China-Ghana Renewable Energy Technology Transfer Project

——Renewable Energy Research Report

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Chapter 1 Overview of Renewable Energy Development in China

In order to present an overview of the development status and successful experience of China's renewable energy industry, improve the executive capacity for South-South cooperation technology transfer project concerning China's renewable energy, and support Ghana's renewable energy technology development, the *Report on China's Renewable Energy Development* is hereby prepared. The *Report* is jointly compiled with the help of consultant experts in the fields of wind energy, solar energy, small/micro hydropower and biomass.

In recent years, the development and utilization of renewable energy, influenced by increasing oil prices and global climate change, has gained a lot of attention from the international community. Many countries have proposed explicit development goals, formulating laws and policies supporting renewable energy development. Therefore, renewable energy, with improved technology and enlarged industry scale, has become a crucial energy source boosting energy diversification and achieving sustainable development.

Renewable energy is a critical energy resource in China, and plays a significant role in meeting energy demand, improving the energy structure, reducing environmental pollution and facilitating economic development. Over the past few years China has witnessed extensive development in the renewable energy industry and impressive achievements in wind energy, solar energy, biomass and nuclear energy. Since the 1980s, wind energy, solar energy, modern biomass energy and other technology applications and industries have developed steadily under the support of the government. Meanwhile, renewable energy technologies and industries in hydropower, solar energy and wind energy have taken the lead in the world. China has abundant resources and a strong industrial foundation for developing renewable energy. Recently, the renewable energy industry in China has been in a stage of rapid development. Considering policies, technological innovation and strategic plans, renewable energy in China will be more competitive in the future.

China boasts abundant renewable energy resources. According to existing resource evaluation results, China has 4,000,000,000 to 4,600,000,000 ton coal equivalent (tce) of potential technology development resources including wind energy, solar energy, biomass energy, hydropower, ocean energy and geothermal energy. China has gone through unprecedented economic growth. With the growth of GDP and industrial structure transformation, people's living standard has been substantially advanced. Increasing demand for energy and requirements for environmental conservation continues to drive renewable energy development.

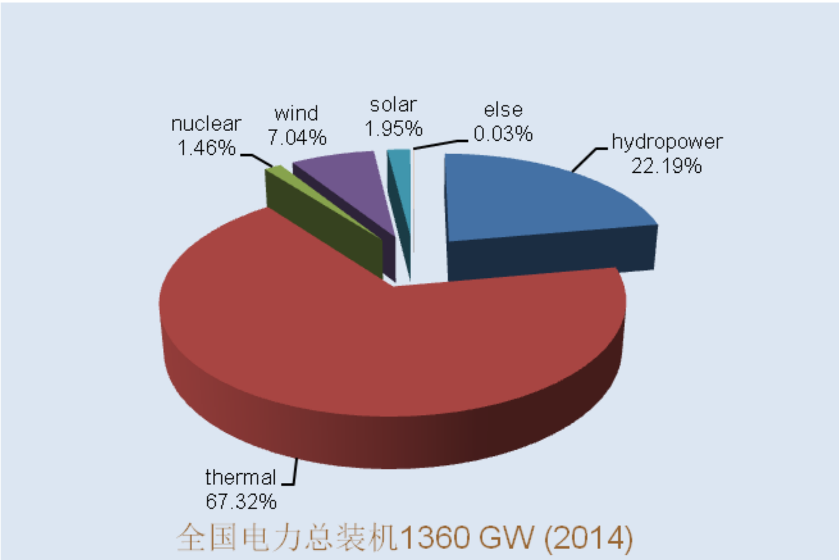


Fig.1-1 The national renewable energy electricity generation proportion of total distribution in 2014

1 China's renewable energy development situation and trend

In recent years, China has experienced rapid economic growth and the living standard of people has improved significantly. The linked conflict between high energy consumption and high pollution however is increasingly serious. Energy and environmental concerns are now a key issue to be solved on the road to sustainable development.

In the Ninth Five-Year Plan of National Economy and Social Development of the

People's Republic of China and Vision Outline in 2014 approved in the fourth meeting of the 8th National People's Congress in 1995, the energy development guideline and policy was established. It is titled "Concerning electric power, based on coal, reinforcing exploration and development of petroleum and natural gas resources, positively developing renewable energy, and improving energy structure". In the same year, the Outline on Developing New Energy and Renewable Energy (1996—2010) was printed and issued by the Planning Commission, Science and Technology Commission and Economic and Trade Commission. In 1998, the Law on Energy Saving was published in 1998, which again affirmed the key strategic role and status of renewable energy in energy saving and emission reduction and environmental improvement. On January 1, 2006, the Renewable Energy Law of the People's Republic of China officially came into effect.

Directed towards global energy utilization, renewable energy industries such as wind power, PV power generation and biomass energy will be extensively used as a major force of the energy system. China should, by seizing the opportunity, build the renewable energy market and industry; vigorously promote the application of renewable energy so as to seize the opportunity in international markets. The development of renewable energy can make the best use of land resources, adjust the energy structure, serve the agriculture industry related to agriculture, farmer and rural area, reconstruct the crop structure in order to further open up a channel for farmers' income generation, accelerate agricultural development and propel the production and development of infant industries. Thus, the expansion of the renewable energy industry in China can speed up construction of new socialist villages and produce enormous social and economic returns.

With intensified energy shortages worldwide and rising concern for environmental protection, it is extremely urgent to substitute depleting petroleum sources with renewable energy. China has tremendous potential and broad prospects in developing renewable energy. However, there are still plenty of barriers in technology and industry development that not only require government support but also concerted effort between industry and research institutes.

2 Development status and trend of solar energy utilization industry

2.1 China's solar energy resources are very abundant

Statistical data of 700 weather stations in China, there are 2 kinds of statistical results from 1961 to 1990 and 1971 to 2000. Later statistics show that the national sunshine duration values in areas with low irradiance decreased, scope was enlarged to the east coast, and irradiation values in areas of high, irradiation values increased slightly. From the view of the distribution of the total annual solar radiation, China's the highest solar radiation strength is in the Brahmaputra Valley in Qinghai Tibet plateau area, the sunshine of each year reached a total of 8820MJ/m2, where the average altitude height above 4000m, the atmosphere thin and clean, good transparency, low latitude, the sunshine time long. Class I area of whole country, the total amount of the sun is more than 6300MJ/m2, mainly in Tibet, Xinjiang, Qinghai, Inner Mongolia, Western Gansu, which accounts for 17.4% of the whole country. Class II areas the total amount of sun is 5040 ~ 6300MJ/m2, West and northwest of china in addition to the Northeast China, including Hebei, Shanxi, Shaanxi, Sichuan, the northwest part of Yunnan, and the southwest part of Hainan Island, accounting for 42.7% of the country. Class III area the total amount of sunshine is 3780 ~ 5040MJ/m2, including the whole northeast, central, eastern coastal areas, most part of Taiwan and so on, accounting for 36.3% of the country. Class IV area the total amount of sunshine is 3780 ~ 5040MJ/m2, including the central part of Sichuan, north of Hunan, northwest of Hunan and other regions, accounting for 3.6% of the country.

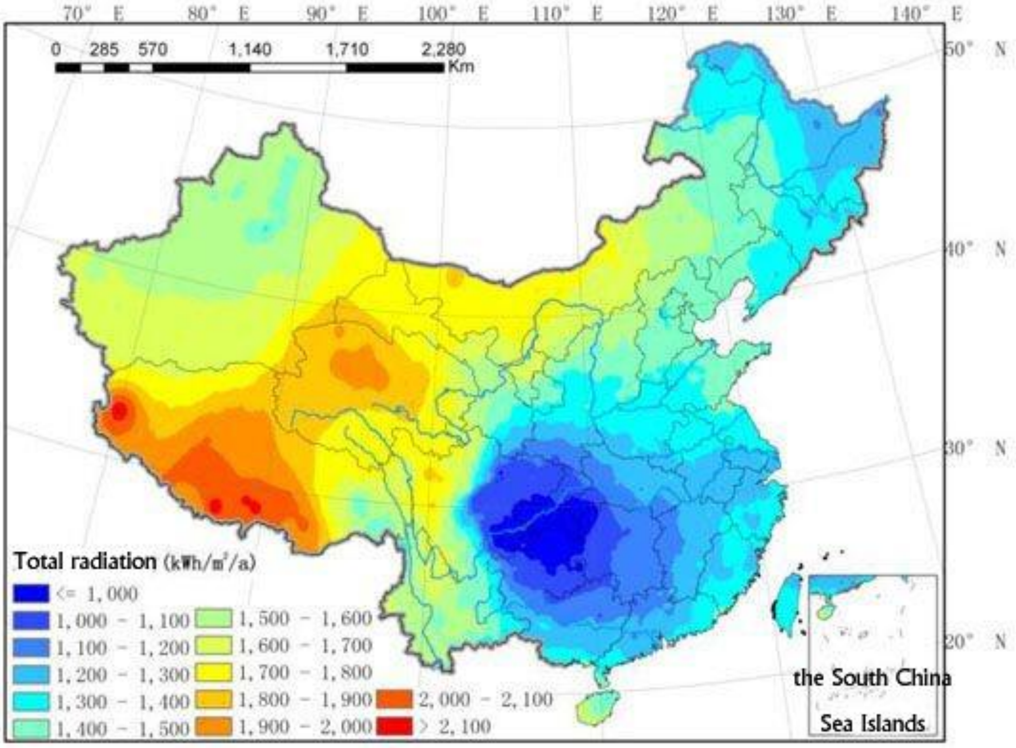


Fig 1-2 Solar resource distribution

Table 1-1 Grades and Partitions of Solar energy resources and full load utilization hours

Resource area	**Provinces and regions**	**Solar radiation value (MJ/m²)**	**Ground station hours (h)**	**Distributed project hours (h)**
ClassI resource area	West of Qinghai, North of Qinghai	6400 ～ 7100	1500 ～ 1700	1300～1400

Class II resource area	Qinghai province Hainan, Guoluo and Yushu, Huangnan, Xining, Haidong; Xinjiang Autonomous Region EastXinjiang(Hami and Turpan), SorthXinjiang（Hotan, Kashgar, Aksu, Bayinguoleng Autonomous Prefecture of Mongolia, Kergez Autonomous Prefecture of Kizilsu); Gansu Province, Jiuquan, Dunhuang, Jiayuguan, Zhangye, Jinchang, Wuwei。	5800 ～ 6400	1300 ～ 1500	1100～1300
Class III resource area	NorthXinjiang of Xinjiang Autonomous Region; Shizuishan of Ningxia Hui Autonomous Region, Yinchuan, Wuzhong, Guyuan; Inner Mongolia Autonomous Region Bayannaoer, Wulanchabu, Alashan, Baotou, Wuhai, Hohhot, Ordos, Xilin Gol; Sichuan ABA, Ganzi, Yulin, Shaanxi Province; Shanxi Province Datong, Shuozhou, Yizhou; Hebei Province Chengde, Zhangjiakou, Tangshan, Qinhuangdao; Other parts of Gansu in addition to class II,; Yunnan.	5400 ～ 5800	1200 ～ 1300	1000～1200
Class IV resource area	Other provinces such as Tianjin, Beijing, Heilongjiang, Jilin, Liaoning, etc.	5100 ～ 5400	1100 ～ 1200	900～1000

2.2 Current situation and trend of photovoltaic power generation

China's solar power construction is suitable for the last century 70's, due to the high cost and other factors, the development of photovoltaic power generation is slow, and is limited to a small power supply system for a long time, it is difficult to achieve large-scale development. After 2000, the state launched the power supply to the countryside, bright project and a series of support projects, to solve the problem of electricity in remote areas without electricity. In recent years, with the maturity of photovoltaic power generation technology, the cost is gradually reduced, Preliminary clear in feed-in tariff. The need to improve the energy structure of the country is increasing, and the power generation of photovoltaic power station has been developed rapidly. From the beginning of 2009, China launched the "photovoltaic building demonstration project", "golden sun demonstration project" and "large-scale photovoltaic power concession bidding", driven by these projects, photovoltaic power generation in our country large-scale development started.

2.2.1 Current situation and trend of photovoltaic power generation project

By the end of 2014, the national solar power grid capacity is 28.07 million kW,of which the grid photovoltaic power station project is 23.38 million kW, distributed photovoltaic power generation project grid capacity is 4.6727 million kW, solar-thermal power generation project grid capacity is 13800 kW.Proportion of all kinds of projects, in turn, is 83%, 17% and 0.05%.

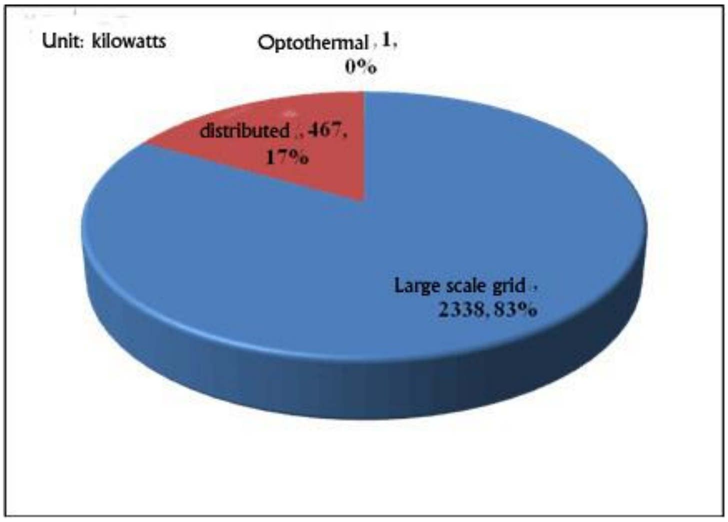


Fig.1-3 At the end of 2014 the solar power grid, distributed and thermal classification

By the end of 2014, the total grid capacity of Gansu solar power generation is 5170000 kW, ranking first in the country;Qinghai total grid capacity relegated to second place in the country is 414 million kW; Inner Mongolia ranked third, the cumulative grid capacity is 302 million kW.

Table1-2 Statistics table of the national solar power generation and grid connected capacity by the end of 2014 (million kW)

Serial number	Province	Photovoltaic power station grid	Distributed photovoltaic(pv) grid	Proportion%
1	Gansu	517	0	18.4
2	Qinghai	413	0.16	14.9
3	Inner Mongolia	284	18.17	10.8
4	Xinjiang	271	4.3	9.8
5	Jiangsu	172	85	9.1
6	Ningxia	217	0.01	7.7
7	Hebei	123	27	5.3
8	Xinjiang PCC	81	0	2.9
9	Zhejiang	3	69.51	2.6
10	Shandong	22	38.41	2.1
11	Shanxi	52	2.81	2.0
12	Guangdong	2	50	1.9
13	Anhui	26	25.46	1.8
14	Shanxi	43	0.59	1.6
15	Jiangxi	13	26	1.4
16	Yunnan	33	1.51	1.2
17	Hunan	0	29	1.0
18	Henan	7	15.9	0.8
19	Hainan	14	4.72	0.7
20	Shanghai	2	16.3	0.6
21	Tebit	15	0.1	0.5
22	Beijing	0	13.97	0.5
23	Hubei	8	6	0.5
24	Fujian	0	11.74	0.4
25	Liaoning	4	5.9	0.4
26	Tianjin	3	6.64	0.3
27	Guangxi	2	6.89	0.3
28	Sichuan	5	1.01	0.2

29	Jilin	6	0	0.2
30	Heilongjiang	1	0.15	0.1
31	Chongqing	1	0.15	0.1
Total		2338	467.27	100

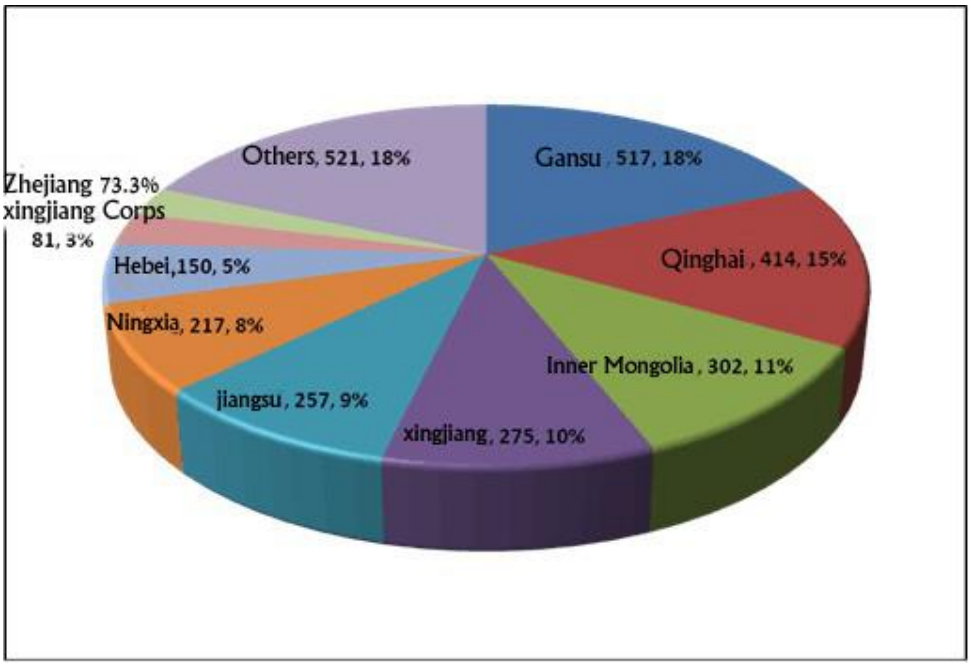


Fig. 1-4 By the end of 2014, the national main provinces (autonomous regions and municipalities) solar power generation

In recent years, the photovoltaic (PV) installed as shown in Fig.1-4, the annual growth rate of 60% in 2004.

