hydropower Management》（Shanzhengfa［2002］No. 11）:

（1）Implement the work of selling the electricity generated by small hydropower to the grid conscientiously. The power sector should accept and admit the electricity generated by small hydropower feeding into the grid at the maximum not to waste the hydraulic resources. The provincial power company and local power company will be responsible respectively for purchasing the electricity by small hydropower stations. The electricity feeding relationship, power supply, electricity dispatch and balance relationship remains unchanged. The electricity by the newly built small hydropower stations will be fed into the grid according to the principle of "feed into the nearest grid，consume on the spot，share the resources mutually". If the newly built small hydropower station is located in one scope, its electricity will be fed into the grid in that scope too, and such grid should also take charge in admitting the electricity by small hydropower station. The provincial local power company should seize the opportunity of upgrading rural grid to open up the electricity market with the increased emphasis on distributing more and more electricity. The provincial local power company within its management scope should try to admit all the electricity by small hydropower stations.

（2）The grid that small hydropower stations feed the electricity into should sign the electricity supply contract with the small hydropower stations. The dispatch center that is responsible for dispatching the electricity by small hydropower station should sign the dispatch contract and balance the electricity fee with the small hydropower station. The electricity fee is calculated and balanced according to the electricity feeding into the grid and at the purchase price the grid offers. The provincial price bureau will check, ratify and publicize such prices.

（3）In order to encourage the counties to make the full use of the small hydropower resources to develop the local economy where small hydropower potential is abundant and the electricity generated is more than electricity consumption，the small hydropower enterprises should invest in the project that consumes the energy in plenty according to the national industrial policy. The electricity supply is mutually supplementary in needs between the big and small grid, and the electricity should be offset month by month. When the condition is provided with，it may tested on the direct negotiation between the independent operated small hydropower station and the big customers，while the grid enterprises may charge the reasonable electricity transmission fee, the transmission fee is implemented on the basis of the provisions concerned by the price sector.

Besides those provinces，other provinces（metropolis、autonomous region）also bring forward a series of policies to promote the development of small hydropower. The policies from the different sides provide the support for the development of small hydropower and create the good social and external environment for small hydropower and have attracted the multi-channel fund of all social community to invest in small hydropower development. The impact is fairly good.

Attached Table 4-1

Technical Exploreable Potential of Small Hydropower in Each River Basin

No.	Water Basin	Total Capacity (MW)	500kW—50MW		＜500kW
			Station Number (Station)	Capacity (MW)	Capacity (MW)
	Whole Country	124619	17425	111000	13619
1	Yangtze River	47455	7743	40021	7433
2	Yellow River	8480	750	8154	327
3	Pearl River	12474	2931	10788	1686
4	Hailuan River	1277	259	1182	95
5	Huai River	791	184	611	180
6	Various Rivers of Northeast Pat	4863	861	4737	125
7	Various Rivers of Southeast Coast	14020	2888	10869	3152
8	Various International Rivers of Southwest	5306	597	4881	425
9	Brahmaputra River and Other Tibet Rivers	16219		16219	
10	Various Rivers of North Inner Land and Xinjiang	13733	1212	13537	196

Note: There are not big changes in small hydropower technical exploreable resources according to the new round survey on hydraulic potential，however, big changes of small hydropower technical exploreable resources take place in different water basins. At present the final result does not come out yet.

Attached Table 4-2

Technical Exploreable Potential of Small Hydropower in Each Province (Autonomous Region、Metropolis)

No.	Province	Total Capacity (MW)	500kW—50MW		＜500kW
			Station Number (Station)	Capacity (MW)	Capacity (MW)
	Whole Country	124619	17425	111000	13619
1	Beijing	984	134	928	55
2	Tianjin				
3	Hebei				
4	Shanxi	666	238	622	44
5	Inner Mongolia	508	96	502	6
6	Liaoning	598	190	578	20
7	Jilin	2137	392	2053	84
8	Heilongjiang	1665	196	1647	18
9	Shanghai				
10	Jiangsu				
11	Zhejiang	4863	1159	3563	1300
12	Anhui	1359	325	1060	300
13	Fujian	6812	1118	5399	1413
14	Jiangxi	5859	954	3117	2742
15	Shandong	66	53	66	
16	Henan	926	211	666	260
17	Hubei	6548	1757	5993	555
18	Hunan	7138	922	4337	2801
19	Guangdong	6210	2015	5205	1005
20	Guangxi	5862	1437	5062	800
21	Hainan	956	85	807	149

No.	Province	Total Capacity (MW)	500kW—50MW		＜500kW
			Station Number (Station)	Capacity (MW)	Capacity (MW)
22	Chongqing	3796	591	3408	388
23	Sichuan	12589	1808	12580	9
24	Guizhou	3665	540	3357	308
25	Yunnan	8891	960	8125	765
26	Tibet	16219		16219	
27	Shan’xi	1762	322	1718	45
28	Gansu	4782	602	4390	392
29	Qinghai	8411	364	8325	86
30	Ningxia	13	8	13	
31	Xinjiang	11334	948	11259	74

Note: There are not big changes in small hydropower technical exploreable resources according to the new round survey on hydraulic potential，however, big changes of small hydropower technical exploreable resources take place in different provinces. At present the final result does not come out yet.

Attached Table 4-3

Installed Capacity of Small Hydropower of Some Countries (MW)

Country	**Small Hydropower Capacity**	**Country**	**Small Hydropower Capacity**
Canada	2000	Argentina	40
USA	3000	**GB**	100
Italy	2209	Indonesia	200
France	1977	Tajikistan	31.4
Brazil	3000	Vietnam	88.2
India	1435	Spain	1271
Turkey	126.5	Laos	14
(EU in total)	9000		

Note: The definition of small-scaled hydropower is different in different countries. We make the list according to their own definition respectively.

Attached Table 4-4

Installed Capacity and Electricity of Small Hydropower of China in Past Years

Year	Installed Capacity (MW)	Annual Energy (hundred million kW·h)	Year	Installed Capacity (MW)	Annual Energy (hundred million kW·h)
1949	3.634		1977	4315.2	85.07
1950	3.696		1978	5266.5	99.73
1951	5.125		1979	6329.4	119.2
1952	5.524		1980	6925.5	127.19
1953	5.608		1981	7573.6	144.40
1954	6.503		1982	8079.7	172.23
1955	6.968		1983	8504.7	199.29
1956	10.539		1984	9066.4	208.36
1957	20.153		1985	9521.0	241.34
1958	77.340		1986	10095.3	244.24
1959	150.282		1987	11106.3	279.02
1960	251.450		1988	11792.1	315.80
1961	216.182		1989	12356.0	352.49
1962	227.420		1990	13180.3	392.83
1963	254.958		1991	13853.4	373.27
1964	285.000		1992	14419.1	442.0
1965	330.000		1993	15055.3	471.21
1966	380.000		1994	15777.7	508.68
1967	440.000		1995	16646.0	553.76
1968	500.000		1996	19200.8	619.6
1969	729.522		1997	20519.6	683.4
1970	1018.963		1998	22024.18	713.39
1971	1536.231	29.6	1999	23480.69	720.07

1972	1830.855	33.5	2000	24851.72	799.82
1973	2200.762	40.5	2001	26262.41	871.41
1974	2593.500	48.68	2002	28489.28	947.24
1975	3083.200	66.86	2003	30832.99	979.16
1976	3601.400	71.42			

- The statistic extent of small hydropower：less than 500kW from 1949 to 1959，less than 3000kW from 1960 to 1969，less than 12MW from 1970 to 1985，less than 25MW from 1986 to 1995，less than 50MW after 1996.
- The installed capacity from 1964 to 1968 is by estimation.
- There are no data of annual energy before 1970.