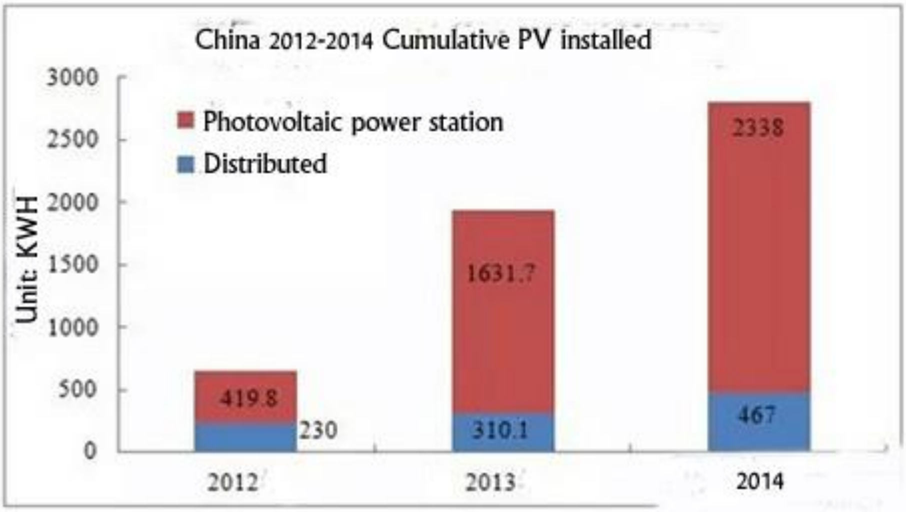


Fig.1-5 Distribution of distributed photovoltaic and photovoltaic power plants in the last three years

By the end of 2014, the main development companies such as :CPI 、China Guodian Corporation、CECEP、China Huadian Corporation and so on ，the total grid photovoltaic power station project is 10.86 million kW， the cumulative market share is 46.4%。Three groups as CPI, CECEP, China Guodian Corporation by the end of 2014 photovoltaic power plant project cumulative grid capacity is the most, accounted for 269 million kW, 162 million KW, 120 million KW, the cumulative market share is 11.5%、6.9%、5.1%。The CPI has been at the first place of cumulative net capacity of photovoltaic power plant project for three consecutive years.

Table1-3 Statistical list of capacity of grid connected photovoltaic power station project of national development enterprise

Serial number	Development enterprise	At the end of 2014 total amount	
		Grid connected capacity (million kW)	Market share(%)
1	CPI	269	11.5
2	CECEP	162	6.9
3	China Guodian Corporation	120	5.1
4	Sanxia	93	4
5	China Huadian Corporation	89	3.8
6	SF-PV	84	3.6
7	CHNT	82	3.5
8	CHINA HUANENG Group	74	3.2
9	China General Nuclear Power Group	57	2.4
10	China Datang Corporation	56	2.4
11	Others	1252	53.6
Nationwide		2338	100%

By the end of 2014, state-owned enterprises photovoltaic power station project total grid capacity is 11.71 million kW.

The road map of China PV power generation installed is shown in Fig.1-6.

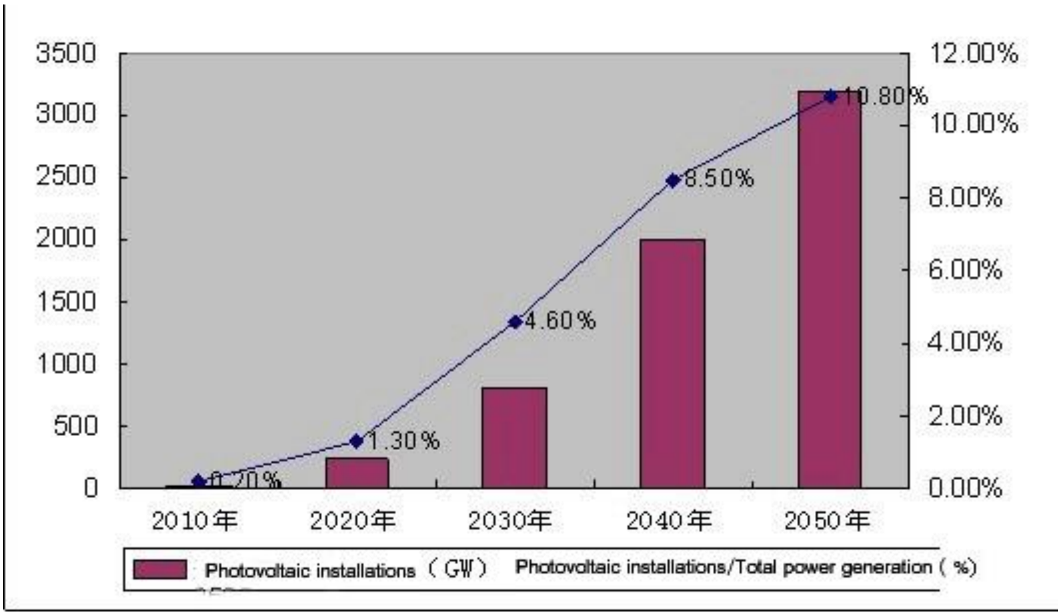


Fig.1-6 Route of Chinese photovoltaic power generation

The cost of solar photovoltaic power generation road map is shown in figure 6.Thus it can be seen that the cost of solar photovoltaic power generation is under 1 yuan.

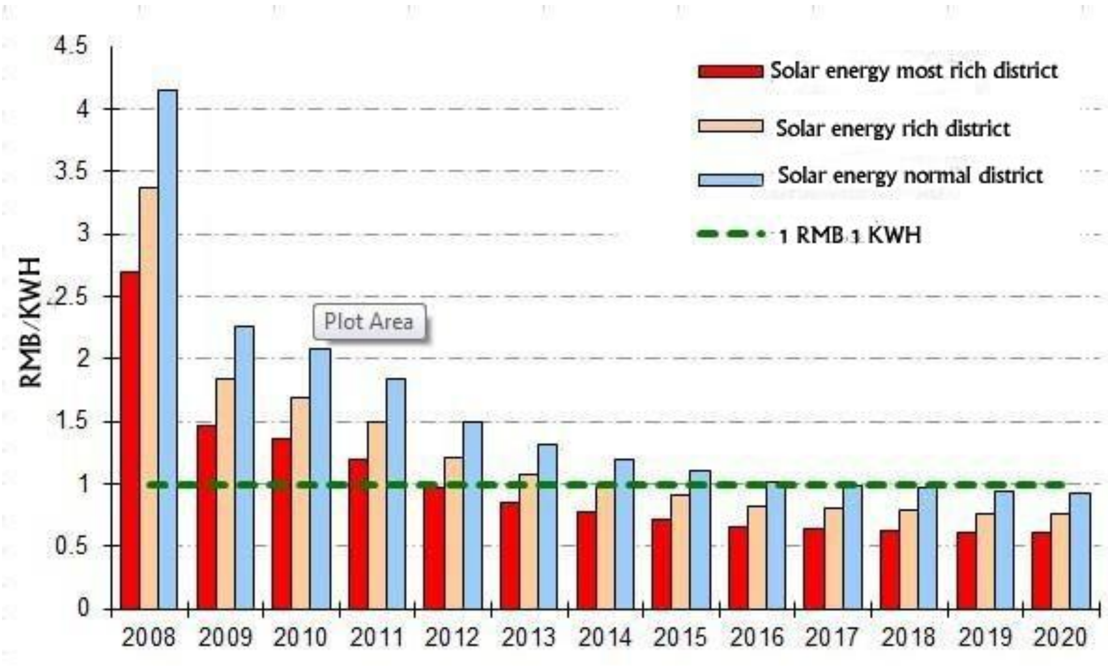


Fig.1-7 Route of the cost of solar power generation

From 2012 to 2014, the unit cost of the project budget of photovoltaic power generation is shown in Figure 7, and the changes of the cost of the PV power plant project is significantly decreased.In 2013 the price cut of 14.58%; in 2014 the price cut of 12.27%, the current estimate index is about 9000 yuan / kWh.

Fig.1-8 budget for the unit cost

In recent years,the ground photovoltaic power plant unit kilowatt cost (final accounts)is 7000 ~ 7500 yuan /kWp，and distributed photovoltaic unit kilowatt cost (final accounts) is 6800 ~ 8500 yuan /kWp.

2.2.2 Present situation and trend of photovoltaic power generation technology

At present, the average conversion efficiency of the production of single crystal silicon and polysilicon battery industry in China has reached 19.3% and 17.8%, and has been in the advanced level of the world.

In 2014, he global polysilicon production steady rise, reaching 280000 tons. China's polysilicon construction enterprises is 18, the production capacity is 156000 tons, the production is about 130000 tons, about 50% year-on-year growth, import volume is 90000 tons per month.As the rebound in the price of polysilicon, several polysilicon companies check into profit, gross profit margin of some leading enterprises is as high as 20% or more。Global pv modules production will continue to grow to 50 GW, photovoltaic module production in China will be more than 33 GW, up to 17% from a year earlier, exports account for between 60% and 70% than expected. Photovoltaic module production enterprise in our country in 2014 ranked as shown in table 1-4.In 2014, polysilicon production enterprise production capacity ranks as shown in table 1-5.

Table1-4 Main components enterprise production capacity in 2014

Enterprise	Annual capacity of 2014（MW）	Output in 2014（MW）
TSL	3800	3700
YINGLI GROUP	4200	3300
Jinkosolar	3200	3000
CSI	3000	2700
JA	3000	2300
Hanwha Group	1900	1420
ReneSola	1350	1200
Hareonsolar	1200	940
TALESUN	1300	700
CHNT	800	700
Tolal	23750	19960

Table 1-5 Major polysilicon production enterprise production capacity in 2014

Enterprise	Annual capacity of 2014(tons)	Output in 2014（tons）
Jiangsu ZhongNeng	65000	65500
TBEA	17000	16000
SINOSICO	10000	9500
Daqo New Energy Co.	6500	6300
Yichang Yibo	6000	4700
ORISI Silicon Co.	5000	4500

Asia Silicon Co.	5000	4500
Sichuan ReneSola	8000	4500
Inner Mongolial JingYang energy Co.	5000	3000
DunAn	5000	3000
Total	132500	121500

2.3 Current situation and trend of solar-thermal power generation

2.3.1 Status and trends of Solar-thermal power generation project

Solar-thermal in stable stage of development in our country, the overall is still in trial and exploration stage. In terms of engineering applications, some small test power plants have been built gradually and come into work. In terms of product manufacturing, some key equipment and products have begun to try to produce, some products have been applied to the test station. However, due to the lack of system integration technology of thermal power stations in China, and the lack of tariff of domestic solar thermal power generation, the development prospects of solar thermal power stations are still not clear, has not yet been built commercial, scale of large power plant.By the solar thermal power plant market development constraints, thermal power station industry chain related equipment and products of industrial production progress is slow, solar thermal power plant industry is still in its cultivation.

Solar thermal power generation market in China has just started, the first 50 MW groove plant franchise bidding completed in 2011，but the project has been slow, the project has not yet started construction。As of the end of 2014, the country has built six experimental demonstration solar thermal power station (system) (such as table 1), installed capacity of 1.3880 million kilowatts.Delingha, Qinghai Province early

10MW pilot plant was built on the basis of the 2012 production of electricity，and Sanya, Hainan 1MW of disc type test station and Hainan Nanshan 1.5MW Fresnel solar thermal power test station has been built one after another，for the future develop of large-scale solar thermal power plants has accumulated experience.There are 12 solar thermal power stations has been put on record (approved)to construction，installed capacity is 49.3 million kilowatts，18 solar thermal power station has been to carry out the preliminary work, installed capacity is about 9.01 million kilowatts, of which has been a clear technical route of the project most of the proposed use of tower technology development, accounting for 53%.

Tabel 1-6 Solar thermal power generation system has been built in China in 2014

The project name	Project owner	Project size(MW)	Technology type	Construction situation
Demonstration project of 1MW solar thermal power station in Yanqing, Beijing	INSTITUTEOF ELECTRICAL ENGINEERING CHNIESE ACADEMYOF SCIENCES	1	tower-type	Has been completed
Delingha Qinghai 50MW solar thermal power generation project	SUPCON	50	tower-type	Built 10 MW power generation at early stage
Sanya Hainan 1MW solar thermal power generation demonstration project	Hainan Keyibo energy co.	1	Caliper Disc Type	Has been completed
Solar thermal power generation demonstration project	CHINA HUANENG Group	1.5	Fresnel	Has been completed

of Hainan Nanshan Power Plant				
Xinjiang turpan groove thermal test station	GOUDIAN XINJIANG POWER CO.	0.18	groove	Has been completed
Gansu province 200 KW groove + Fresnel type solar thermal power generation test system	DCTC	0.2	groove	Has been completed

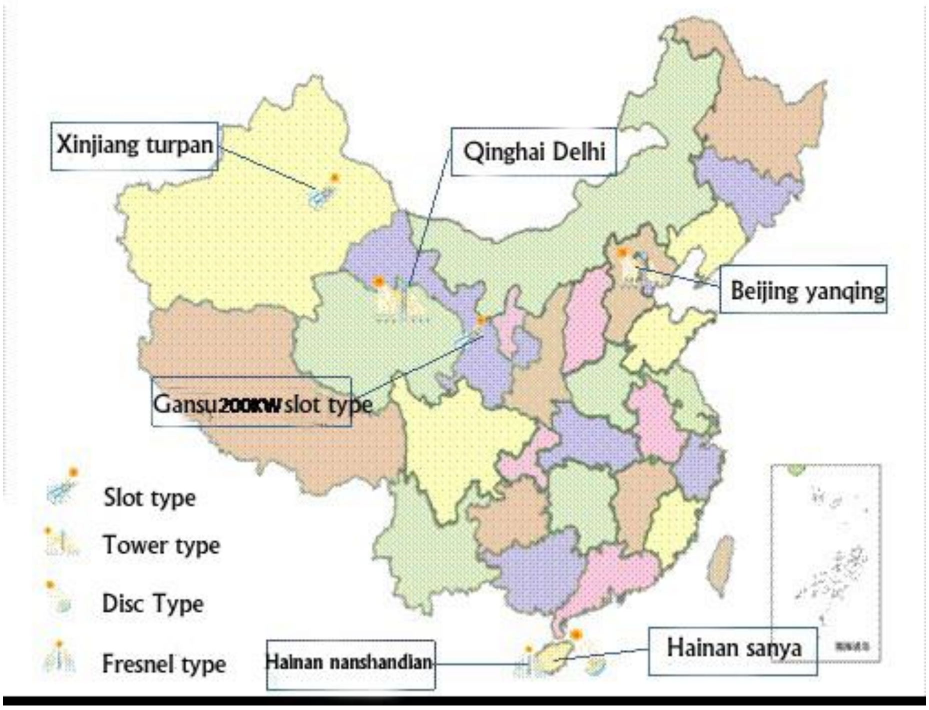


Fig. 1-9 Distribution of solar thermal power generation demonstration projects in China

Thermal development is the necessary of "three north" area of field of renewable energy development and large-scale system coordination of construction operation .In order to meet the "Three North" area of wind power and photovoltaic scale construction and output change, ensuring the reliable operation of the system and improve the utilization efficiency of the transmission line,using with energy storage system of solar thermal power generation to replace the conventional thermal power is economically reasonable and necessary.

Solar thermal electric field include tower, groove and disc type solar thermal power generation key equipment,suitable for Tibet, Xinjiang, Qinghai, Inner Mongolia, Gansu, Ningxia and other Western Regions.

At present, there are 14 companies can produce groove type vacuum heat tube，4 companies can batch production slot type glass mirror，two companies can provide tower heliostat and the field lens package, two companies can be provided heating special steam turbine power generation，and there are a number of solar thermal power generation special materials and equipment have been exported to foreign commercial power plant.

There are 5 grade A Design Institute in the country directly doing the related design of solar thermal power plants, there are four units engaged in solar thermal power plant installation and commissioning as a whole.In the National 863 plan, 973 Plan, the national science and technology support program, the National Natural Science Foundation of China, National SME Innovation Fund and other national funds to give a long-term support.Many provincial and municipal governments, the Chinese Academy of Sciences and other scientific institutions and universities have also put a lot of effort. Solar thermal industry innovation strategic alliance has become a national alliance with the support of the industry.

2.3.2 Solar thermal power generation technology and trends

（1）At present, the cost of solar thermal power generation technology is higher than the traditional fossil energy, in consideration of the solar thermal industry environmental benefits, social benefits and pull effect on the related industries,countries around the world generally support the development of solar thermal power generation industry through the policy-related subsidies.As China has not promulgated the relevant subsidies for solar thermal power generation and the standard system management measures, the development of solar thermal power generation industry in China is relatively slow.

（2）After initial calculations found that every 1% increase efficiency in solar thermal power generation system is equal to the initial investment is reduced to 5% ~ 7%.Therefore, to improve the system efficiency is an important way to reduce the cost of power generation.

（3）In terms of groove heat power generation

Trough solar thermal power generation technology is a mature technology of solar thermal power generation,the technical characteristics and the development direction of the trough solar thermal power generation is：

1）The focus tracking is based on single axis tracking. The main research needs to improve the mechanical performance of mirror，scaffold materials，design and installation of the mirror and so on, and in the aspect of application, need to seek the most reasonable and economic way of cleaning.

2）In the tube, in addition to development of better performance of selective absorption coating and glass antireflection film, between glass and metal sealing connected directly affects the life of the tube, domestic enterprises and institutions should be vigorously research the key technology, in order to break the monopoly of foreign companies.

3）In the aspect of heat absorption and heat storage medium, DSG and molten salt heat is still a long way to go, the current reliably using is still the heat conduction oil absorption of heat - double pot of molten salt heat storage technology, which can be consided the use of ternary salt to increase the molten salt available temperature interval, to try to save the cost of molten salt，and in the storage time, its not economic to be too short or too long.The current mainstream 50MW installed capacity power plant is used in heat storage time around 8h.

4）The scale of 100MW or more will become the future development direction.

（4）In the aspect of tower thermal power generation system.

1）Take Chinese Academy of Sciences electrician established 1MW power station as an example, the quantitative study of factors affects cost, heliostat price accounts for about half of tower power plant investment, the discount rate was 8%, the heliostat price reducd from 1600 yuan to 1200 yuan per square, the cost price reducd from 3.06 yuan / kWh to 2.63 yuan / kWh. Heliostat price is 1200 yuan per square, in the amount of radiation rise from the 5.0GJ to 5.7GJ, the cost of electricity reducd from 3.05 yuan /kWh to 2.63 yuan / kWh.The mirror field area, steam temperature and steam pressure are the best.

2）In order to improve the economy of the tower thermal power generation, the tower thermal power generation system should be designed with high parameter and large capacity.

3）To reduce the cost of heliostat is effective measures to reduce the cost of thermal power generation tower.

（5）Heat storage material selection

A variety of thermal oil used for heat transfer and sensible heat storage of , due to the use of the working temperature is not more than 400, the cost is generally high.Although a large number of applications used in solar thermal power stations in the past, but has great limitations in higher parameter application solar thermal power station, still need to improve performance or develop new products.Compared to the use of the molten salt temperature heat conduction oil has increased, especially in the heat transfer heat storage using molten salt as the integration of the power station, can be generated by heat transfer of more than 500 ℃ high temperature and high pressure steam, is expected to promote the supercritical unit to realize high efficiency power generation。It has been successfully used in the Gemasolar power station in Spain, and 24h continuous power generation is realized.Therefore, the heat transfer of molten salt and sensible heat and latent heat storage material will dominate the solar thermal power generation system in the supercritical units.The cost of high temperature concrete is very low, and the working temperature of the thermal storage system is relatively high.German DLR high temperature thermal storage system of concrete pilot has been achieved, but high temperature concrete is explicit solid heat accumulation, The thermal storage density and thermal conductivity of its simple concrete heat storage material is small , covers an area of a larger system.The concrete heat storage system with phase change thermal storage materials will be the direction of the research and application。Metal materials are used for sensible heat thermal storage material,because the heat capacity is too small to cause the thermal storage cost is high, lack of competitiveness and application prospects.However, metal alloy used as latent heat storage material,having high energy storage density, high thermal storage temperature, good thermal stability, high thermal conductivity and good cost performance, has the very good application potential.However, due to corrosion and other reasons, there is no large-scale application.High temperature ionic liquid has a high cost, but the current research on the heat transfer characteristics of high temperature and high temperature is insufficient.Chemical thermal energy storage materials have a broad application prospect, but also need to solve the problems such as corrosion and cyclic stability.

China have identified the technical route project of which 53% adopted due to its high efficiency in the tower technology, using technology more mature groove proportion is 38%, there are a few adopted linear Fresnel and disc technology.

（7）To the Chinese solar thermal power generation development cost curve of the decline is greater than the global cost of ESTELA curve 20% of this situation as the foundation of China.From the current case of the first unit of the power plant investment 29119 yuan /kW as the starting to predict that in 2015 China's unit investment costs will be dropped to 23004 yuan /kW, 2020 will be reduced to 14268 yuan /kW, 2025 will fall to 12521 yuan /kW.

（8）Assuming that the average cost of the drop is greater than the ESTELA global curve 40%, in 2025 and 2020, China's solar thermal power generation units compare to ESTELA global curve will be reduced by 30% and 36% respectively, which is consistent with China's cost reduction achieved in other renewable energy technologies.

（9）When the solar thermal power generation system efficiency changes in the ±2%, the initial investment of each kilowatt hour will be changed to ±1%.

（10）Economic evaluation of solar thermal power generation:

1）The capacity of solar thermal power generating units should be at least more than 3MW, under 3MW units due to the relatively high cost of labor and investment, even in the same unit price, the price is higher than the above 3MW units 0.1-0.15 yuan / Kwh .

2)When the amount of investment over 60000 yuan / kWh, the electricity price basically reached 2 yuan / kWh, The market potential of solar thermal power generation will be difficult; high operation cost, the benefit is lower than that of solar photovoltaic power.

3）When the amount of investment reached 40000 yuan / kWh, the electricity price is basically close to 1.4 yuan / kWh, if the national compensation price is 1- 1.1 yuan / kWh, then the initial market of solar thermal power will come.

4）When the amount of investment reached 20000 yuan / kWh, the electricity price will be around 0.7-0.8 yuan / kWh, the market of solar thermal power generation will come true.

5）When the amount of investment reached 10000 yuan / kWh, solar thermal power tariff will be close to the current market price, about 0.47 degrees, then the popularity of solar thermal power generation will come.

6）The above data is calculated and analyzed with the good solar radiation area.Solar radiation rich area, and relatively rich area,due to the difference of the solar energy, under the same conditions of generating capacity will increase, according to the analysis, the resulting price difference, is about 0.05- 0.10 yuan/Kwh.

（11）Due to the intensity of solar radiation in one area is different,Under the condition of the same investment capacity is different.The solar radiation energy of the third regions as a reference point, first, two regional energy accounted for 138.5%, 115.4%.

2.3.3 Solar power construction layout in 2020

（1）Large ground stations

Superior resources in the west region mainly carried out large-scale ground power station construction, to enhance photovoltaic technology progress and the optimization design, to promote the photovoltaic power generation costs down to a reasonable level, to promote the health development of large ground station

（2）Distributed photovoltaic

In central and eastern regions actively promote the construction of distributed energy technology development and project innovation, to promote the development of photovoltaic technology and diversified business model.“Fifteenth Five Year Plan” period, through the construction project technology innovation, market exploration of business model, and micro power grid, energy storage and other distributed energy combination, effectively promote the domestic PV industry market development and development, and further promote the national power system reform.

（3）Concentrating Solar Power

“Fifteenth Five Year Plan” period, strengthen solar thermal power generation planning, promote technical standard system construction and improve the storage characteristics, promote the industry to mature,Summarize the experience of the construction of demonstration projects, improve the economic efficiency and management level; relying on the related research and the introduction of price policy, promote the development of thermal emerging industrial scale.

“Fifteenth Five Year Plan” solar power generation planning and prediction are shown in Table 1-7.

Table 1-7 “Fifteenth Five Year Plan” solar power generation expansion planning

Area	Photovoltaic power generation									Concentrating Solar Power	
	In 2015 is expected to			The new increase of “Fifteenth Five Year Plan”			The cumulative 2020			The new increase of “Fifteenth Five Year	The cumulative size of 2020
	The ground station	Distributed	小Subtotal	The ground statio	Distributed	Subtotal	The ground statio	Distributed	小Subtotal		
North China	596	180	776	854	720	1574	1450	900	2350	64	65
North west	2093	40	2133	2007	270	2277	4100	310	4410	366	370
Northeast	35	30	65	75	310	385	110	340	450	0	0
East	487	665	115	248	2010	2258	735	2675	341	0	0

China			2						0		
CentralChina	94	180	274	111	650	761	205	830	1035	0	0
Southern China	28	185	213	42	760	802	70	945	1015	5	5
South west	221	20	241	179	310	489	400	330	730	59	60
Total	3542	1300	4855	3515	5000	8545	7070	6330	13400	495	500

2.4 Present situation and trend of low temperature heat utilization in solar energy

2.4.1 Present situation and trend of low temperature engineering in optothermal

Solar thermal utilization according to the working temperature generally divided into three areas: which is suitable for low temperature below 80 ℃, 80 ℃-250 ℃in medium temperature field , 250 ℃-800 ℃in high temperature areas.Field of low temperature heat utilization technology at home and abroad have more mature, mainly to provide water for life; The application of heat utilization technology in the field of medium temperature and heat utilization is related to all aspects of industry, and has a broad prospect of business. It is one of the most widely used technologies for solar thermal utilization, which is one of the most effective ways to solve the current energy shortage, environmental pollution and global warming.

Table 1-8 solar energy in low-temperature heat utilization

Industrial field	process engineering	range of temperature（℃）

Food and beverage industry	Dry Heat treatment Clean Disinfection Boiling Sterilization	30-90 40-60 40-80 80-100 95-105 140-150
Textile printing and dyeing industry	Clean Bleach Printing and dyeing	40-80 60-100 100-160
Petroleum Chemical Industry	Crude oil heating Boiling Distillation Various chemical processes	70-80 95-105 110-300 120-180
Transportation industry	Vehicle cleaning Cement curing Asphalt heating	70-80 70-90 100-180
All industries	Plant heating Boiler water preheating	30-80 30-100

Our solar heat utilization situation is basically the same, the installed solar collector is mostly used in various types of large and medium-sized domestic solar water heater and solar hot water system, for instance and reports are very rare in industrial heating.Nowadays, the application of solar energy industry heating system involves many industrial fields.The industrial fields and processes involved in the use of solar energy are listed in Table 8.Seen from table 8, the potential of industrial areas and the process of solar heat, not only include some process of food and beverage industry, textile industry, petroleum chemical industry, transportation industry,some process also includes all areas of industrial plant heating and boiler water preheating.

In 2013 the use of solar thermal market impact by such as home appliances to the countryside policy exit, an increase compared to 2012 decreased by 8%, the market competitive pressures continue to increase.The layout of the market, the solar water heater retail market is gradually shrinking, but the engineering market rapid growth, an increase of more than 50%, accounting for 30% of total market sales.In terms of product structure, flat products market proportion gradually increased, some combination of solar energy and heat pump, focusing collector and other new products to promote the use of solar thermal products,solar energy heat utilization product appears the development trend of diversification.

In 2013, China's solar water heater production and operation of ownership remain first in the world.The solar water heater production reached 66000000 square meters, an increase of 3%, operating reserves reached 310000000 square meters, a year-on-year increase of 20%.In 2013, the solar water heater retail market was essentially flat compared with 2012, the rapid growth of the construction market, compared to 2012 increased by more than 50% ,2013 water heater product exports to $322000000, an increase of 7.3% compared with 2012.

China's solar energy heat utilization application field is mainly living hot water supply, accounts for about 98% of the cumulative installed capacity market, mainly with the application of solar water heater, accounts for about 90% of the market cumulative installed capacity, used in the hotel, the bathroom markets such as central heating water accounted for about 8% of the market cumulative installed capacity, the rest for solar power and other energy, solar hot water, heating and cooling applications of composite system.Implementation of the application of solar hot water, heating and cooling composite system.In 2013, all glass vacuum tube the total sales volume is 57060000 square meters, with basically the same as in 2012 Flat plate collector products increased significantly, 2013 annual output of 6500000 square meters, with a year-on-year growth of 27.3% last year.

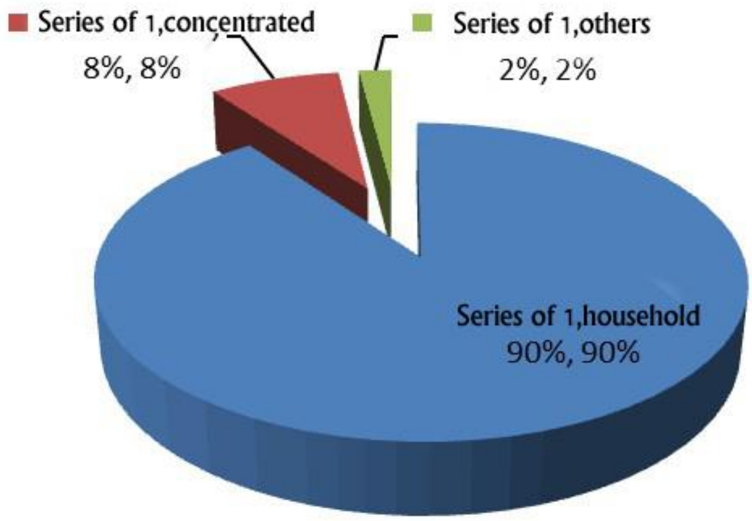


Fig. 1-10 the use of solar water heaters classification

In terms of Solar heating, in recent years, due to the promotion of policy, China has built a number of solar heating heating demonstration project.In Beijing suburbs, Tibet, Xinjiang, Inner Mongolia, Qinghai, Gansu, Ningxia and other western regions of the solar heating project built on the basis of the operation, in 2013 solar heating began to try, Gansu, Hebei and other places some of the solar heating project has been completed, for the future development of the scale of solar heating has accumulated experience.

Solar thermal utilization of retail market growth is slow, the market structure gradually changed, so the solar thermal utilization manufacturers will focus on large-scale solar energy projects market.In recent years, due to the increasing pressure of energy saving and emission reduction, the application of solar energy heat utilization in industrial and agricultural applications is gradually increasing.The solar thermal utilization is further applied in the fields of industry, agriculture and animal husbandry as a demonstration project, which is based on the application of printing and dyeing, drying, etc.