Attached Table 4-5

Installed Capacity and Energy of Small Hydropower of Each Province (Autonomous Region、Metropolis) at the end of 2003

Region	**Installed Capacity (MW)**	**Annual Energy (ten thousand kW·h)**	**Region**	**Installed Capacity (MW)**	**Annual Energy (ten thousand kW·h)**
Whole Country	30832.99	9791633			
Beijing	42.92	2224	Hubei	1856.817	659262
Tianjin	5	866	Hunan	2433.094	840577
Hebei	346.534	30034	Guangdong	4601.531	1269495
Shanxi	150.93	27991	Guangxi	1706.7	619203
Inner Mongolia	49.53	9317	Hainan	229.443	73247
Liaoning	256.18	37972	Chongqing	868.002	337011
Jilin	265.708	60137	Sichuan	3876.587	1657332
Heilongjiang	183.835	50814	Guizhou	1005.772	400540
Shanghai			Yunnan	2444.362	1009102
Jiangsu	34.451	4071	Tibet	158.798	18300
Zhejiang	2297.783	400854	Shanxi	512.362	146286
Anhui	383.997	106647	Gansu	511.494	184676
Fujian	3882.808	1066508	Qinghai	275.125	124839
Jiangxi	1380.076	335580	Ningxia	3.2	800
Shandong	66.449	6276	Xinjiang	676.906	175473
Henan	326.598	77393			

Chapter 5 Study on the Incentive Policies and Experiences of Foreign Legislation on Renewable Energy

1 Background

Renewable Energy is clear energy that can be recycled and will be the terminal energy choice to assure the sustainable development of human society. Renewable energy could be categorized as conventional renewable energy (mainly conventional biomass) and new renewable energy (including small hydro power below 50MW, solar energy, wind energy, biomass with new application technology, geo-thermal and ocean energy). Among this, conventional energy represents 85%, whereas the rest 15% is new renewable energy.

The human application of energy began with application of biomass including burning firewood and stalks. Later high density fuel like charcoal was used and finally, fossil fuel such as coal took the dominant role in energy application. It is safe to say that the application of conventional biomass has a same long history as human society. In 1970s, two petroleum crisis raised human awareness of the importance of Renewable Energy. Especially the increasing awareness of environment protection and the attention to the global climate change recently accelerate the development of renewable energy. For example, the development of wind power and solar PV technology increase 30% annually. Nowadays, renewable energy has become important option to optimize energy structure, reduce Green Horse Gas emission and assure sustainable development. On this background, many countries made ambitious plan to promote renewable energy. For instance, according to the plan of EU, renewable energy will account for 20% of the total energy supply by 2020 and 50% by 2050; besides, the medium and long term energy strategy plan issued recently by U.S.A and EU member countries attached great importance to renewable energy. The international renewable energy application status and trend also shows that many renewable energy technologies became mature and some are commercially feasible and they will be the fourth generation of energy following coal, petroleum and natural gas.

With awareness of the strategic role of renewable energy, every country made various incentive policies to promote and encourage the development of renewable energy. With regard to economic incentive policy, the following two systems are widely adopted: one is regulations or rules made by the government; the other is law or legislation issued by the Council. In terms of the technology, some give general support to all renewable energy, others

encourage specific category of renewable energy. Nevertheless, the basic principle is the same, i.e, combination of government promotion and market drive. Through economic incentive policy driven by market demand, the sustainable development of renewable energy is achieved.

2 Overview of International Incentive Policy

2.1 United States

United States is a big country in terms of development and application of renewable energy. To some extend, the technical tendency of United States will impact the direction of the global renewable energy technology. In this sense, United States is one important source when analyzing global renewable energy incentive policy.

United States is a federal country. The Congress has the legislation authority, at the same time, every state has relatively independent legislation freedom. Therefore, in United States, the renewable energy legislation is viewed as federal legislation and state legislation. In Unite States, the federal government made renewable energy law to promote the development and application of renewable energy, meanwhile, state parliament also made renewable energy law based on the distribution of the renewable energy resources as well as the application status of renewable energy.

With the aim to diversify energy, optimize energy structure as well as ensure energy security, the federal government attaches great importance to the development and application of renewable energy. Compared with conventional energy, renewable energy is expensive, which makes them less competitive in market. In this case, the government promote the development of renewable energy via various incentive policies. The renewable energy law includes “PURPA” passed in 1978, “Energy Efficiency Competition Law” passed in 1986 and “Energy Policy Law” in 1992 and etc.

The PURPA passed in 1987 takes the milestone role in promoting the development of renewable energy, which requires that public utility has to purchase all renewable energy electricity generated by stand-alone, small or heat-power cogeneration programs. Besides, a fixed price was given to renewable energy electricity. Because PURPA ensures that the electricity generated from renewable energy is encouraged to feed the grid with fixed price, PURPA made great contribution to the development of the renewable energy at early stage.

In order to reduce the initial high investment, shorten investment payback period, and reduce the risk, the Congress passed “Energy Efficiency Competition Law” in 1986, which requires

establishing a public fund to support renewable energy projects. The fund comes from the end users who paid the electricity. According to quota policy, additional 0.05 cents per Kwh is charged for 4 years, which means 147 million US$ is collected annually. With the subsidy from the fund, the development of renewable energy is greatly promoted.

Before 1992, the federal government subsidized installation of renewable energy programs to promote renewable energy, however, operation and maintenance after installation is unsatisfactory, thus the effect of the programs is far from expectation. On this background, the Congress passed "Energy Policy Law" in 1992, which required 1.8 cents income tax credit regarding to 1 Kwh electricity generated by renewable energy. Furthermore, no investment tax is charged for renewable energy programs. Final, Energy Bureau should subsidize renewable energy pilot or commercial programs. To sum up, this law is of great significance to promote the development of renewable energy, especially wind energy.

In recent years, so as to promote the development and application of renewable energy, different states of United States adopt various incentive policies such as favorable private income tax, favorable company income tax, favorable sales tax, favorable property tax and low interest loan, etc. Besides, a series systems come into being with the implementation of renewable energy law, such as RPS, Public Fund System, Green Certification Purchase System and Grid System, etc.

California: among all the states California has the longest history, sufficient categories and richest resources in terms of renewable energy. Aiming to optimize the energy structure, the state passed a series laws to promote the development of renewable energy. In 1996, House of Representatives passed No.1890 Act: it requires that 540 million US$ should be collected via quota system during 1998 to April of 2002 to promote renewable energy. In order to implement the Act, additional 0.05 cent is required to end users. In 1997, Senate passed No.90 Act: according the Act, renewable energy fund was established in California, the fund was operated and managed by the state energy commission to promote renewable energy. In 2000, House of Representatives and Senate passed No.995 Act and No.1194 Act respectively: according to them, from January 2002, 135 million US$ should be added to Renewable Energy Fund by quota system. In 2002, Senate passed No. 1038 Act: the Act give authority to Energy Commission to use and distribute the Renewable Energy Fund. In 2002, House of Representatives passed No.1078 Act: it requires establishing RPS with an aim to increase the proportion of renewable energy electricity by 1% annually from 2002. And by 2017, renewable energy should account for 20% of wholesale electricity. Furthermore, it gives the authority to State Energy Commission, Power Monitoring Commission and other responsible sectors in charge of RPS.

Texas: Texas is the second biggest state of United States with rich resources of petroleum and gas, however, because of huge consumption by heavy industry like chemical industry, steel industry and fertilizer industry, the energy demand is also very big. Because of decreasing petroleum and gas storage, Texas realized the importance of optimizing energy structure, diversifying energy categories and promoting renewable energy through legislation. In June 1999, the bill of Reconstruction of Electric Power was passed, which aimed that the installed capacity of renewable energy power should be increased to 2000MW by 2009 and the cumulative installed capacity should be increased to 2880MW by 2009(of which 880MW comes from the existing installed programs): furthermore, the target for different phases are 1280 MW by 2003, 1730 MW by 2005, 2280 MW by 2007 and 2880 MW by 2009. This provided detailed objectives to RPS.

New York: In order to promote renewable energy, New York is now making RPS. In next decade, the electricity generated by renewable energy should represent 25% of the total power generation. The law is anticipated to be available in 2004. Apart from RPS, New York also established Energy Research and Development Commission and collect fund to promote renewable energy.

Maine: The Law of Reconstruction of Electric Power was passed by Maine in May 1997, which was the first state to bring RPS into the law. This law required all the electricity retailers to supply 30% eligible energy to end consumers from March 2000. The eligible energy included renewable energy like fuel battery, tide energy, solar energy, hydropower, biomass (below 100MW) and joint-production by heat and electricity.

Wisconsin： Appropriate objective and strategy were put forward in this state. The RPS was estimated to rise to 2.2% by 2010 from 0.5% in 2001, 0.6% of which should be produced by the equipments that have been installed before January 1998. And the other 1.6% are produced by the newly-built renewable energy power equipments such as wind power, solar energy, biological energy, terrestrial heat, tide energy and small hydropower (below 60MW), etc. Private, state-owned as well as joint electric power enterprises are obligated to accomplish the task.

2.2 EU

With rapid development of economy and politics, EU set up unique features in terms of

development of renewable energy technology and incentive policies. Since the first white book of renewable energy development strategy was published in 1997, EU tended to adopt consistent policy gradually to promote renewable energy. In March, 2004, EU Congress approved the objective of EU and its members in terms of the development of renewable energy in 2020, which requires a target of 20% of electricity generated from renewable energy. And the members are encouraged to make their own development objective based on their own situation. Although EU takes consistent step to develop renewable energy, the systems and policies vary from country to country.

UK

The renewable energy began to develop in Great Britain comparatively late but steadily because of the implementation of the Non-Fossil Fuel Obligation (NFFO) policy. The NFFO is mainly concerned that the power companies in England have the obligation to promise that a certain part of the electricity they provide is from the non-fossil fuel. This policy gives the non-fossil fuel electricity a guaranteed market system, which aims to set up a primary renewable energy market. In this way, renewable energy power can compete with conventional power without the fiscal support from government in near future. To reach this goal, the price of renewable energy power must be drawn close to the conventional power. Therefore, a competitive distributing measure or management system is needed to ensure the implementation of NFFO. The unique feature of NFFO is that it is issued by the government and the program developers are selected through bidding. The winning bidders will sign the contract with the local power companies in accordance with the bidding price and the term of the contract is defined in the NFFO pact. Since the cost of renewable energy power is still higher than that of conventional power at present, the government will subsidize the additional cost that is caused by the difference between the bidding price and the average selling price. The subsidy comes from the fossil fuel tax. This measure attracts many companies and enterprises to invest in renewable energy power.

From the issue of the first NFFO in October 1990 to the fifth NFFO in February 1997, renewable energy has developed with a fast speed in England. By September 30, 1997, the installed capacity signed in the contract has amounted to 2094.195 MW, among which 444.32 has been accomplished. At the same time, the cost has decreased greatly. For example, the price fell down by 19.5% in the fourth NFFO comparing with the third one.

In April 2000, UK government released Renewables Obiligation Order defining the

obligations that electricity suppliers must fulfill, i.e. renewable energy power must take a certain percent among the power they supply. The ratio of renewable energy power is prescribed by the government each year according to the objective of development, practical development status of renewable energy and status of market. It is actually a quota system. The Renewables Obiligation Order also prescribes the eligible areas and target for renewable energy power specifically, including wind power, wave power, hydro power, tidal power, PV power (at least 0.5MWh per month), geothermal power, landfill gas/sewage gas and biomass power, etc. *Renewables Obiligation Order 2002* and *Renewables (Scoland) Order 2002* were on effect in April 2004 and established the Renewables Obligation(RO) System. In 2002/2003 fiscal year, the stipulated ratio of reneable energy power was 3%, while in 2003/2004 fiscal year, it is 4.3%. It will be increasd annually and in 2010/2011 fiscal year, it will reach 10.4%. Simultaneously, UK also established renewable energy trading system and market which permit each 1MW eligible renewable energy power as a computation unit (called a ROC) trade in the market. UK government appoints the OFGEM to supervise and manage it. As power supply and generation system was successfully privatized in 1990, all power suppliers must fulfill their obligations, which means to reach the stipulated annual quota of renewable energy power, purchase eligible power from renewable energy power enterprises obtaining the ROC Certificate or purchase it directly from the OFGEM. If the suppliers failed to fulfill it, they would be fined 10% of their turnover at most according of the regulation of the OFGEM. If there is surplus ROC, i.e. the renewable energy power market is in the state of seller's market, the OFGEM can buy them at the price of 30 pounds per ROC which is actually equal to the bottom price of renewable energy power stipulated by the government. But is actual practice, the government requires to guarantee the stipulated annual quota is a little bit higher than that can be reached practically so as to maintain a comparatively higher market price and therefore encourage the investment in the renewable energy power. In 2003/2004 fiscal year, the market price for renewable energy power is 45-48 pounds/MWh (the corresponding grid price is 15-18 pounds/MWh)

Spain

Spain is one of the countries that develop fastest in the aspect of renewable energy, especially in wind power, ranking the third now. In 2003, the output of renewable energy took 6.8% of the total primary energy supply, among which hydro power takes 2.5%, wind power 0.8%, biomass 2.9%, methane and biogas 0.2%, bio-fuel 0.1%. Also, renewable energy power takes 15.9% of the total power generation, among which, hydro power takes 10.7%, wind power 4%, biomass and methane 0.9%, PV power 0.01%, and others 0.3%.But Spain has no specific law that aims to promote renewable energy. The support to the development of renewable energy actually began with the implementation of *Act 54/1997 on Electricity Sector*. Apart

from that, the *Royal Decree 2818/1998* issued in December. 23,1998 and the Sixth Environment evaluation law issued in 2000 is the supplement and perfection of the *Act 54/1997 on Electricity Sector* with regard to promote the development of renewable energy and also the implementing details in other words. The *Act 54/1997 on Electricity Sector* in Spain began to be effective from November. 11, 1997, primary goals of which is to set up a power market of free competition, and build the national *Pool Based System* through the reform of power system and the privatization of the power generators and gird operators. All the power generators sells electricity to the power pool system, and all the grid operators purchase electricity from the power pool system. Moreover, the National Power Supervision & Management Commission was founded to be responsible for the administration of power market. Stipulations on the development of renewable energy are specified in the *Act 54/1997 on Electricity Sector* which is mainly summarized as the following aspects: 1) Special regime for renewable energy sources (RES) (<50MW);2) Guaranteed grid access; 3) Are not obliged to submit bids to the pool; 4) Special price is designed for the renewable energy power and the interest of investors will also be considered while the special price is set. In the mean time, the objective for the renewable energy development is also specified, i.e. by 2010, the renewable energy will take 12% of the total consumption of energy. Moreover, it is also required to frame out the renewable energy promoting programme. In 1998, the Ministry of Economy in Spain authorized the IDEA subjected to it to preside over the framing of 2000-2010 renewable energy promoting programme as well as assisting the Ministry of Economy to supervise its implementation according to the *Act 54/1997 on Electricity Sector*. The programme was passed by the Council of Ministers in December 30, 1999, in which the objective is specified again that renewable energy will takes 12% of the total consumption of energy by 2010, and the renewable energy power will take 29.4% of the total power and in which it is also prescribe that specific annual developing goal will be set according to the practical situation of development during the programme.