2.4.2 Technology and trend of low temperature in optothermal

After many years of accumulation, China has made great progress in the field of solar heat absorption, heat storage material, concentrating equipment, groove type vacuum tube, different forms of heat absorbing device, power system design and so on.2008 Beijing Olympic athletes apartment solar hot water heating system efficiency is 43%-55%, the solar energy guarantee rate is 29%-65%; Beijing new rural construction Pinggu County solar heating demonstration village, set the daily average efficiency of the thermal system 42%-56%, the monthly total useful heat of solar energy guarantee rate is 40%.Large-scale solar energy central heating, heating, seasonal heat storage, solar assurance rate is 40%. Large-scale solar heating system for central heating and thermal station seasonal heat storage technology in the heating system to replace conventional energy consumption can reach more than 30%.In solar energy industry and agricultural utilization, the conventional energy consumption of solar energy in the hot water and steam system is more than 30%, and the conventional energy consumption of solar drying system is more than 40%.Seawater desalination system YOFC alternative energy consumption can reach more than 40%,and the former two are suitable for the lack of freshwater resources of new energy demonstration city, green energy demonstration counties, the latter is suitable for the lack of freshwater resources in coastal city, island, new energy demonstration city, green energy demonstration county.

In September 13, 2012, the national energy administration issued the solar power development “Twelveth five year plan” ,the national policy guidance is still dominated by solar power.Whether the solar photovoltaic power generation, or thermal power generation, the market application of the solar energy conversion rate is only 15% or less. Compared to the solar energy collection system of 45% or more of the solar energy conversion rate, it is much lower.But in the medium temperature solar energy, the relevant state departments attach importance to low level, few support policies, which also limits the medium temperature of the solar energy technology development and industrial upgrade.On the basis of scientific research, part of the solar energy heat utilization enterprise has obtained the support of the national capital, have a greater role in promoting the technological upgrading of medium temperature.In the medium temperature solar energy technology market and pilot, should give greater policy support and tilt, which effectively promote the development of solar energy market.At present, At present, shandong linuo rhett company has realized the high temperature of 90 ℃ hot water as boiler preheating, obtained the certain effect.. In Shandong Weifang, according to the characteristics of the comprehensive utilization of seawater, Tsinghua SunShine Co.design the most advanced, the largest installed CPC medium temperature solar collector system, used for seawater desalination application .Hebei light source develop the "big solar drinking boiled water systems engineering".In 12 provinces, autonomous regions and municipalities directly under the central government, more than one thousand colleges and universities and enterprises and institutions, installed solar hot water system engineering,the total lighting area of 10.41m2,the total daily output of 291 liters of hot water, to achieve the development of solar energy in the industrial development.

The main factors influencing the medium temperature solar energy marketization is a cost.Compared with conventional energy, although solar energy collection has many advantages, such as energy saving, environmental protection, low cost, etc., due to the failure to form large-scale production, in the medium temperature collection thermal system energy production and storage costs are higher, the initial investment is large, the system is complex and difficult to maintain.Potential application of enterprise investment return period is long.At the same time, the medium temperature solar system is influenced by solar radiation and weather, and can only be used as the auxiliary energy used in the industry, but it can not provide continuous and stable energy.In order to provide more solar energy, in many industrial plant with large heat, requires the construction of less than thousand square meters, more than 10000 square meters of solar collector area.As for the potential users of land, land area is a large cost.The above factors, led to the medium temperature solar energy marketization process is slow.In recent years, PM2.5 problem in China has increased the potential user’s fear of medium temperature solar energy market,, many processes in the industrial process with the use of thermal temperature is between 80 ~ 250 ℃, and the medium temperature solar energy heat utilization system just can meet the demand of the temperature range of the corresponding heat.Therefore, the research and industrialization of the medium temperature solar energy utilization technology has a profound meaning.Temperature in solar technology in the industrial application of the industry, including the provision of process heat.The system of medium temperature solar thermal energy can provide the temperature for industrial production process with heat, such as wood, textile printing and dyeing, bleaching and drying of plastic products, hot embossing chemical distillation and refrigeration etc.

3 Development status and trend of wind energy utilization industry

3.1 introduction

China has overtaken US as the first energy consumer in the world since 2011, taking great pressure on air pollution and carbon emission due to its coal-dominated energy system. In order to mitigate climate change and improve air quality, renewable energy, especially wind power, has been regarded as the key solution for sustainable energy by Chin. Wind power has seen a significant progress in China particularly after the Chinese Renewable Energy Law came into force in 2006. By the end of 2014, the cumulative on-grid wind power capacity has reached 96 GW, the world largest wind industry has contributed 153.4 TWh, 2.78 % of electricity generation. Although the installation of wind turbine is increasing, the annual growth rate of wind capacity has decreased below 33% since 2011. In addition, National Energy Administration has announced a decrease adjustment of feed-in-tariff for wind power by the end of 2014, which is expected to decelerate the new installation.

In order to reach the goal of achieving a wind power capacity of 100 GW by 2015 and 200 GW by 2020, the deployment of wind power is the leading question to allocate new installation among different regions with various resource and demand characters. From the perspective of carbon emission reduction, three main types of policies exist to promote development of wind power among countries: a price instrument imposing an external payment for emitted fossil fuel plants (e.g., a CO2 emission tax), finical subsidy for wind power to cover the cap between generation cost and market price (e.g., feed-in-tariff) and quantity instrument imposing an emission cap or renewable penetration (e.g., cap-and-trade market or renewable penetration standards). All the types of policy instruments would require a cost of CO2 abatement on existing power sector. Therefore, it is essential to investigate the abatement cost and emission mitigation of wind power, in order to provide solid supporting information for a mixture of public planning including various instruments such as taxes, regulation, and feed-in-tariff for wind development in China.

The essential difficulties in estimating appropriate abatement cost and the relevant emission mitigation potential lies on wind resource, regional disparities of electricity demand and generation fleet, as well as electricity price for coal-fired power . The economic deployment of wind energy should have the least total incremental cost on existing power system, with the same amount of emission reduction. A widely used methodology to estimate how expensive it would be to achieve the specific emission reduction is marginal abatement cost curves (MACCs). The MACC curve can plot the corresponding cost to tighten the emission mitigation target further, which links marginal cost of abating an incremental emission to an emission cost. The purpose of present study is to generate cost curve of carbon emission for wind power utilization, providing the account of emission could be reduced by the deployment of wind power and the related emission abatement cost at high spatial resolution. The two important factors that impending carbon emission abatement cost by wind power for each region is the generation cost of wind, and the current electricity price which reflects regional disparity of power supply, electricity consumption and electricity trade. In 2014, coal power accounted for 75% of total electricity generation, which is expected to be replaced by renewable energy progressively. Thus, the carbon emission abatement cost is defined as the incremental electricity cost between coal-fired power and wind power, divided by the carbon emitted gap between coal-fired power and wind power. To investigate the economic wind deployment to mitigate carbon emission, the purpose of our study is to determine the potential and cost to offset carbon emission by wind power from regional perspective. The paper first lists existing wind potential assessment in China, and then describes the wind resource as well as on-going development plan. The methodology and data used to calculate wind power's carbon dioxide (CO_2) mitigation potential and abatement cost are introduced. The results could supply an overall message regarding the cost and amount of wind power to deploy at provincial levels to both national and local policymakers and investors.

3.2 Wind power potential and development plan

Existing assessment on wind potential in China has focused on physical capacity or generation wind resource potential, which represents the upper limit of usable wind electricity with assumption of fully integration into electricity grid. Leading literatures have concluded that China's total wind ranges from 832 GW to 2600 GW, which is several times of China's national targets of 200GW wind installation by 2020. The China Meteorological Administration (CMA) has developed a wind energy numerical simulation and evaluation system, which indicates that the theoretical wind resource potential ranges from 2000 GW to 3400 GW. McElroy and Lu et al. concluded that approximately 10% of Chinese CO_2 emission could be avoided if 0.62 PWh wind electricity are generated per year to replace coal-fired power, at the price of 0.4 RMB/kWh. He and Kammen combined geographic information system (GIS) and wind hourly profile simulation, providing high spatial resolution resource analysis at provincial level which indicates technical wind potential varies from 1243 TWh to 2643 TWh due to different assumptions of wind turbine spatial density. For offshore wind, Hong and Möller reported offshore wind could technically contribute 2450 TWh in 2020 and 2758 TWh in 2030, relatively. In summary, the previous studies concentrate attention on wind resource assessment while the potential to mitigate carbon emission and the related abatement cost are simply calculated based on national average coal-fired power energy efficiency, while the regional heterogeneity of rest of power system except wind power is overlooked.

Specifically, majority of existing installed wind turbine are located in provinces with abundant wind resources including high wind density and available land, such as Inner Mongolia, Hebei, Gansu, and Northeast China. By the end of 2014, 16 provinces have cumulative installed capacity of over 1 GW, and the 10 leading provinces with the biggest wind installation fleets have account for 80% of the national wind installation, shown in Fig.1-11. Along with existing high level of capacity concentration, in 2008, National Energy Administration of China have released development planning for seven 10GW large-scale wind basements by the end of 2020 . In 2012, China's 12th Five year plan for renewable energy has announced the target of 100 GW wind installation by 2015, and 200 GW by 2020, following by regional targets for main wind basements as well shown in . These targets imply the construction of 25 GW of new wind turbines from 2013–2015, and at least 20 GW per annum from 2016–2020. These mostly of announced planning large-scale wind bases were supposed to be installed in north and northeast China (see Fig.1-12). But no new projects would be arranged in Xinjiang, Jilin, Liaoning and other provinces with high rate of wind curtailment in the first quarter of 2015.

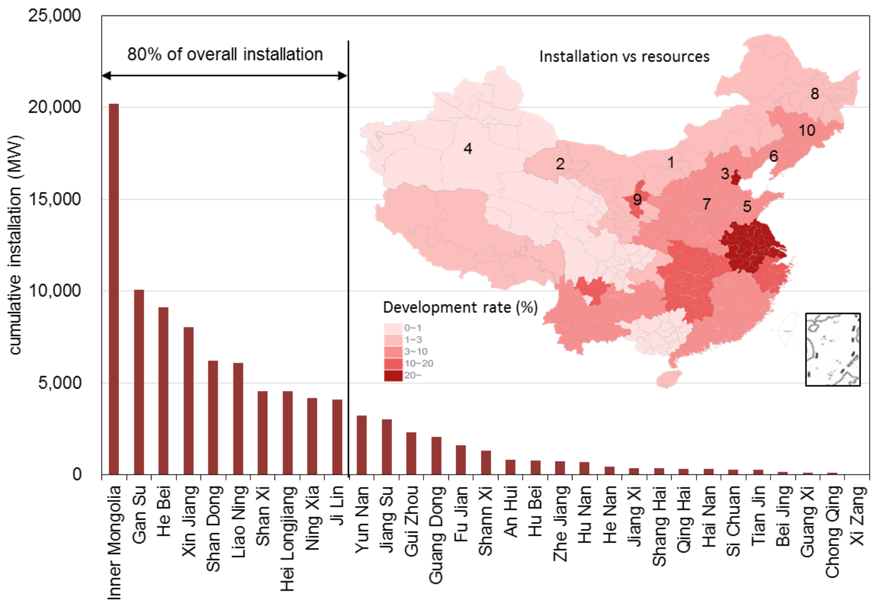
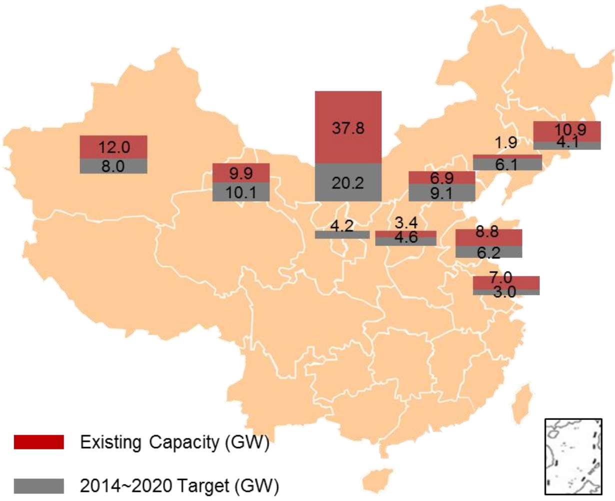


Fig.1-11. Provincial accumulative on-grid wind capacity by the end of 2014.



a. For Ningxia province, existing wind capacity has exceeded 2020's target by 0.2 GW.

Fig.1-12. Planned large-scale wind basements towards 2020.

4 Development status and trend of small hydropower

China's hydroelectric generation originates from small hydropower. At present, 1/2 of the country's territory, 1/3 of the counties and cities and 1/4 of the population has power supplied by small hydropower, thus playing a key role. Hydropower resource potential in China is 600GW, including 128GW of small hydropower; by the end of 2014, hydropower installed capacity was 302GW, of which 72GW was small hydropower; of annual energy output at 944TWh, small hydropower provides 220TWh.

The installed capacity of small hydropower has had different definitions for various periods. Currently, it refers to hydropower stations and supporting grids with the installed capacity of a single station at or below 50000kW. Small hydropower is now a crucial infrastructure and public facility for rural areas, and is a vital component of renewable energy. It primarily provides power and services for the economic and social development in rural areas. China has witnessed the growth of small hydropower from small to large scale, from weak to strong, from a single location to area-wide, all encompassing significant changes.

China's small hydropower development has undergone three stages. During the

30 years from the foundation of new China to the end of the 1970s, small hydropower enabled hundreds of millions of Chinese to access electric power, end a period without electricity and thus enter modern civilization. However, confined by limited access to funds, technology and appropriate systems, small hydropower developed at a slow pace and in small scale, and its supply was mainly scattered and remote. Total installed capacity at the time was merely 6,330,000kW, and annual average production capacity was at 210,000kW. Owing to a lack of national electric power, the power transmission and transformation facilities lagged far behind. Consequently millions in the rural population lived without power.

The 20 years from the reform and opening-up policy to the end of the 20th century was a period of rapid advancements. As the reform and opening-up policy vastly boosted productivity, the key emphasis of the state gradually focused on economic construction. The weak electricity infrastructure became increasingly prominent. At that time, financial resources were still unable to meet the increasing energy demand. It actively mobilized all aspects of power construction, and accelerated development and widespread use of power. China, through means of policy support, financial aid and technical training, encouraged local governments and farmers to independently set up small hydropower, carving out a rural electrification road with Chinese characteristics. The rural electrification rate in 1978 was: 94.5% for counties, 86.83% for towns and 61.05% for villages. Over its 20-year endeavor, the total small hydropower installed capacity by the end of 1999 had reached 23,480,000kW, increasing by 17,150,000kW, with an annual average production capacity of 850,000kW, ultimately resolving the issue of local power supply. Of the rural electrification rate in 2008, the county electrification rate increased to 100%, that of towns to 99.68% and villages to 99.74%. Small hydropower thus lighted up rural areas in China.

The decades following the beginning of the new millennium brought a new level of breakthrough development. Once entering the new century, China's rural hydropower and electrification entered a new phase, undertaking new objectives and carrying out a new role. The Chinese government place greater emphasis on the role of small hydropower in rural economic and social development, supported rapid development of small hydropower, rural electrification as well as small hydropower replacing fuel projects. On the financing and policy aspect the state continued to assist small hydropower development. In 2001 and 2006, the “Tenth Five-Year Plan” and “Eleventh Five-Year Plan” for rural electrification were launched, respectively. In 2003, a pilot project for small hydropower replacing fuel was commenced and further extended in 2006. With the deepening of economic system reform, social capital gained access to small hydropower development, boosting rapid small hydropower growth that has consequently resolved the problem of power supply in mountainous rural areas and overall economic and social development. Small hydropower has not only contributed to energy supply, improved the energy structure, helped to preserve the ecological environment and reduce greenhouse gas emissions, but has also played a unique role in emergency power security.