Royal Decree 2818/1998 issued in December. 23,1998 is the supplement and perfection of the *Act 54/1997 on Electricity Sector* with regard to promote the development of renewable energy and also the implementing details in other words. It specifies the contents as follows:1) Establishes the administrative procedure for the access to the Special Regime; 2) Regulates relationship between renewables electricity generators and grid operators; 3) Establishes the prices for renewables electricity. The producers can choose between a fixed feed-in tariff, or obtaining a premium price in addition to the poll price. The adjusting measure is as follows: all the renewable energy power generators are supposed to report to the price adjusting organization (IDEA at present) authorized buy the government, making out the change of the renewable energy power cost. Then the organization will calculate the two specific prices for the next year according to the report and other research materials and information. The price is not the same for different forms of renewable energy power. But for the same form of

renewable energy power, the price is the same regardless the conditions of resources.

Germany

Germany probably is a country that has the most developed renewable energy in the world, the power generated by renewable energy has reached 46.3 TWh in 2003, which is 8% of the total generation. Amongst this figure, wind power is the most rapid developed industry. The installed capacity is 14.61GWh by the end of 2003, which is about 40% of the world in total. Amongst the renewable energy generation, small hydro and wind are taking the leading position, which were 44% and 40% of the total; the rest is biomass generation, which is approximately 15%. The Germen also made a stand out achievement on promoting the PV generation, it became the first country which has its PV power generation reached 1% of the total power generation. It shows the possibility for PV to be developed from small portions to bigger portions, and in the end to inhabit certain percentage of the energy structure. The success of the renewable energy development in Germany was believed because of the sufficient design and implementation of the renewable energy policy and law.

There're three stadges of the renewable energy legislation development:

The first stadge – in 1991, Feed in Tariff was established: The German Federation Government established the Feed-in-tariff , which force the public utilities to buy the renewable energy generated power. According to this law, the public utilities have to purchase the renewable energy such as wind, hydropower and etc. at the price of 90% of the electricity sales price. The establishment of the *Feed-in-tariff* has build a strong foundation for the development of renewable energy. Since specific and clear principles, policies, stratagems and legislations have been build, which has promoted the development of renewable energy; the installed capacity of Wind Power was increased from 56MW in 1990 to 2,080MW in 1998, and in the same duration, the average single capacity of the WTGs were increased from 160KW to 470KW. The second stage – in year 2000, Renewable Energy Act: it mainly clarified following key points: For applicable renewable energies, the power sector shall have a fixed purchase price for those; The fixed power price presented the difference amongst the different renewable energy technologies, and the resource difference between the same technology application power generation systems; To accelerate the technology improvement and the cost reduction of renewable energies, clarified the timetable for the reducing of the fixed purchase price for renewable energies, for instance, there is a gradual percentile reduction in the fee levels for new-built biogas power generation plants (degression, generally 1 % reduction per annum) after 2002; Canceled the Maximum restriction on 1998, which limited the renewable energies within 5% of the regional total power consumption. A new renewable energy proportion was made, it prescribed the TSOs to be responsible on balance the renewable energies generation quantity within the grid, which means the increased cost brought in by renewable energies shall be shared by the national grid, the entire power

consumption, this ensures the fair competition among the TSOs. In this duration, a renewable energy development target was made by Germany, which is to reach the 12.5% ratio of the total energy supply for renewable energies by year 2010, and reach 20% till year 2020. To apply the target, *Renewable Energy Law* was redacted in year 2004 and lead German renewable energy law into the third stage.

The renewable energy development promotion mechanism that the German renewable energy act builds is a fixed power price mechanism. This machanism has three key characteristics: Forced grid connection. TSOs and DSOs have the obligation to connect the renewable energy power to the grid; Priority on purchase. TSOs and DSOs have the obligation on purchasing all the power that renewable energies generated; Fixed price. TSOs and DSOs have the obligation to pay the fixed price for renewable energies according to the prescribed in renewable energy law.

Denmark

In order to accelerate the development of renewable energy, a serial measures were taken by Denmark. First, “Energy in 21 Century” plan was constituted, aiming at reducing nationwide CO2 emission to 80% of that in 1998. By the end of 2030, CO2 emission will be only 50% of that in 1998. With this objective, Danish government began to devote to two missions. One is to increase application efficiency as well as conserve conventional energy. The other is to raise application of renewable energy to 12%-14% in 2005 from current 10%. It was also estimated that this rate can reach 35% in 2030, i.e. annual growth is 1%. Second, power mechanism reform was carried out and power reform plan including objectives of developing renewable energy power was approved in March 1999. This plan stated that it was a must to increase green power to 20% in 2003 from current 10%. To ensure the implementation of the plan, it is clearly stated in the new power supply law that power companies were obligated to purchase renewable energy power from small thermo-electric plants and power suppliers at a fixed price. Meanwhile, the plan also prescribed that RPS based on competition and trade would be adopted to support renewable energy power. By the end of 2003, renewable energy power must cover 20% of the total consumption. Third, green certificate system was advocated in this plan, which was implemented through tender bidding program for offshore wind farm. Finally, transitional policies were made by Danish government, including: gradually cancel wind power subsidy (0.17krone/kWh); levy tax on CO2 (0.10 krone/kWh) and use the money to support wind power enterprises; the government determines maximum limit for renewable energy price until green market operates effectively.

Netherlands

In 1998, a new law related to electric power was enacted by the government, which announced a serial standards for the production, transportation and provision of electricity.

More important, in the new law, “green certificate” plan was written, which prescribed an obligation for customers to buy a certain sum of green electricity. In February 1998, Holland government negotiated with Holland Electric Power Association, a representative of all the electric power companies, for agreement of free quota. The agreement claimed that by 2000, among total consumption of electricity, 3%(1700 GWh) should come from renewable energy. This standard was adopted for total sale rather than a product or contract of a company. Under the plan, the manufacturers would get a “green certificate” for 10 GWh renewable energy power at 0.03-0.05florin/kWh. On the contrary, if companies failed to meet the requirement, they would be charged with 5 florins as punishment.

2.3 Other Countries

Besides, there are some other countries, whose incentive policies to renewable energy made great achievement.