Small hydropower resources are of moderate scale, require less investment, a shorter project period and generate quick results. For this reason, it can mobilize multiple initiatives, and is suitable for encouraging and guiding communities, enterprises and individuals to exploit. Electricity generated from small hydropower resources may be supplied and consumed locally, without the need for remote transmission of high voltage with high capacity. Furthermore, generation and supply costs are fairly low. Small hydropower is an important component of the power industry and beneficial for supplementing large power stations. In addition, it provides strong support for China’s“West-East Power Transmission”project. Small hydropower, as an internationally recognized renewable green energy, boasts mature technology and lower construction costs relative to other renewable energy sources (ie solar, wind and biomass energies). Therefore, it is fit for distributed power supply and electrification construction in rural areas. Its development will help optimize energy restructuring, balanced development of the population, resources and environment as well as sustainable economic and social development.

4.1 The current status of hydropower resources of China's medium and small rivers

4.1.1 Overview of China's hydropower resources

China has a vast land, with a national territory area of 9,600,000 km2. Meanwhile, it contains numerous rivers and lakes. Additionally, China is located within the monsoon climatic region. Influenced by warm and wet airflow, the southeast, southwest and north east of China are replenished by abundant moisture and plentiful precipitation. Therefore, it is one of the regions in the world with relatively abundant water resources.

With a total river length of about 43,0000 km, China is one of the nations with the most rivers in the globe. According to statistics, the average runoff of China's rivers is 2,711,500,000,000 m^3 , and the average annual precipitation is around 6,190 km2, enjoying a large quantity of water resources. Apart from the seven main streams namely Songhua River, Liao River, Hai River, Yellow River, Huai River, Yangtze River and Pearl River, there are over 50,000 medium and small rivers, including 5,000 rivers with a drainage area above 200 km2 and more than 1,700 rivers with areas exceeding 1,000 km2. The river banks are covered by cities, towns and farmlands. Ample hydropower resources are the requisite resource for hydropower development. Furthermore, the geographical descent between the high west and low east significantly benefits hydropower development.

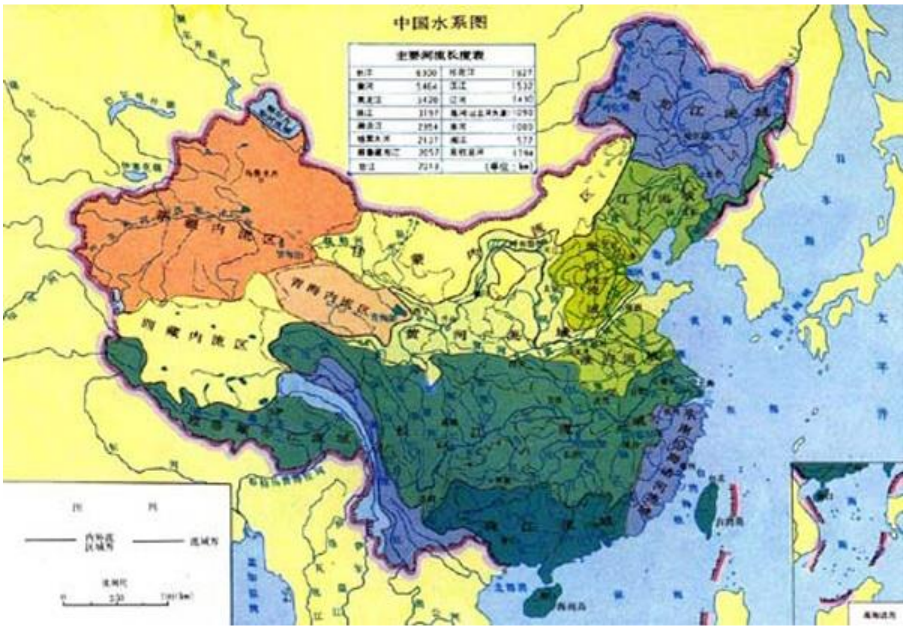


Fig.1-13 Distribution Map of China's Hydropower Resources

Currently, due to fast economic development and a sharp increase in energy demand, the intensity of hydropower resource exploitation is constantly expanding. In particular, hydropower development and planning, development program design, hydropower resource survey and manufacturing of hydropower station equipment have been flourishing. It is predicted by experts that the level and degree of China's hydropower development will approach or reach that of developed countries before 2020. By that time at least half of the electricity used by people shall derive from hydroelectric generation.

4.1.2 Hydropower planning and development principles

Hydropower development is a systematic and comprehensive undertaking involving many issues. There are numerous structural styles, such as dam-rear and volute type, with each style possessing its own advantages and disadvantages. The selection type depends on local geological conditions, hydrology conditions, weather conditions and available financing. A selection is made following a comprehensive study by experts, careful calculation and complex measurements and comparisons that aim to guarantee safety. Safety and the avoidance of unnecessary hazards is the primary consideration which the style selection is based upon. Furthermore, the regular efficiency of the hydropower plant is thus guaranteed. In addition to the primary goal of normal generation, other aspects such as flood control, irrigation, ecological landscape, transportation and local livelihoods are all taken into account and incorporated during hydropower development.

a. Combine generation with flood control. During hydropower development, hydropower station construction may easily lead to flood drainage issues which can endanger the daily livelihoods of local inhabitants, including their lives, property, and safety. For this reason, it is important to effectively combine generation with flood control during hydropower development.

b. Combine generation with irrigation. Currently, farmers account for a high proportion of China’s total population. Even now the majority of crop irrigation relies on nearby rivers. Hence, observing regular river irrigation functions during hydropower development, to some extent, ensures protection of farmers’ rights and interests, a crucial aspect to hydropower development. In order to successfully combine both generation and irrigation requirements it is necessary to execute adequate consideration for distribution of generation hydropower and irrigation hydropower during the design stage, or to build some equipment to separate the generation area from the irrigation area. In conclusion, the chief principle in developing hydropower is to ensure sufficient irrigation that is people-oriented.

c. Combine generation with preservation of ecological landscape. Some areas excessively pursue economic benefits and energy generation during development while ignoring preservation of the local ecology. However, impact on the ecological environment is permanent and may be caused by hydropower development. For example, the rock excavation required during construction of the hydropower station destroys the soil structure. Of great concern is the increased possibility for earthquakes. During station generation, impounding is required but will flood a large quantity of lands, in particular cultivated land, thus converting the land’s geography into a river or wetland, and consequently affecting local climatic conditions. At the same time, the growth and reproduction of animals and plants will change, to the extent that some may become extinct. After impounding for the hydropower station, the previously flowing water body will then become static and the exchange speed between water and external water and the capacity for pollutant disposal will decline.

Hence, fish living in the body of water will be affected.

d. Combine generation with shipping. Regular transportation operations shall be guaranteed during construction of the station to ensure cargo transportation. For this purpose, the construction program shall be carefully considered when designed. When the hydropower of medium and small rivers is developed, measures should be adopted to ensure access to trasportation. Meanwhile, it is of equal importance to maintain stable social conditions both for migrant workers and local residents.

4.1.3 World hydropower prospects

At the 2015 World Hydropower Congress held in Beijing the World Energy Council published the Report on the Upsurge of Developing Hydropower, stating that the energy quantity provided through global hydropower will double by 2050. The hydropower markets with the most potential include China, India, Brazil and southeast Asia. Data shows that existing hydropower comprises as much as 76% of the world’s renewable energy. According to the forecasted growth, the energy quantity in the markets will be 2,000 GW in 2050. If governments and multilateral banks can take more measures targeted at the hydropower sector, the goal may be realized prior to 2050. Water plays a vital role in energy production for various capacities. For example, thermal power generation from coal power and nuclear power require water to cool down production equipment. By contrast, hydropower production consumes less water. Future prospects for hydropower markets depend on the strength of transnational trade, government policies and market measures. Although some governments and multilateral banks have begun to support and encourage hydropower cooperation among neighboring countries, the market needs more progressive developments.

4.2 China’s small hydropower development status and trend

4.2.1 Development status of China’s small hydropower resources

The generation capacity of hydropower resources in China’s rural areas is 153 million kW, of which 128 million kW comes from small hydropower resources at or below 50,000 kW. Small hydropower resources cover a broad area expanding over 1,700 mountainous counties in 30 provinces (districts, cities) except Shanghai, and predominantly located in central, western and eastern mountainous regions. About 70% is concentrated in the Western Development Region. At present, 90,000,000 to 100,000,000 kW of hydropower resources in rural areas have not been developed. The annual generated energy is 300 billion to 400 billion kWh. The power energy volume is equivalent to five Three Gorges Projects (TGP) and benefits millions of farmers in poor mountainous areas. By the end of 2011, 45,000 small hydropower stations had been built, with an installed capacity of over 62,000,000 kW, harmoniously producing economic, social and environmental benefits.

During hydropower development, the river flow is effectively regulated through construction of a dam and reservoir that enable flood control by cutting down peak discharge. In addition to generation and flood control, hydropower engineering integrates comprehensive functions such as water supply, irrigation, cultivation and shipping. Proper site selection and planning, optimum design and high quality construction are integral to the sustainable development of the ecological environment, economy and society.

The total installed capacity of China’s small hydropower has increased from 1,000 MW (1GW) in 1970 to 10GW in 1989 and 58GW in 2010, accounting for nearly 30% of total hydropower, a scale exceeding two TGPs. Currently, the annual energy output of China’s small hydropower has reached 160G kWh, most of which has been incorporated into the state grid. Small hydropower now plays a significant role in China’s power production.

According to plans by the Chinese government, by 2020 small hydropower will be available to nearly 100 million people, resulting in an increase of installed capacity to 170GW. Another project underway seeks to supply power to “regions with water but no power” via small hydropower. China’s experience with energy production indicates that in remote areas not connected to the power grid, lacking transmission facilities and with low load density levels, small hydropower is most suitable for the dispersed population. For this reason small hydropower has been developed quickly.

Although energy generated from small hydropower totals that of other renewable energies combined, there remains a vast untapped potential.

4.2.2 Experience and trend of developing small hydropower in China

China's experience with developing small hydropower is based on several important tenets. a. Respect people's innovative abilities, and utilize the experience and practices of communities and local governments to carry out national policies. Small hydropower is an effective channel for power supply of remote rural areas, adopting preferential policies such as "independent construction, management and use" to safeguard and advance the power supply of these areas.

b. Another important tenet seeks to adhere to the needs of agriculture, rural communities and farmers. Small hydropower development clearly boosts rural economies and society. Since various governments consider hydropower resource development and small hydropower construction as key to local economic development, profits generated from small hydropower taxation account for a large proportion of local financial revenues, up to half in some counties. By developing and building small hydropower, thousands of medium and small rivers have been controlled, reservoir capacity increased, irrigation areas enlarged, and overall flood control and drought resistance ability improved. Moreover, it has improved local infrastructure, expanded the collective economy, and advanced public welfare services. As a result, previously closed off mountain villages now have access to electricity, water and roads. The popularization of rural science and technology has influenced farmers'mental attitudes. Funds from power construction have benefited the culture, education, communication, medical treatment, social security and other public welfare services in many villages.

c. Explore the effective integration of small hydropower development with ecological conservation. In order to protect the ecological environment and convert agricultural lands to forests, the Chinese government has launched the environmental protection project titled "Small Hydropower Replacing Fuel". Through government support, small hydropower is offered to farmers at a low price with the objective to supply their fuel needs. In this manner farmers cease to cut trees for firewood, thus preserving mountain vegetation. This project has decreased manual labor, boosted rural economies, protected local ecosystems, enabled mountain villagers to end a culture of deforestation, avoid the smog caused by burning firewood, and enter the modern era. Hence, a new path integrating the development of small hydropower with ecological protection has been discovered.

d. Establish an advanced technical service system for small hydropower. China has always made use of scientific planning to effectively carry out small hydropower development, electricity construction, small–hydropower-replacing-fuel project, comprehensive utilization of rivers, and construction of regional power generating facilities and power grids, as well as promotion of rural economic and social development. In this way, it gradually established a thorough technical standard system for planning, design, construction, installation, testing, operation and equipment manufacturing of small hydropower, thus providing comprehensive technical support and service for its development. Up to now, over 100 scientific research institutions, 1,000 design and construction companies and 500 small hydropower equipment enterprises in China provide small hydropower products and services, and have received international recognition.

4.3 China's small hydropower current status and trends

Reflecting on China's small hydro development over the last century, important milestones include rural electrification and construction programs, and the replacement of fuels such as firewood with clean energy. Implemented by the state and carried out through extensive efforts by small hydropower workers, small hydropower has developed from a position in which it was considered inferior in production capacity into a large-scale and high-quality renewable energy. Small hydropower is distinct from traditional hydropower, and integrates social, environmental, and economic benefits through the application of advanced modern science and technology. China's small hydropower provides a model for sustainable development within the international power industry.

4.3.1 Current status of China's small hydropower industry

During China's small hydropower construction, it was initially launched with the purpose of supplying electricity to rural areas and in conjunction with rural small hydropower engineering. Its development is now large-scale, with annual production exceeding thousands of megawatts in the last ten years. Over the decades, its steadfast development is regarded a miracle in the world's hydropower history, thus attracting the interest of relevant United Nations departments. It is regarded a paragon among developing countries in independently solving energy problems and accelerating local social development.

Small hydropower is a regionally centralized industry. China's small hydropower development is primarily concentrated in 20 provinces and cities, of which Guangdong, Sichuan, Fujian, Yunnan, Hunan and Zhejiang account for 60% of installed capacity. These examples illustrate local resource advantages and the pivotal role of local governments in small hydropower development.

In addition to a rapid increase in scale, China has created a unique management system for small hydropower, composed of three operation methods: 1) directly incorporate into the state grid as in eastern regions; 2) local grid construction as in central and western regions; 3) isolated small grid with its own power supply area. Furthermore, both small hydropower stations constructed by local governments for public welfare purposes, as well as profitable independent small hydropower plants with group and individual investors have appeared. China's small hydropower stations are classified according to installation scale (see Table 1-9). The micro, mini and small hydropower stations in the table refer to stations in 2001 with installed capacity below 100kW, between 101kW - 500kW and 501kW - 25000kW, respectively.

Table 1-9 Classification of China's Small Hydropower Stations as per Installed Capacity

Type		Micro	Mini	Small	Total
Power station	Number	18944	19606	4427	43027

	%	44.0	45.6	10.4	100
Installed capacity	MW	687	7171	18404	26262
	%	2.6	27.3	70.1	100
Annual energy output	GW·h	1860	20245	65036	87141
	%	2.1	23.2	74.6	100

Moreover, small hydropower development enables expansion of China's local grid, boosts the power structure of the supply area, and guarantees continuous growth of rural industries and rural households. Electrification rates in towns, villages and households within hydropower supply areas has increased from 91.8%, 78.1% and 65.3% in 1985 to 99.57%, 99.48% and 98.85% in 2004, respectively, providing power to nearly 300 million people in rural areas. The significant change indicates that small hydropower is playing an increasingly important role in rural social and economic development and environmental conservation. It is not only a technology and tool for addressing rural energy issues, but also a novel industry that emphasizes equal importance of social, economic and environmental benefits, and strongly supports the development of rural areas.

Throughout China's small hydropower history, several factors supported its rapid development, but three main reasons cannot be ignored. ① Government support: The state, in order to encourage the development of small hydropower, has enacted a bundle of preferential policies, including property rights and low taxes. This funding has largely driven social capital investments in small hydropower. During the "Ninth Five-year Plan", the central government provided RMB 1,350,000,000 ¥ in subsidies to rural hydropower. As a result, capital investments in rural hydropower construction totalled RMB 42,010,000,000 ¥. ② Development of the hydropower equipment manufacturing industry has produced local suppliers of small hydropower equipment, decreased construction costs and increased local construction capacities. For example, in the 1970s China required 200,000 - 300,000 kW of hydropower equipment per year. However, manufacturing capacity was limited to 100,000 kW, creating situations where plants lacked equipment. Through independent efforts, the annual output of small hydropower equipment in recent years has increased to 4500 - 5000 MW. The design, manufacturing technology, and performance of large-capacity hydropower units has approached international standards, and the products, quality and price for medium and small-capacity units not only meet domestic needs but moreover are exported overseas. ③ Compared with large-capacity power stations, small hydropower possesses unique features and advantages. Small hydropower requires lower technical standards, simpler engineering, shorter construction period, small capital construction costs, minimal inundation damage, and minimal overall impact on local inhabitants, the environment and ecology. In addition, since small hydropower is located near end-users, the equipment for electric power transmission and transformation is simpler, and there is less circuit transmission loss. Most small hydropower has its own grid and power supply area, and often connects to a point on the large grid to fully utilize the seasonal electric energy and mutually complement and regulate each other, further turning small hydropower into sustainable rural energy. For installed capacity and generated energy increase of China's small hydropower and its proportion to total hydropower, please refer to Fig.1-14.