Australia

In November 1999, Australian Federal Government announced national plan to support renewable energy development, which claimed that renewable energy power should be increased to 25500GWh, equal to 12% of national power by 2010. At the same time, renewable energy supply should grow with 2%. This plan was supposed to be undertaken by power retailer and wholesaler throughout the country driven by law from federal government. The plan was to start in 2000.In practice, green certificate system was prescribed in this plan. First, eligible renewable energy was identified as solar energy, wind, ocean energy, hydro, geothermal, biomass (methane), farm fallout, forestry fallout, food process and process fallout, sewage, urban rubbish, solar water system, individual renewable energy power system and renewable energy battery. The plants involved in such fields as mentioned above were renewable energy plants. They could get a green certificate for producing 1MWh electricity. Obligated business part could obtain green certificates by contracting with these plants or bought them from individuals at negotiated price. The certificates were allowed to sell and buy in market. At the end of the year, obligated wholesalers and retailers were asked to show enough green certificates to management department. The ones who failed to accomplish the task would be punished at $40/MWh. Meanwhile, if they made up the unfinished quota in the following 3 quarters, the money would be returned. It was estimated that by 2010 average price of electricity would be increased by 1.3%-2.5%(about 38c-95c/MWh), i.e. 1.8billion-0.3billion Euro, with the effectiveness of the policy.

Japan

In 1997, “Special Measures to Promote New Energy Application” was constituted by Japanese government, which encouraged enterprises to apply 10 kinds of new energy

technology such as PV power, wind power, pollutionless vehicles, rejectamenta fuel production, rejectamenta power, rejectamenta thermal application, application of difference in temperature, natural gas thermal-power hybrid system, fuel battery and solar thermal application. At the same time the law asked government to undertake a serial compulsory measures to promote new energy application including: the government was supposed to take a integrated comprehensive measures to encourage customers and developers to develop new energy application, urge suppliers to supply new energy and compel local public parties to apply new energy. Furthermore, except government subsidy, the government, local public parties and enterprises should increase awareness of applying new energy and provide assistance whenever necessary.

India

In 1990s, Indian government set up Unconventional Energy Department and Renewable Energy Development Unit to administrate and accelerate the development of renewable energy. Meanwhile, they adopted some specific measures like 100% depreciation to promote the commercialization of renewable energy. The adoption of these measures boosted Indian renewable energy industry. By 2000, India had had a capacity to build 10MW PV power system and over 600kW wind power generators. In addition, installed capacity of PV power and wind power had respectively exceeded 100MW and 1000MW, which tripled that of China.However, Indian policies are unstable as China, which leads to ups and downs in the development of renewable energy.

Brazil

Brazil government always pays great attention to develop alternative energy. To deal with the petroleum crisis since 1970s, release dependence on imported petroleum, Brazil began to develop ethanol fuel. With rich agricultural resources, Brazil took the advantage of sugarcane and made the plan to develop ethanol fuel by raising sugarcane. Through 30 years' efforts, Brazil not only became a country with huge production of ethanol, but also grasped mature ethanol fuel technology. Currently, there are 15.5 million cars and 3.5 million motors using ethanol gasoline(gasoline with a portion of ethanol), besides, there are 2.2 million cars using pure ethanol fuel. Brazil has become unique country without supply of pure gasoline and also one of the countries that successfully use ethanol as fuel for cars.

The initiation of ethanol plan began from 1975 to 1999. In 1973, the first global petroleum crisis brought great impact to Brazilian economy, which depends on imported petroleum. To meet the increasing demand of energy brought be rapid economic development and serve themselves in terms of energy, Brazil started to implement ethanol plan since 1975. They scaled up the production of ethanol, increased application technology of ethanol as fuel for

cars. With support of World Bank, Brazil government and private sector had joint investment to extend areas for sugarcane, establish ethanol processing factories and promote ethanol fuel. In the same year, the government issued laws and gave authority to Brazil Petroleum Company to mix a portion of ethanol in gasoline, which was known as ethanol gasoline. In 1979, after frustrated by the second global petroleum crisis, the production technology of ethanol was much improved. And the first car using pure liquid ethanol came into being. With the subsidy from the government and favorable loan, the production of car fueled by ethanol account for 94.4% of the total production in 1984. During 1979 to 1995, Brazil produced 5.4 million cars fueled by liquid ethanol. However, because of release of petroleum crisis, decrease of petroleum price and increase of sugar price in 1986, the Brazilian companies use more sugarcane to produce sugar instead of ethanol, which caused insufficient supply of ethanol in 1989 and drop down in the number of production and sale of ethanol cars. With the aim to boom ethanol development plan, the government issued relevant laws in 1991, which specified objective of ethanol development plan, and required 20-24% ethanol mixed in gasoline fuel in all gasoline station all over the country.

In 1999, the technology of ethanol fueled cars made great achievement. The sales of ethanol fueled cars accounted for 0.69% of the total sale in 2000, whereas, it reached 6.9% by 2003, with a number of 80000 cars. In March 2003, Brazil Fort Company introduced the first gasoline and ethanol fueled car, which can use either gasoline or ethanol, or mixed gasoline and ethanol. The power and price was similar to common cars. In 2003, the sales of such cars was 30000 and will reach 250,000 in 2004. This new technology not only offer the customers a new way to use fuels, but also became a important way to balance the price of gasoline and ethanol.

3 Evaluation on Foreign Policies in Renewable Energy Field

Judging from the proposed and existing policies and measures of supporting renewable energy development, three characters can be concluded: Compelling Policy, Incentive Policy and Voluntary Policy.

3.1 Compelling Policy

Compelling policy is adopted by most countries as the base for legislation, which is displayed similarly in policy making and differently in juristic form. In USA especially some states,

RPS is undertaken to require power plants to produce or purchase a certain sum of renewable energy power. While in Germany and Denmark, power companies are asked to purchase renewable energy for electricity supply and provide assistance for renewable energy power grid-connecting.

Compelling policy can also be categorized as objective and mission. Objective policy is the base of implementation by force, in reverse, compelling method ensures the accomplishment of the objective, which is evidenced by RPS policy in U.S.A, green certificate policy in Holland and high price policy in Germany. While NFFO claimed Compelling purchase with mission policy, which is characterized as government purchase or market purchase by government. Another example is "Xiangxiangtong Program" in our country, which aims to speed up renewable energy development and realize rural electrification through government purchase.

3.2 Economic Incentive Policy

Although incentive policies are diversified, the following four are used frequently and widely:

- Subsidy Policy: this is common incentive policy adopted nationally and internationally. Generally speaking, it is classified as three types: one is investment subsidy, which is to subsidize investors. Examples include investment subsidy to local small hydro building in our country and wind power subsidy in Germany. Investment subsidy has such advantages as increasing investors' enthusiasm, raising production capacity and enlarging industry scope; while the disadvantage is that it can't promote technology improvement and reduce the cost since the subsidy has nothing to do with the operation of the enterprises. The second is output subsidy, which is to subsidize enterprises according to the output of renewable energy products. This kind of subsidy is not available now in China. The obvious advantage of this kind of subsidy is to increase production, reduce cost and raise profit of the enterprises. So it is widely adopted in USA, Denmark and India. The third is customer subsidy. For example, in most countries in Europe, subsidy is provided to solar water heater users, which covers 20-60% of the price.

- Tax Policy: favorable tax policy is made for renewable energy industry including reduction or remittal of tariff, capital asserts tax, value-added tax and income tax (enterprise income tax and individual income tax). The other policy is to undertake force tax on non-renewable energy such as carbon. It is proved by practices in every country that carbon tax especially high standard and tax policy is a perfect way to accelerate clear energy development and application and encourage enterprises to apply advanced technology and improve technical level. Therefore, force tax policy

is also a compulsory incentive measure.