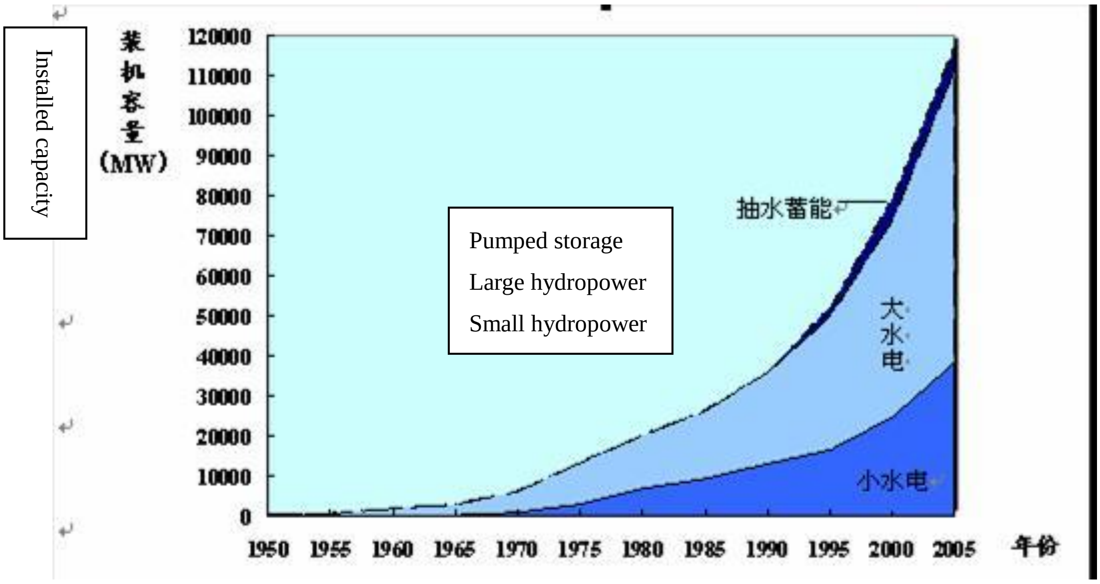


Fig.1-14 Graph of Hydropower Installed Capacity

The vital functions of China's small hydropower currently are reflected as follows:

a. Display the superiority of small hydropower, and implement distributed rural electrification. The Chinese government has always attached importance to small hydropower's role in social sustainable development. For this reason, the State Council has resolved to construct 400 rural hydropower counties with the highest standards. Funds were allocated by the central government during the "Tenth Five-year Plan", and it is based on the experience of 652 rural electrification counties where power is supplied primarily by small hydropower to meet local energy and livelihood needs.

b. Implement village electrification programs, thus transforming the impoverished condition of remote areas. According to the national census, China's population lacking power is largely concentrated in Sichuan, Qinghai, Xinjiang and Tibet. By the end of 2000, there were still 16,509 un-electrified villages and about 28 million people without access to electricity. The program is a rural energy and environmental conservation project aimed at western poverty-stricken areas without electricity. It focuses on development of small hydropower through the integrated management of mountains, water, forestry and roads, development of the economy, and protection of the rural environment, thus facilitating the social, economic and environmental development in poor mountainous area.

c. Protect the ecological environment, implement small-hydropower-replacing-fuel project, and advance the construction of sustainable energy in remote areas. According to survey results, one household with an average of four people will require about 2000-3500 kg of firewood every year just for cooking, boiling and heating, an astonishing consumption that produces significant ecological problems in the region. By contrast, when cheap small hydropower is made available for cooking and heating, forest coverage rates consequently increase, water sources are conserved, thus reducing water and soil run off. As a result, the state has enforced the "Small Hydropower Replacing Firewood" project to boost overall social and economic development locally.

d. Adapt to the strategic transformation of international hydropower development, and vigorously build small hydropower plants in all kinds of economic conditions. Small hydropower is a high-quality electricity source that represents the newest phase and direction of development within the power industry. Given multiple resources and wide distribution, local economies can be developed by building a large number of independent small hydropower plants owned by investors. Meanwhile, it can break through the power monopoly; improve upon traditional large units within the power industry; integrate its operation to include generation, transmission, distribution and supply of long high-voltage transmission circuits; and gradually develop a new distributed supply model for self-consumption, with extra capacity for the Internet. Thus, it synergizes benefits, and achieves the best allocation of resources. As a result, in comparison to alternative options it is an adequate option for facilitating sustainable social development and providing a clean development mechanism.

e. Carry out the Going out Policy for small hydropower, and actively participate in international competition. During the past decades, China has experienced considerable development in designing, constructing and manufacturing small hydropower equipment. At present, verified electrification counties are all able to independently design, construct and install power stations with capacity below 15 MW and 35 KV power transmission projects. Several have even independently built 50 kW small hydropower stations and 110 KV power transmission projects. There are approximately 660,000 employees in the small hydropower industry, including 300,000 technicians and rural electricians capable of completing all ranges of small hydropower engineering. Over eighty major equipment manufacturers in China produce a wide variety of small hydropower equipment. Hence, China is competent in carrying out all scales of small hydropower projects abroad. In implementing the Going out Policy, successful construction of small hydropower projects can create economic benefits and exert a favorable influence on the host country, as well as help to develop close Sino-foreign relationships.

f. Drive and participate in the reform of the power system. Due to historical reasons, large-scale electricity and the main grid have been constructed by the state while small power grids are established locally, each type with its respective power supply area. This divided supply management system requires many problems to be addressed in the reform. On the one hand, the small hydropower industry, as the main force of anti-monopoly, should facilitate the change in government functions so as to end the industry's tight control over the market; break enterprise monopoly; change the vertically integrated business practice of power companies; form a new mechanism with consumers as the main market players; and promote market-oriented trading practices and prices that mutually develop both the power industry and society. On the other hand, as the target for reform, it should extensively research the differences between centralized power supply enterprises with large plants and grids and rural power enterprises with small and distributed power supply; research the impact of separation of plant and grid and the impact on rural power systems supplied by multiple rural hydropower stations resulting from the cancellation of licensed power supply area. In this manner, the small hydropower industry may be substantially developed in the reform.

g. Innovate the small hydropower industry. Small hydropower has entered a new phase that requires the development of new industrial concepts. For example, the focus of local small hydropower enterprises on public welfare and environmental protection is a unique non-profit model. In rural power supply, small hydropower provides clear social and environmental benefits irreplaceable by commercial supply, and quite different from the power plants owned by private investors. The integrated management of mountains, water, forests and roads, and the protection of rural environments, boosts social stability and economic development. Since enterprises have not received compensation for the extensive social and environmental benefits produced by local small hydropower, they are thus non-profit. Legislation should be enacted to provide these small hydropower enterprises a special non-profit status within the power market.

The primary objective of China's small hydropower industry is to establish three categories of power markets: a local service-oriented rural power market; a competitive power market within the traditional power system; and a distributed power market owned by the users. Through industry innovation, it can determine the internal mechanism required by sustainable development of small hydropower, and bolster external relations between small hydropower and its supply area and the large grid. In accordance with the strategic shift in hydropower development, combine the sustainable developments of small hydropower and society so as to develop a sustainable energy policy.

4.3.2 Future outlook of China's small hydropower industry

Currently, the world's power industry is transforming from demand type and focused on meeting power shortages into a clean and high-quality energy targeted at sustainable social development. Meanwhile, it has transferred from developed countries to developing countries, in particular China. Since soil, flowing water, vegetation, organisms, the climate and human activities are impacted by large hydropower projects, and often lack necessary safeguard procedures and environmental measures, the proportion of large hydropower in total installed world power capacity is decreasing year on year. Moreover, the United States and European Union have declared that hydropower above 15 MW shall not be classified a renewable energy. Thus, the focus of hydropower development has turned from large to small hydropower, initiating a new phase for international small hydropower. In addition, following the deepening of the power system reform, and in consideration of the implemented Kyoto Protocol, new development, management, and clean development mechanisms for power are taking shape. Small independent power plants owned by investors are on the rise. The advent of concept and operation models for distributed power supply has significantly changed the definition of small hydropower and its status in the power industry. This trend provides a favorable environment for the innovation of the small hydropower industry.

a. New impetus for developing small hydropower. For the past several years, environmental conservation has attracted global attention, and emphasis placed on the exploitation of renewable energy. For the purpose of encouraging the utilization of renewable energy, many countries have provided support for electricity generation from renewable energies. Public concern for sustainable social development has largely driven small hydropower.

b. The context within which small hydropower is developed and reformed has significantly changed. Reforms in the power industry such as anti-monopoly policies and deregulation have offered advantageous opportunities for small hydropower. The primary beneficiaries of this reform are consumers and the power industry. Moreover, technical progress based on promoting and applying information technology (IT) and automated equipment enables the infrastructure to overcome limitations and the provision of specialized high-quality services that meet individual consumer needs. Maintenance service costs for power enterprises can therefore be drastically reduced. For example, automated technology facilitates the operation and management (O&M) of power plants, thus promoting a greater focus on the reform and development of rural power and the acceleration of small hydropower O&M innovation.

c. Existing problems within small hydropower development have already garnered attention. Several questions have been posed, for example: 1) How to distinguish commercial enterprises with a centralized supply from rural power enterprises with small and distributed supply? 2) Is it possible to regard small hydropower enterprises as non-profit organizations as done in other countries? 3) As part of the power system reform, power suppliers can choose users and users have the ability to choose suppliers. Can users within the small hydropower supply area, hydropower plants and rural power supply stations be organized to establish their own local power companies as prescribed in the American Bill of Rights for Power Users? 4) What is the impact on rural power systems supplied by multiple rural hydropower stations resulting from the cancellation of a licensed power supply area and separation of power plants and networks? 5) How can the power supply market and local grid be developed to integrate generation, supply and utilization in a small hydropower supply area? 6) How can China, as a member of the World Trade Organization (WTO), align to international standards, end industrial monopoly, and more effectively develop high-quality small hydropower through renewable energy legislation? These are issues gathered from practical experience and of public concern, and have greatly changed the external context of small hydropower.

5 Experience in Development of Biomass Energy Technology

Biomass energy is solar energy stored in the biomass in the form of chemical energy. It is a form of energy carried by biomass. As defined in the Renewable Energy Law of China, biomass energy refers to the energy source converted from plants in the natural world, excrements, as well as urban and rural organic waste. Biomass energy is an important renewable energy resource with promising exploitation and utilization. Biomass energy features renewable, clean and low-carbon, advantage of substitution, and abundant raw materials. Biomass energy utilization technologies include direct combustion, biomass gasification, liquid biofuel, methane, and biomass electricity generation, etc.

5.1 Combustion

Biomass combustion is the traditional form of energy conversion, and one of the currently most mature, most convenient, and most feasible ways of various applications and conversion of biomass. Its extended application will play an important role in promoting the development of biomass utilization technologies in China, protecting the environment and improving the ecology, and improving the farmers' living standard. Biomass combustion technologies are classified into direct combustion and compacting combustion.

5.1.1 Direct Combustion

Direct combustion of biomass refers to pure combustion of biomass. It is an ancient way of energy utilization, mainly classified into stove/hearth combustion and boiler combustion. The study of direct combustion technology focuses on the design of dedicated combustion equipment. With the traditional stove/hearth combustion, the combustion efficiency is very low, and the thermal efficiency is only 10%~18%. In the early 1980s, the agriculture, animal husbandry and fishery authorities of China began to promote the technology of firewood/coal-saving stove/hearth/kang (a heatable brick bed in North China) in the rural areas across the country in order to solve the problems such as shortage of firewood, low energy utilization rate, and severe waste. At present, there have been 187 million firewood/coal-saving hearths, 20.50 million energy-saving kang, and 33.42 million energy-saving stoves throughout China, which have benefited 500 million farmers directly. The promotion of firewood/coal-saving stove/hearth/kang technology has created huge comprehensive benefits, very popular among the farmers, and well received nationally and internationally. Along with the development of rural economy and the constant improvement of farmers' living standard, farmers will necessarily pose higher requirements for their housing and indoor environment. Through standardized design and industrialized production, new stove/hearth/kang products that are diversified, nice to look, energy saving and low-carbon, clean and healthful will become a new trend of upgrading and updating of firewood/coal-saving stove/hearth/kang in the future.

5.1.2 Biomass Briquette Combustion

Biomass briquetting is a technology to compress various biomass into briquette feedstuff or fuel in the shapes of rod, block or particle with greater density at certain temperature and pressure. Briquette fuel can substitute coal and fuel gas for cooking and heating purposes as a household fuel, and for industrial heating and electricity generation purposes, etc.

Since the 1980s, China has been carrying out R&D of biomass briquetting combustion technology, overcoming technological difficulties on the one hand, and introducing foreign advanced types of machine on the other hand, developing various types of biomass briquetting machines suitable to the situation of China upon digestion and absorption, which are used for producing biomass briquette in the shapes of rod, block or particle. Now a series of achievements and progress have been made. Of which, the preheating hydraulic briquetting technology and roller-die particle forming technology have been becoming mature, and market-oriented operation has been initiated. Various associated equipment and technologies as well as applicable stoves/hearths have been well developed. It is estimated that there are some 1000 sets of biomass briquetting equipment that have been put into use, which produce less than 100,000t biomass briquette per year. However, relevant technologies are still lagging behind foreign counterparts. To develop efficient and economical biomass briquette combustion technologies possessing our proprietary intellectual property rights is an important trend of future development in China.

5.2 Liquid Biofuel

Liquid biofuel refers to fuel ethanol and biodiesel produced from biomass resources.

5.2.1 Fuel Ethanol

In order to drive the development of rural economy, consume the surplus aged grain, mitigate the shortage of fuel and ease the pollution of fossil energy to the atmosphere, China introduced the fuel ethanol program in 2000. In March 2002, China issued the Plan for Pilot Use of Ethanol Gasoline for Motor Vehicles, and the Implementation Rules for Pilot Use of Ethanol Gasoline for Motor Vehicles, defining the scope and manner of pilot, establishing the policies and basic principles in respect of finance, tax and price in the pilot period, offering preferential and subsidy-based financial and pricing policies. At the same time, China imposes rigid control over the development scale and scope of fuel ethanol. The pilot production project of biofuel ethanol is strictly limited to four designated companies, i.e. Jilin Fuel Ethanol Company, Henan Tianguan Fuel Ethanol Company, Anhui Fengyuan Biochemistry Co., Ltd. (now the COFCO Biochemistry Co., Ltd.), and Heilongjiang Zhaodong Huarun Alcohol Company (now the COFCO Biochemical Energy (Zhaodong) Co., Ltd.). To avoid vicious competition, the government has delineated the scope of sales. With the guarantee of raw materials of aged grain and policy support and orderly control from the government, fuel ethanol experienced rapid development at the early stage and witnessed a strong momentum, with its total capacity reaching 1.02 million tons.

Along with the consumption of aged grain, and for food security, China National Development and Reform Commission issued the Notice on Strengthening the Management of Biofuel Ethanol Project Construction and Promoting the Sound Development of Industry, and the Urgent Notice on Suspension of Maize Processing Projects in December 2006, expressly suggesting to drive the development of biofuel mainly by using non-grain materials. In June 2007, the State Council convoked the renewable energy conference, at which the maize-to-ethanol projects were called off formally, the development of non-grain ethanol was required to follow the principle of "not occupying any arable land, not consuming any grain, not destroying the ecological environment". In August of the same year, China issued the Medium- and Long-term Development Planning for Renewable Energy, requiring no increase in the production capacity of fuel ethanol using grain as raw materials, but reasonably using non-grain biomass materials to produce fuel ethanol. The development focus should be put on the technologies of fuel ethanol using cassava, sweet potato, sweet sorghum as raw materials; in the long run, technologies of bio-liquid fuel using cellulosic biomass as raw materials should be development positively. Fuel ethanol manufacturers began to develop new raw materials and production processes, expand or transform their equipment, increase the production capacity of potato ethanol; and work with research institutes in the research of cellulosic ethanol production process. In 2008, Guangxi COFCO Biomass Energy Co., Ltd., who used cassava as the main raw material, put its equipment into production. After 2011, ZTE Energy (Inner Mongolia) Co., Ltd. and Shandong Longli Biotech Co., Ltd. were approved to produce fuel ethanol. These 7 companies were responsible for the supply of all fuel ethanol required for the closed operation in 6 provinces and autonomous regions, i.e. Heilongjiang, Jilin, Liaoning, Henan, Anhui and Guangxi, along with 30 prefecture-level cities in Hubei, Hebei, Shandong, Jiangsu, Inner Mongolia. In 2013, China produced 2.217 million tons of fuel, becoming the third largest biofuel ethanol producer and consumer next to Brazil and US. In 2013-2014, China approved another 4 companies to produce fuel ethanol, which are in the phase of construction. So far, the total capacity of completed fuel ethanol equipment and those being constructed upon approval is 3.1 million tons/year, 53.2% of which as grain-based fuel ethanol, 45.2% as cassava- and sweet sorghum stalks-based fuel ethanol, and 1.6% as cellulosic ethanol.

5.2.2 Biodiesel

Biodiesel industry started late, in the 10th Five-Year Plan Period, in China, when some private companies used waste grease to produce biodiesel in a traditional chemical method. In 2001, China's first biodiesel plant funded by Hainan Zhenghe Bioenergy Co., Ltd. was put into production in Wu'an, Hebei Province, which symbolized China's biodiesel began to step into the process of industrialization process. In 2004, the Ministry of Science and Technology launched the national research program, "Biofuel Oil Technology Development" project for the 10th Five-Year Planning, and incorporated biodiesel related research tasks. Since then, China's biodiesel industry has seen its accelerated development. A large group of companies proactively built biodiesel projects with a capacity of thousands of tons per year. In 2007, China introduced its first national standard, Biodiesel Blend Stock (B100) for Diesel Engine Fuel, and the Standard for Biodiesel Fuel Blends (B5) in 2010. Since their introduction, the two standards were revised in 2011 and 2012 respectively to include more technical indicators and approximate the US or European standards stepwise. They have facilitated the sound development of biodiesel industry while regulating the biodiesel market in China.

The raw material of grease is one of the important factors restricting the development of biodiesel in China. Over the recent three years, benefiting from China's severe punishment for reuse of swill-cooked dirty oil and intensified supervision of waste oil recovery, China's biodiesel yield has increased significantly. The figure increased 5% from 2013 to 1.13 billion liters in 2014. Now, there are totally 53 plants producing biodiesel in China, with a capacity at 4 billion liters approximately. However, their capacity utilization rate has been at a lower level of less than 28%, which was caused by shortage of raw materials of grease and limited product marketability. Currently, China has not forcibly incorporated the biodiesel into the marketing system of finished oil. Therefore, the prosperous development of biodiesel industry in China still needs further improved and intensified supervision and support from the country.

5.3 Biogas

Biogas is a kind of combustible gas converted from biomass energy. It is a kind of combustible gas generated from various organic substances upon fermentation in the absence of air and at a suitable temperature and humidity. Mainly containing methane which is similar to natural gas, biogas is an ideal gaseous fuel.

Biogas digester comes in two types in terms of its size and application. One is called household biogas digester used for the purpose of generating biological energy. Such engineering and process is called household marsh gas. Such biogas digester is classified into 6 m3, 8 m3, and 10 m3 forms by national standards. They have a simple and applicable structure; there's also another type of biogas digester is a simple enlargement of household biogas pit, in the size of 10 m3-50 m3, mainly used in rural breeding industry, using fecal sewage to make marsh gas, called small-sized household biogas pit, also a kind of household biogas pit. The other type is called medium- and large-sized biogas digester or anaerobic treatment engineering, used for the purpose of treating medium- and high-concentration organic wastewater and degrading COD and BOD, with biogas as the byproduct in this process. As a product of the development of modern environmental engineering and biotech, such type of biogas digester is now widely applied in organic wastewater treatment, especially playing a unique role in wastewater treatment in food and chemical industry and agriculture. Generally with a capacity of 50m3 over, they have different structures, design methods and strength principles.

China is a country where more biogas has been developed. Initially, rural household biogas pits were developed mainly to solve the problems of crop stalk incineration and shortage of fuel supply; subsequently, the creation of medium- and large-sized wastewater, breeding industry slops, biomass waste in villages and towns, and biogas of municipal waste widened the scope of biogas production and application. Since the 1980s, the established technology of comprehensive utilization of biogas fermentation has been using biogas to create an efficient agriculture model allowing multi-level utilization of substances and reasonable flow of energy, and has gradually become an effective way for promoting the sustainable development in rural areas of China by using the biogas technology. With the technology of comprehensive utilization of biogas fermentation, the biogas is used as energy for farmers' living and used for the production and processing of agricultural and sideline products. The biogas slurry is used for the production of feedstuff, biopesticide, and culture compost liquid. The integrated biogas eco-agriculture model of plastic greenhouse, biogas digester, livestock and poultry house, and toilet popularized in the northern part of China, the biogas-based eco-orchard model in the middle part of China, the "pig-orchard" model in the southern part of China, and such models as "breeding-biogas", "pig-biogas-fish", "grass-cattle-biogas" in other parts of China are all agriculture-led and biogas-based eco-agriculture models allowing multi-level utilization of biogas, biogas slurry, and biogas residue.

5.3.1 History of Biogas Development in China

China's biogas utilization and development went through several important phases:

1) The period of non-government spontaneous biogas utilization and promotion campaign (1929-1942), also the first biogas promotion.

2) The "biogas" campaign period after liberation, which saw the second (1957-1961) and third (1967-1979) biogas promotion. The biogas development in this period was politically affected, with insufficient emphasis on science and technology, no management, shortage of funds and building materials, and poor effect of biogas application. Then, affected by the "Cultural Revolution", numerous biogas pits were scrapped for various reasons in the late 1970s.

3) The "Summarization and Demonstration" period (1978-1990). In this period which was dominated by economic development, the New Energy Group of National Science and Technology Commission was established. Rural energy drew the

attention of governments and the public. China's rural biogas projects were on a track of scientific guidance and positive and steady development. In 1979, the State Council established the National Leading Group for Biogas Projects, seriously summarizing the experience and lessons in biogas projects. In 1988, China Biogas Society was established to organize more than 1700 biogas technology staff to collaboratively tackle the key technology for biogas. In the 6th Five-Year Plan period, China decided to arrange subsidized loans of RMB 40 million every year to support rural biogas projects. In 1983, rural energy was included in the 7th Five-Year Plan and the international planning for development of science and technology in the 1990s. In 1984, 5 national standards on rural energy were released, including the atlas of rural household hydraulic biogas pits. In 1990, a total of 4.7663 million rural households become biogas users in China, when the annual biogas yield was 1.042 billion m3.

4) The period of "100-county integrated construction of rural energy" and "ecological home" construction

From 1991 which represented the beginning of the 8th Five-Year Plan period, China's biogas began to develop in a scientific and correct way. The biogas development in this period fell into 3 steps. Step 1 (1991-1995), the "100-county integrated construction of rural energy" was launched. Totally, 109 State-level counties and 32 provincial-level counties for integrated construction of rural energy were included in the project. For State-level projects, the Central government appropriated RMB 3.15 million to each county every year, which was shared at the ratio of 1:1:2 among the province, prefecture and county. The funds were mainly used for technical guidance, training, pilot and demonstration, and daily management, etc. In 1995, there were 5.69 million owners of agricultural biogas digester. Step 2 (1996-2000), the "100-county integrated construction of rural energy" was further implemented. In this period, China's biogas projects, as an important part of the integrated construction of rural energy, kept stable development. Not only rural household biogas digesters developed further, but also medium- and large-sized biogas projects were initiated. In 10 years from 1990 to 2000, there were 8 million new rural users of household biogas digester. And a group of excellent models emerged, including the “4-in-1” model (integration of plastic greenhouse, biogas digester, livestock and poultry house, and toilet) in the northern part of China, the “pig-biogas-orchard” model in the southern part of China, and the “5-in-1” model (integration of biogas digester, solar heating sheepfold, water cellar, sanitary toilet, and water-saving orchard) in Hanyuan, Weibei, Shaanxi province. Step 3 (2000-), the “Program of Enriching People through Eco-home” was implemented in the western part of China. As the biogas technology had been well implemented in the eastern and developed areas of China, the demonstration of the program “enriching people through eco-home” was launched for 10 villages in 7 western provinces including Shaanxi, Gansu, Ningxia, Qinghai, Sichuan, Guizhou and Yunnan. By the end of the same year, 76 demonstration villages were deployed across the country. Subsequently, the “Program of Enriching People through Eco-home” was implemented successively, which received RMB 3.4 billion from the Central government, and benefited 3.75 million farmers. In the project area, the objective of “warm and clean home furnishing, efficient courtyard economy, and harmless agricultural production” has been achieved. By 2004, China had 15 million household biogas users, and produced about 5.6 billion m3 on annual basis, equivalent to 4 million tons of standard coal. Farmers’ life quality has been improved.

5.3.2 Current Situation of Biogas in China

In recent years, more importance has been attached to other functions of biogas. The technology of comprehensive utilization of biogas fermentation is the current trend of biogas development. The biogas-based efficient agriculture model allowing multi-level utilization of substances and reasonable flow of energy has gradually become an effective way for promoting the sustainable development in rural areas of China by using the biogas technology. With the technology of comprehensive utilization of biogas fermentation, the biogas is used as energy for farmers’ living and used for the production and processing of agricultural and sideline products. The biogas slurry is used for the production of fertilizer. The integrated biogas eco-agriculture model of plastic greenhouse, biogas digester, livestock and poultry house, and toilet popularized in the northern part of China, the biogas-based eco-orchard model in the middle part of China, the “pig-orchard” model in the southern part of China, and such models as “breeding-biogas”, “pig-biogas-fish”, “grass-cattle-biogas” in other parts of China are all agriculture-led and biogas-based eco-agriculture models allowing multi-level utilization of biogas, biogas slurry, and biogas residue.

China’s biogas industry has undergone more than 80 years of research and production application. China-style biogas technologies have become mature stepwise. In terms of biogas digester types, China has developed a series of standard biogas digester types adaptable to different climate, raw materials and service conditions. In general, there are 4 basic types, i.e. hydraulic biogas digester, floating-cover biogas digester, semi-plastic biogas digester, and tank-type biogas digester. On this basis, professional technicians of China have improved the household biogas digester according to different operating requirements, and conditions such as temperature. In terms of biogas digester construction, the concrete cast-in-situ construction technique is widely adopted now. The biogas digester steel mould and wood mould pouring technology is developing. Assembled biogas digester is also being developed proactively. Currently, fiberglass single biogas digesters will have the best market prospect upon developed and commercialized. They have changed the construction concept of biogas digester, and can be purchased and directly used by farmers. In terms of daily management and biogas digester maintenance, various convenient and practical feeding and discharging devices and tools have been developed. High-flow feeding and discharging has been evolved to feeding at any time, automatic and semi-automatic discharging, which has made the use and management of biogas simpler and easier.

According to incomplete statistics of authorities, by the end of 2010, there had been 73,032 small-, medium-, and large-sized biogas projects, including 4963 large-sized, 22795 medium-sized, and 45259 small-sized biogas projects; there were already-existing 191600 biogas projects for treatment of domestic sewage, and 38.5 million rural families of household biogas digester. Nearly 150 million people of 40 million households were benefited.

In the process of biogas development in China, there have been also many problems. 1) The management skill needs to improve further. Though China has established the rural biogas management and promotion system at all levels from the Central to local levels, poor management still exists during the actual promotion as the biogas development takes place mainly in rural areas. Especially, emphasis is put on the biogas digester construction, but no emphasis on the post-construction management and maintenance. In some areas, in order to fulfill the planned tasks of biogas construction, great efforts were made in the early-stage construction. But there were no necessary measures for management and maintenance after construction. In the event of malfunction, some biogas digesters cannot be repaired without delay. In rural areas, most young and strong labors go out as migrant workers. It is hard for the women, children, the sick and the elderly who stay at home to manage the biogas digesters. The service system needs to be improved further. 2) The supply of raw materials is unstable. Biogas fermentation needs raw materials with reasonable C/N ratio. According to the current situation in rural areas of China, human excreta in the toilet and pig excrements are generally considered as good raw materials. But along with the development of large-scale breeding industry, numerous rural families are not engaged in breeding industry any longer, or decrease the quantity of livestock they raise. Biogas digesters traditionally using excrements as raw materials face insufficient supply of raw materials. Farmers often add a large amount of rice straw to their biogas digesters, making them blocked and not generate gas, thus affecting the promotion and use of biogas digester. 3) The comparative benefit of biogas development is low. Currently, more and more farmers use induction cookers and LPG, which are more convenient than biogas. As biogas digesters involve higher lump-sum investment and higher cost of construction, and need subsequent maintenance, some farmers consider it is not cost-effective to invest in and construct a biogas digester.

5.4 Biomass Power Generation Technology

Biomass power generation technology is a technology converting biomass energy to electric energy, mainly including agricultural and forestry waste power generation, garbage power generation, and biogas power generation, etc. Since 2003, China has approved three crop stalk power generation projects in Jinzhou of Hebei Province, Shanxian County of Shandong Province, and Rudong of Jiangsu Province successively, issued the Renewable Energy Law, and implemented supporting policies such as preferential feed-in tariff for biomass power generation, thus enabling the biomass power generation, especially the crop stalk power generation industry to develop rapidly. Coal-fired power generation is a main force in China's electricity supply. Its mature technology can be applied smoothly in the direct biomass-fired power generation. This determines that biomass power generation can be mature rapidly and has the greatest potential of industrialization. By the end of 2012, the cumulative grid-connected capacity of biomass power generation was 5891MW. Of which, projects using the direct combustion power generation technology accounted for 55% of national cumulative grid-connected capacity, known as the widest form of biomass energy utilization, followed by the garbage incineration power generation projects which accounted for 41.71% of national cumulative grid-connected capacity. Biomass power generation projects accounted for 3.54% of national cumulative grid-connected capacity.

Though biomass power generation is developing rapidly, there are still many problems. Biomass power generation involves large lump-sum investment and high cost of raw materials. In addition to the purchase cost of raw materials such as crop stalks, the cost of fuel used for biomass power generation includes a larger portion of processing cost, transportation and storage costs, and losses; furthermore, biomass power generation has a smaller scale than conventional coal-fired power generation, and is relatively costly in respect of grid connection and equipment maintenance.

Chapter 2 China's Renewable Energy Management and Relevant Policies and Regulations

1 Overview of China's Renewable Energy Management

Renewable energy is an emerging industry of strategic significance, characterized by wide resource distribution, huge development potential, minimal environmental impact and sustainable use. Currently, the renewable energy industry in China has entered a new phase. In the latter part of 2013, the installed hydropower capacity reached 275 million kW; the installed capacity of integrated wind power reached 75 million kW; that of solar energy generation reached 15 million kW; and biomass generation was 8,500,000 kW. Renewable energy installed capacity accounted for about 30% of total installed capacity while renewable energy generation accounted for about 22% of total generation. As a matter of fact, renewable energy has already become a key part of China's energy production and consumption structure.

In 2006, the Law on Renewable Energy formally came into operation, legally defining the significance and necessity of developing renewable energy. Since then, related departments have launched multiple supporting measures, and in this way determine the policy system framework of developing renewable energy. In 2009, the Standing Committee of the National People's Congress amended the Law on Renewable Energy. Promoted by the Law on Renewable Energy, the amendment and the supporting measures, renewable energy of China has entered a comprehensive, rapid and large-scale development stage.

2 Management, policies and regulations on China's solar energy

2.1 Institution at the national level

(1)National Development and Reform Commission

The people's Republic of China National Development and Reform Commission (abbreviation: NDRC), as a functional institution of the State Council, development policy is a comprehensive study of the formulation of economic and social, to carry out the total balance,and the macroeconomic regulation and control departments to guide the overall economic system reform.The predecessor of the national development and Reform Commission is the National Planning Commission, was established in 1952. In 1998 The former State Planning Commission changed its name to the State Development Planning Commission, and in 2003 incorporated into the original Economic Restructuring Office of the State Council and the State Economic and Trade Commission some functions and reorganized into the national development and Reform Commission, referred to NDRC.