- Price Policy: compared to conventional energy products, it is more expensive to produce renewable energy products. In this case, favorable price policy is adopted by many countries in the world. For example, “power law” in Germany states that power companies are obligated to purchase renewable energy power and pay 90% of the consumption price to renewable energy power plants; furthermore “energy policy law” of America announced that public power companies have the duty to purchase renewable energy power at cost price. At the some time, pure consumption charge method is used in some states of America. These policies mentioned are actually favorable price policy. And former Power Department of our countries has ever made such policy. In a word, it is proved theoretically and practically that favorable price policy is an effective incentive measure to promote technology improvement and reduce cost if it is applied appropriately.

- Low Interest (discount) Loan: Low Interest (Discount) Loan can release enterprises from paying high interest and contribute to reduce the cost. But the disadvantage is that the government has to collect some money as discount or interest reduction subsidy. In this case, the more loans are released, the more subsidies are needed, and i.e. the more financing is demanded from the government. Therefore, financing support has a great impact on the sustainability of this policy. At present, German government is undertaking such policy to support wind power projects and PV projects with an interest rate at 2.5-5.1%.

- Government Purchase Policy: the ongoing “Roof Plan” in America, Japan and Germany is actually government purchase or purchase supported by government to assist immature PV industry. Apart from this, technical research and development supported by government also belong to this category.

3.3 Voluntary Policy

Voluntary Policy is one of the measures that is researched and undertaken by some developed countries to promote the development of renewable energy. The essence is that some residents and enterprises voluntarily pay higher price for renewable energy (including power), and promote renewable energy development via the price difference. Green power price in Holland is one example. Voluntary policy is based on environmental awareness of the people and enterprises. There is excellent foundation for conducting this policy in Europe especially north Europe since the people there have stronger attention of their environment.

3.4 *The features of Foreign incentive policies*

Comprehensive analysis on the foreign incentive policies to renewable energy shows the following features:

- Confirm the development objectives: the development objective is the base of legislation. There must be clear objectives in the countries and regions with laws of promoting renewable energy development. For example, in EU, renewable energy production is required to cover 50% of total energy production by 2050. Driven by this objective, the members have made their own development objectives including periodical aims. For instance, Danish government claimed that application proportion of renewable energy would rise to 12-14% in 2005 from current 10% and it was estimated that the amount would reach 35% by 2030. In Germany, the new renewable energy law announced that renewable energy power would rise to 10% by 2010 from 5% in 2000.

- Confirm Eligible Resource and Technology: detailed analysis and demonstration have been made in the process of legislation. Provided the laws that deal with renewable energy application is economically reasonable, it can be undertaken stably and sustainably. For example, in Germany and some countries in north Europe, wind and biomass are developed greatly. While in some countries in South Europe like Spain, emphasis is put on the development of solar energy. Law conducting in these countries cost little since the technology is matured or commercialized. However, in Texas of America, eligible energy includes solar, wind, geothermal, hydro, tide, biomass, biomass rejectamenta and rubbish burying gas. Since these energies vary in cost, laws have to be made complicated, which increases the cost of undertaking the laws and reduces their effectiveness.

- Concrete and Clear Measures: foreign legislation includes not only clear objectives but also concrete measures to accomplish them. For instance, America determined power subsidy at 1.5cents/kWh and Denmark made it at 0.17 krone/kWh. While Germany made a calculation formula for grid price under different condition. In this case, it simplied the implementation of the laws.

- Concrete Prescript of Effect: In some countries deadline was given to the laws since renewable energy technology is still under development. This flexible measure pacificate dispute in legislation and accelerate the process.

4 Analysis of implementing effectiveness of all kinds of economic incentive policies

To sum up, incentive policy of promoting renewable energy is led by compelling policy accompanied by economic steering and resources measures. As for compelling policy, it mainly consists of compelling quota system, purchase system and tendering purchase system. The comparison is made as follows to analysis the effectiveness of the three systems.

4.1 Compelling quota system

Compelling system is the mainstream of incentive policy of renewable energy. The basic characteristics of quota system of renewable energy include the following: 1) the compelling quota policy adopts the format of legislation and regulation to guarantee realization of quantitive objective of renewable energy, i.e. to guarantee the market demand of renewable energy power; 2) market mechanism is set to develop renewable resources in most effective way in compelling quota system; 3) As for the difference between renewable power price and conventional price, social sharing principle is applied, i.e. consumers sharing principle. Those who consume more pay more. It fully indicated the environmental and social value of renewable energy power.

The value of renewable energy power is divided into two parts in the quota system: One is the basic part, indicating that the value of electrical energy produced by renewable energy in the present conditions of power market are just the same as the it produced by the conventional energy. This value is reflected as real cost of electrical power trading and the consumers benefit from it. The other part refers to the value that renewable energy power generates from the environmental and social benefits, the beneficiary may be all the people in a country or in a area, which is meaningful globally. In practical trading of electric energy, the environmental and social value of renewable energy can not be embodied. Green Certificate is designed in quota system to stand for the environmental and social value of renewable energy. Green Certificate is tradable and could be encashed. Social sharing principle is used in the quota system to absorb the energy and environmental values of renewable energy, i.e. the society, or the consumers share the price difference between renewable energy power and conventional energy power.

Main characteristic of renewable energy quota system is to develop renewable energy power in lowest cost through market mechanism. The quota system of renewable energy is different

from the other incentive policy before in that it enables a change from the policy depending on financial support from the government to a market oriented mechanism under the control of the government, which facilitates the large-scale development of renewable energy. There is no fair environment for quota renewable energy power to compete as the conventional fossil fuel power plant doesn't take the cost of pollutions to the environment to the cost, while the environmental value of renewable energy power is social but the cost is taken by single enterprise. It is most unfair. The quota system adopts the format of legislation to transfer the cost of single enterprise to all the power products to share, which creates a fair market for renewable energy power and conventional fossil fuel power. The Green Certificate creates a new mechanism to embody the value of environmental benefits generated by the enterprises, which amounts to a trading market of environmental benefits. Different enterprises take the responsibility of environmental protection fairly through the trading system of Green Certificate. The combination of quota system of renewable energy and Green Certificate create market demand and trading measure, but the disadvantage is that it is hard to evaluate precisely the cost of policy.

The countries where quota system is implementing are US, Australia, Britain, France and so on. From the analysis of implementing effects, the quota system do promote the development of renewable energy, and guarantee the scale up development of renewable energy within the quota, but also confines the development beyond the quota. It is reflected mainly in the following aspects:

1) The objective is not fully reached with regard to encourage the development of renewable energy. As the government pre-set the developing objective and quota, the suppliers will not purchase more renewable energy power and no surplus market admission is created. Moreover, it is impossible for more renewable energy power since the quota subscribed by the government is equal to the top line for the development of renewable energy.

2) There are more risks for the renewable energy enterprises. The dominant feature of the market mechanism makes the market price for renewable energy power unsteady which increases the risks of investing in renewable energy power and thus causes it difficult for the financing of renewable energy projects.

3) It brings the unfair competition among different scales of renewable energy enterprises. Since power supply companies own their own grid resource as well as more renewable energy resources data and related information, the smaller scaled enterprises or investors will be in disadvantage once the power supply companies develop their own renewable energy power projects. Several reasons account for this. First, they have convenience ensuring renewable energy power on grid. Second, they can develop more economical projects. Last they can get more favorable loan for financing form the bank with the background of power supply companies. Thus

unfair competition exists. Therefore, the legislation of UK protects the benefits of big enterprises and groups, and restricts and repulses new and independent small-scaled companies to invest in renewable energy power market to some extent, which tends to form monopolized management and makes it hard to achieve the objective of promoting the development for renewable energy market.

4) Unfair competition was caused in renewable energy power technologies. It appears that all forms of renewable energy power can participate in the market trading, and the price is the same for different forms of renewable energy power at the same time and in the same place. But actually, power suppliers are more willing to purchase big scale of renewable energy power as big scale power (such as big scale wind power, methane power) is connected to grid usually from high voltage end so that the suppliers can get the profit from power transfer fee just as they can get from conventional energy power, while small scaled renewable energy power system can only be connected to the grid from the low voltage end due to its small capacity, and the power is directly sent to the electricity distribution system entering the end consumption, and in result the suppliers can not get any profit from power transfer fee. Therefore, the implementation of legislation met great blocks from power supply companies in the terms of small system, which is quite disadvantageous for the development of small system and small renewable energy power enterprise.

It is safe to conclude that the *Renewables Obiligation Order* appears to adopt the market system to form an open and fair competition environment, but hard to reach real fairness in practice.

4.2 Fixed or Incremental Price System

The core contents of fixed or incremental price systems are: Forced grid connection. TSOs and DSOs have the obligation to connect the renewable energy power to the grid; Priority on purchase. TSOs and DSOs have the obligation on purchasing all the power that renewable energies generated;Fixed price. TSOs and DSOs have the obligation to pay the fixed price for renewable energies according to the price and payment period prescribed in renewable energy law; Cost share. End users will cost share the additional electricity price.

At present, the countries who adopted fixed or incremental price system are Greece, Spain, Denmark and Germany. Among them, Germany is the first country who adopted this system. Thus analysis on the features of German system could also give us a picture of other countries.

The features of Germany are: development targets made by the national government, under the fixed power price support, the investors actually applied the targets under the market mechanism. Since the renewable energy developers can forsee the profits and the cost, and the

central concept of the renewable energy act is to ensure that the renewable energy developers will not benefit nothing, so the fixed power price mechanism is giving the developers an obvious benefit, low risk advantages, which encourage the renewable energy developers. Under the fixed power price mechanism, the ratio of the renewable energies in the energy structure has increased dramatically. The increase ratio of WTG installed capacity has been 55% after 1991, and facility manufacturer industry has grown stepwise, technology improved all these has reduced the cost in the end.

The sufficient implementation of renewable energy act in Germany was benefited from the efficiency of the national legislation and the consolidated volition of the nation; besides, the self-discipline and consciousness of the German enterprises did support the successful result too. The renewable energy act prescribes that the development target, renewable energies that meet the standards, and the price will be authorized by the parliament, once in two years. There're 4 TSOs in Germany, more than 900 DSOs, and more than 1000 power sales companies. Since the distribution of the renewable energy resource is various, the burden of each grid companies is various. So, the Act prescribed that 4 TSOs shall share the extra cost for purchase the renewable energies, and concrete implementation methods are prescribed. All these will have to be balanced amongst the companies. The connection with the grid can be undertaken through power supply companies, DSOs and TSOs, but the balance method is the best for the developers: the power-grid connected company will pay in advance, and then they will have to manage the balance with up-level grid companies. This needs the enterprises to be self-disciplined and support the implementation of the act. In this sense, Spain makes improvement to this policy when they make their compelling purchase system.

4.3 Bidding Purchase System

Bidding Purchase System is characterized as selecting renewable energy developers through government bidding. The winner of the bidding will sign an electricity agreement based on bidding price and the difference between the bidding electricity price and market electricity price will be compensated by government subsidy or shared by end users. Bidding purchase is realized through two options. One is what NFFO of UK adopted in 1990. The government only made the objective, quantity and scope. The bidders determine the programs they invest. The other option is concession bidding China attempts to try, i.e. government issue the bidding for specific project and sign concession agreement with the winners. The government also designs electricity purchase contract and cost share policy. And appropriate investors are selected by bidding. The key features are:

- Under the scheme of concession agreement, utility and investor sign long term purchase contract to assure that all the electricity generated will be purchased. The contract period covers the whole operation period of the project, which guarantee that the project has no risk in terms of sales. The grid price is determined by bidding.

The electricity purchase contract is guaranteed by concession agreement.

- The grid price is shared by the whole grid and eventually the customers of the grid share the additional cost.
- Incentive tax policy is offered to concession projects.

NFFO bidding purchase system of UK was effective for about 10 years and made some achievement. For example, the renewable energy developed in UK with a rapid speed. At the same time, the cost of the application of renewable energy is also reduced. The lowest bidding price, taking electricity generated by burning urban yrubbish and industry waste, is 2.66 pence/Kwh, which is close to the Average Pool Price in 1996 at 2.5 pence/Kwh. But the disadvantage of the system is that the contract is not strictly followed. Many investor didn't complete the project as required by the contract.

China only adopted concession bidding for wind power. The basic idea is to select investors by bidding for large scale(100MW) project with requirement of grid price and local equipment. The government committed to determine the grid price by bidding and purchase all the electricity generated. In 2003, Chinese government fulfilled two bidding projects known as Rudong of Jiangsu and Huilai of Guangdong with a capacity of 100 MW for each. The two bidding attracted 9 companies, of which 3 are foreign companies and 1 is private company.

The successful factor of the wind farm concession projects is that it reduce the grid price greatly. For example, the grid price for the two projects mentioned above is 0.43 and 0.50 yuan/Kwh, which bring an end to the history of high grid price of wind power. The wide source of investment increase competition and innovate wind power industry as well as make wind energy competitive in the power market; besides, it accelerates the localization of equipments and enhance the production capacity of national manufacturers. At least 5 big international wind turbine manufacturers began to build factories locally. At the same time, it raised the interest of national manufacturers to invest in wind turbine manufacture. With successful experience of the two projects, Chinese government began pilot projects in Jiangsu, Inner Mongolia and Jilin provinces with capacity of 100 MW for each. Before 2006, about 30 feasibility study on big wind farms should be finished and ready for bidding with the aim to further lower the grid price of wind power. But there is also doubt about how many contracts can be strictly followed, which has to be proved by history.

4.4 Comparison on the Effects of Different Systems

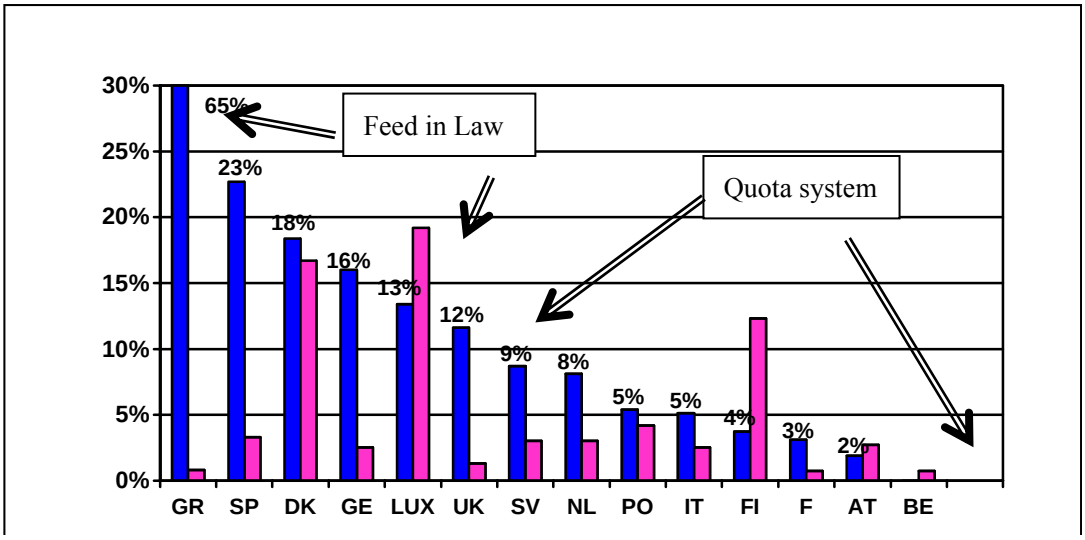
Since the effect of bidding purchase system is not yet obvious, the comparison here is made only between RPS and fixed or incremental price systems.

From the point of mechanism, the two mechanism definite the objectives and promises for the development of renewable energy through setting up the targets. The difference is the detail measures adopted. RPS is to regulate the ratio of renewable power in the total power generation sold by the grid companies, and the grid companies have the obligation to purchase a certain ratio of renewable power, to reach the national target of renewable energy development and utilization. Therefore, the implementing agencies are the grid companies. While compelling purchase system is characterized as fixed renewable power price, and through the fixed power price, a definite signal is provided to the investors to give more investment on renewable energy. The grid companies are only the medium parts, in other words, their function is providing the service for balancing. So the stimulating factor is from investors mainly.

From the development pace, it is obvious that the fixed or incremental renewable power price is the most effective method. From the situation in Europe, the countries adopting fixed or incremental price have developed much more fast than the countries adopting RPS or quota system on renewable energy development. The reports in the past deemed that if adopts the fixed or incremental price, it is not benefit for competitive market and difficult to reduce the cost of renewable energy, and the cost of implementing policy or act is too much. However, because of the fixed power price, the market has been enlarged rapidly, the industry developed and technology makes progress. Therefore, the cost of renewable power and grid-connected power price reduce. Table 5-1 and chart 5-1 show the different grid-connected power price and development level from the countries adopted different mechanism. The renewable power price in those countries adopted fixed or incremental price is much more lower that in the countries adopted RPS or quota system, however, from the developing speed, the former is morn than the latter. At present, some countries which adopted the RPS or quota system begin to consider stopping the RPS or quota system and using fixed or incremental power price policy, such as Denmark and Austria. There are some countries, such as France and Italy, intend to use similar power price policy. All of the realities illustrate that the fixed or incremental power price is a simple and effective method. RPS or Quota system needs the developed market mechanism, effective supervise and penalties method. All of those three factors might be the reasons that affect its implementation. In another word, RPS is like “big stick” , whereas fixed or incremental price is more like “carrot”. In practice, the most effective way is the combination of the two systems as adopted by Spain.

Table 5-1: Compare of grid-connected renewable power price in several countries

	Country	Price (EURO cents/kWh)	Capacity (MW)	Employment (2003)
Feed in law	**Germany**	6.6 – 8.8	14,609	46,000
	Spain	6.6	6,202	20,000
Quota system	UK	9.6*	649	3,000
	Italy	13	904	2,500



5 Conclusion and Recommendation

5.1 Basic Conclusion

Through study and analysis on the foreign incentive policies to renewable energy, the following conclusions are made:

1) Renewable energy developed so fast that it has become the choice for the most countries to make their resource more multiply of energy source. Besides the UK, Spain and Germany, the development of the renewable energy has become strategic choice to ensure the resource more multiply for most developed and developing

countries. Therefore, most countries in have established the target of the development of renewable energy. The detail target of those countries is that by 2010, the utility of renewable counts for 10%, 20% in 2020 and 50% till 2050. That is to say the renewable energy gradually become the substitute energy, not just the supplement energy. The experience of the last 10 years illustrate that those target can be achieved. For example, Spain and Germany etc. have finished the goal in advance.

2) Steady policy mechanism and legislation is the insurance to facility the development of renewable energy in a rapid and steady way. No matter what method to adopt, most European countries adopt some steady and consecutive policy mechanism and law method, such as legislation by parliament, governmental order and national policy white paper etc. All of those methods are the main reason to insure the renewable energy development in those countries.

3) Combination with the impelled by government and market mechanism is the important principle for the legislation on renewable energy. Although there are some different mechanisms in different countries, the principle is the same that is the target is made by country and then the market body realize the target. Meanwhile, judging from the policy priority, the compelling policy takes the main role with support from incentive policies.

4) Middle and small enterprises might be the main body in the development of the renewable energy. The distributing of renewable energy is dispersed and the energy density of it is small, so the investment in small size is more suitable. The policy that encourage the middle and small scale investors in Germany fit for the development rule on renewable energy, so the utility of renewable energy develops rapidly in Germany. On the other hand, the mechanism in UK is more benefit for large enterprises, other than the middle and small scale enterprises. Therefore, there is gap on the pace and level of the renewable energy development between UK and Germany.

5) Feed in law system and quota system has their own advantages and disadvantages. On one hand, feed in law system is fit for the middle and small scale investors. On the other hand, quota system is more fit for the development of large enterprise. The choice of those two lie on the policy direction.

5.2 Recommendation and suggestion for the legislation of renewable energy in China

Based on the discussion and analysis above, there are some advices on the renewable energy legislation in China.

1) There should be a clear objective of the legislation. The objective of the legislation in European countries is to make the energy more multiply and to reduce the GHGs emission. Associated with the commitment on reducing the greenhouse emission, European countries have concrete target. Therefore, the renewable energy legislation

in China should has its own target and objective.

2) Combination with the national responsibility and citizen obligation is the principle of the legislation. In European countries, especially in Germany, the rudimental successful experience of renewable energy is to combine the responsibility of the country with the direct and indirect obligation of local citizen. The whole citizens take on the cost. Therefore, there is a solution for the extra cost.

3) To exert the market effect and drive the investment multiply is the important mechanism in legislation. In the legal system of the countries, it is the responsibility for the government to make the development target and policy framework etc. to ensure the competitive environment on the market. As to the market main body, according to the policy and law framework market as well as the market mechanism, the market main body will finish its task or realize the target made by the government.

4) Simplified mechanism and effective ensure measures are the new direction of renewable energy legislation in China. As to China's situation, we do not have the perfect electricity market like European countries such as UK, and Chinese enterprises do not have strict self-discipline, like Germany enterprise. Therefore, simple, effective, easy for check and supervise measures are the main method in renewable energy legislation. Fixed or incremental renewable power price might be the first choice.

5) To ensure the seriousness of the law. The seriousness of the law is the guarantee to implement the law smoothly. In UK, the order clearly that if the enterprise can not finish the portion of the law and does not buy sufficient ROC, it will be fined. The top of that kind of fine will be up to 10% of the enterprise's turnover. In Germany and Spain, there also exist the law responsibility for the electricity which do not carry out their obligations. So there should be relative and clear penalties to Chinese enterprises if they do not carry out their obligation according to the law.

6) Compromise is the best way to weaken conflict of stakeholders. So as to accelerate the process of legislation, it is advised that negotiations and compromise should be followed to deal with concrete issues whereas the essential principle should not be touched. In this sense, we should take the mixed systems adopted by Spain especially the way to decide electricity price as a example.