(2)National Energy Administration

The main responsibility of National Energy Administration is to formulate and organize the implementation of energy development strategy, planning and policy, to put forward suggestions on the reform of the energy system, to responsible for the supervision and management of energy etc.The establishment of comprehensive, policies and regulations, development planning, energy conservation and technology equipment, electric power, coal, oil and natural gas, new energy and renewable energy, the International Cooperation Department of the nine Division.

(3)State oceanic administration

The State Oceanic Administration (SOA): approved by the State Council in 1964 formally established which is the government administration of national marine planning, legislation, administration and the National Bureau of the Ministry of land and natural resources.The State Oceanic Administration is the administrative agency for the administration of the land resources management, which is the administration of the marine environment protection, the protection of the marine rights and interests, and the scientific and technological research of the sea. In 2013 the State Council reestablishment of the State Oceanic Administration, conducting maritime rights enforcement by China Police Department of the Ministry of public security business name,accepting the business guidance of Ministry of public security.

(4)Treasury department

The Ministry of finance of the people's Republic of China is responsible for the financial affairs of the State Council of the people's Republic of China. Mainly includes the office, the general affairs department, division of low, tax policy, tariff division, department budget, treasury secretary, Department of national defense, division of administrative and law, Division of UNESCO,division of the economic construction,division of agriculture,social security division, corporate and financial division, international division [5], accounting division, bureau of supervision and inspection, National Agricultural Comprehensive Development Office, Department of personnel and education, authority party, division of retired cadres, the rural tax and fee reform office, and other departments.

(5)Ministry of science and technology

The Ministry of science and technology of the people's Republic of China is the State Council, the main work is to study and put forward the macro strategy of science and technology development and technology to promote economic and social development of guidelines, policies, laws and regulations,to study the major issues of science and technology for promoting economic and social development; research and identify the major layout and priority areas of scientific and technological development, and promote the construction of national scientific and technological innovation system, improve the national science and technology innovation ability.Guidance department, local science and technology system reform

(6)Provincial Energy Bureau

The provinces according to the regulation of the CPC central committee and provincial people's government, to set up the province bureau of energy, which is general Deputy departmental level units, for the provincial development and Reform Commission Management Mechanism. Research and put forward suggestions on energy development strategy,Within the framework of the province's economic and social development planning, formulating energy development planning, industrial policy and organize their implementation, to draw up local laws and regulations on energy, promoting the reform of energy system, and ro formulate relevant reform plan, organizing and to implement the national plan about energy, policy and reform, coordinating energy development and reform of the major issues such as energy regulatory agencies at the provincial level.

(7)Solar energy industry association, alliance

Solar industry association is engaged in solar energy and new energy and renewable energy research of scientific research institutes, colleges and universities and the solar energy enterprises and other units and individuals of voluntary nonprofit corporations in the province， the association subject to the guidance and supervision of the competent departments of the provincial economic and Trade Commission and the registration and management authorities of the Province Civil Affairs Department。

The main work of the Association is to service for the province's solar business and to promote the development of the province's responsibility for the solar industry, as a government adviser and assistant。Actively participate in the development and utilization of solar energy, participated in the revision of product standards, strengthen self-discipline, promote the coordinated development of the industry, to provide information for the member unit, consulting, rights and other service。

According to the needs of the work, the association set up the office, Department of management, enterprise information and Technology Department, market supervision and management department and other functional departments.

(8)National energy policy advisory unit

Provide technical support for the establishment of the national energy policy, such as China Renewable Energy Engineering Institute,Electric Power planning &Engineering Institute,etc.

(9)China Renewable Energy Engineering Institute

(referred to as CREET),is the business unit in 2002 December approved by the State Council in the reform of electric power system reserve in December 2002, now under the management of Power Construction Corporation of China .Positioning of China Renewable Energy Engineering Institute is to provide support and security for the exercise of the functions of the government and to provide public services ,and can be realized by the market allocation of resources in enterprise management institution, the relevant state departments entrusted by the industry technology such as hydropower, wind power, solar photovoltaic power generation management unit, and being industry policy research center of development and construction of water conservancy and electric power and clean and renewable energy.

China Renewable Energy Engineering Institute is the only one ,who has been undertaking centralized management work of institutions of hydropower, wind power, solar photovoltaic power generation technology.Since 2002 the China Renewable Energy Engineering Institute authorized by the relevant departments of the state, responsible for the industry planning, technology management, project acceptance, quality supervision, standard setting and policy research work and entrusted with the management of renewable energy (hydropower, wind power, tidal power) fixed station, hydropower, wind power and safety facilities completion and acceptance.Quality Supervision Station of the national renewable energy power generation project, the national renewable energy information management center; is one of the 16 energy research advisory base for the establishment of the national energy administration; at the same time, assume the management of hydroelectric power, wind power industry Standardization Technical Committee (Group) total of 8.

(10)Electric Power planning &Engineering Institute

(referred to as EPPEI)As a national high-end consulting institutions, mainly provide services to the government departments, financial institutions, power and related businesses ,Main business field is on the electric power industry development strategy, industrial policy, electric power development planning of new technology and power engineering review, evaluation and consultation of the project, standardization of scientific research work and so on, with the national development and reform commission of electric power project evaluation.

In 2009, approved by the national energy administration, electric gauge institute has become one of China's energy industry standardization management agencies,for electric power planning and design related standard setting work the exercise of management functions.And is responsible for the energy industry power system planning and design, power design, network design, thermal power and grid engineering major in technology and economy for a total of four Standardization Technical Committee of the daily management and standard approval, approval, and other work.

China's new energy management agency has stimulated the enthusiasm of domestic investors and manufacturers in the development of new energy sources, and regulate the market operation environment of new energy sources.

2.2 Elevant policies and regulations for solar energy utilization

In 2006, "the people's Republic of China Renewable Energy Law" formally implemented. The legal status and policy framework of China's new energy and renewable energy development is established in the form of law, will include new energy such as solar energy, wind energy, as a priority area of new energy development, And put forward the total target, the annual scale, mandatory access, classification price, cost sharing and special funds and other basic system, laid the legal foundation for perfecting new energy policy.

Table 2-1 policies and regulations promulgated in the past two years

	Name	Release time
1	Comments on the work of distributed power grid service	March 2013

2	Working scheme of distributed photovoltaic power generation demonstration zone	June 2013
3	Several opinions on promoting the healthy development of photovoltaic industry	July 2013
4	Notice on the construction of demonstration zones for the development of distributed photovoltaic power generation	August 2013
5	Notice on promoting the healthy development of photovoltaic industry by the use of price leverage	August 2013
6	Notice on the relevant issues concerning the adjustment of the additional standard of renewable energy electricity price and the price of environmental protection	August 2013
7	Opinion on supporting distributed photovoltaic power generation financial services	August 2013
8	The Interim Measures for the management of photovoltaic power plant project	September 2013

9	知 Notice on the value-added tax policy for photovoltaic power generation	September 2013
10	Photovoltaic manufacturing industry standard conditions	September 2013
11	The Interim Measures for the standard management announcement of photovoltaic manufacturing industry	October 2013
12	A letter on the construction scale of 2013 and 2014 PV power generation	November 2013
15	Interim Measures for the operation and supervision of photovoltaic power generation	November 2013
16	Notice issued in 2014 on the annual new construction scale of photovoltaic power generation	January 2014
17	Implementation advice on strengthening the inspection and verification of photovoltaic products	February 2014
18	Notice on the organization recommended of key projects in 2014 PV industry	March 2014

19	The Interim Measures for the new power grid supervision	March 2014
20	Notice of the National Energy Bureau on strengthening the work of strengthening the monitoring of the photovoltaic industry information	March 2014
21	Notice on strengthening the information statistics and reporting of photovoltaic power generation project	May 2014
22	Notice on strengthening the construction of renewable energy demonstration city statistical information and monitoring work	June 2014
23	Notice on the recommendation of the distributed photovoltaic power generation demonstration zone	June 2014
24	Notice on strengthening the construction and operation management of photovoltaic power	July 2014

	station	
25	Notice on further implementation of distributed PV related policies	July 2014
26	The Ministry of Finance additional renewable energy tariff subsidies directory (Fifth Batch)	May 2014
29	Notice on Further Strengthening the construction and operation management of photovoltaic power station	October 2014
30	Notice on the issuance of the implementation of the programme of work of photovoltaic poverty alleviation projects	October 2014
31	Notice of the national energy board on the increase of the size of the annual construction of photovoltaic power generation in Xinjiang in 2014	October 2014
32	Notice of the National Energy Bureau on regulating the order of development of photovoltaic power plants investment	October 2014
33	Strategic action plan for energy development	November 2014

	(2014-2020)	
34	Consultation letter of technical specification of photovoltaic power plant performance monitoring and assessment of the quality of the grid (filing draft)	December 2014
35	Notice on promoting the construction of distributed photovoltaic power generation application demonstration zone	December 2014
36	Notice on preparation in Compiling "45" solar energy development planning	

China's solar energy industry is dominated by photovoltaic power generation, and the main supporting policy is fixed price policy. In August 2013, the national development and Reform Commission issued “the national development and Reform Commission on giving full play to the role of the price lever to promote the healthy development of the photovoltaic industry notice ", the original 1 yuan and 1.15 yuan per kilowatt hour of electricity price, adjusted for the country is divided into three kinds of solar energy resources area ,respectively carry out 1 yuan, 0.95 yuan and 0.9 yuan per KWH of feed-in tariff ,explicitly implemented for a period of 20 years.The implementation of distributed photovoltaic power in accordance with the full amount of subsidies policy,feed-in tariff standard is 0.42 yuan per kWH.

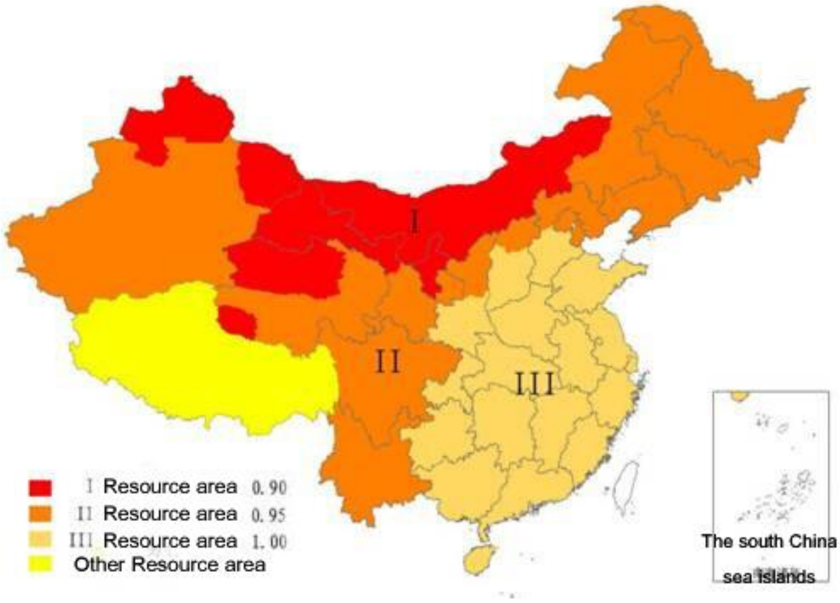


Fig.2-2 regional plans for the benchmark price of photovoltaic power plants

In addition, in order to promote the development of distributed photovoltaic (PV), in 2012 and 2013, the national energy administration, respectively, published《Notice on reporting scale application of distributed photovoltaic power generation demonstration area》and《Notice on carrying out the construction of demonstration area of distributed photovoltaic power generation applications》.

Table 2-1 list of policies for photovoltaic power generation

Posting time	**Document unit**	**File name**	**Document number**	**Implementation date**	**Main content**

2011/07/24	National Development and Reform Commission	《Notice on the improvement of solar photovoltaic power tariff policy》	NDRC price [2006]No.7		In addition Tibet other Province's benchmarking feed-in tariff according to the project approval date is divided into 1 yuan and 1.15 yuan per KWH
2012/01/18	Ministry of Finance Ministry of science and technology National Energy Bureau	《Notice on informing golden sun demonstration on work in 2012》	Ministry of Finance and Construction Department[2012] No.21		The project unit capital is not less than 30% of the project investment .Photovoltaic power generation focused application demonstration projects need to be integrated, the total installed capacity is not less than 10MW, the construction of the user side of the construction of the power generation project installed capacity is not less than 2MW.

2012/02/24	Ministry of industry and information technology	《Solar photovoltaic industry "12th Five Year" development plan》		2011-2015	By 2015, the cost of PV modules dropped to 7000 yuan / kWh, the system cost down to 13000 yuan / kWh, power generation costs down to 0.8 yuan / kwh. Polysilicon production average comprehensive energy consumption is less than 120 degrees / kg.Single crystal silicon battery industry conversion efficiency reached 21%, polysilicon reached 19%.

2012/03/27	Ministry of science and technology	《Solar power generation technology development "Twelfth Five Year" special plan》	Ministry of Science and Technology[2012]No.198	2011-2015	By 2015 strive to achive crystalline silicon solar cell efficiency of 20% above, silicon-based film solar cell efficiency of 10% or more, the tellurium cadmium, copper indium gallium selenium cell to realize commercial application.Preliminary realize user side grid parity pv system on the Internet, utility grid side grid pv system feed-in tariff is lower than 0.8 yuan/KWH.

2012/07/07	National Energy Bureau	《Solar power development "12th Five Year Plan"》	Department of new energy and renewable energy - National Energy Bureau[2012]No. 194	2011-2015	By the end of 2015, China's solar power installed capacity reached 21 million kw or more,the annual output is 25 billion KWH.In central and eastern regionsthe the construction of distributed photovoltaic total installed capacity is 10 million kilowatts, In qinghai, xinjiang and other solar energy resources area and unused land resources rich area grid photovoltaic power station built a total installed capacity of 10 million kilowatts.

2012/09/14	National Energy Bureau	《Notice on reporting scale application of distributed photovoltaic power generation demonstration area》	Department of new energy and renewable energy - National Energy Bureau[2012] No.298		Each province (area, city) to declare the number of support does not exceed 3, the total installed capacity of the declaration should not exceed 500000 kw.The state shall implement a demonstration area of photovoltaic power generation project unit electricity norm subsidy policy,Standard for the implementation of the unified subsidy for the spontaneous self occupied and the excess of the Internet

2012/10/26	State Grid	《Comments on the work of distributed photovoltaic power generation grid service》			To 10000 volts and the following voltage levels of access to the grid, and a single network and the total installed capacity of not more than 6MW;Distributed photovoltaic wind power project is protected from the system reserve fee,The grid placed under the authority of the municipal company, grid process period of about 45 days; public access caused by distributed photovoltaic power grids, all fees and access to public power grid by grid bear.
2013/07/	The State	《Some	National	2013-2015	In 2015 the total

04	Council	opinions of the State Council on promoting the healthy development of the photovoltaic industry》	Development and Reform Commission[2013]No. 24		installed capacity of more than 35000000 kilowatts of photovoltaic。New photovoltaic manufacturing project monocrystalline silicon solar cell conversion rate is not less than 20%, polysilicon is not less than 18%, the film is not lower than 12%, polysilicon production integrated power consumption is not higher than 100 kwh / kg。

2013/08/06	National Development and Reform Commission	《Notice of the national development and Reform Commission on the price leverage role to promote the healthy development of the PV industry》	NDRC price [2013]No. 1638		The country is divided into three types of solar energy resources, the implementation of the benchmark price of 0.9 yuan per kilowatt hour, 0.95 yuan and 1 yuan, a clear implementation period of 20 years; the implementation of distributed photovoltaic power in accordance with the policy of full power subsidies, tariff subsidy standard of 0.42 yuan per kilowatt

2013/08/09	National Energy Bureau	《Notice on the construction of demonstration zones for the development of distributed photovoltaic power generation》	Department of new energy and renewable energy - National Energy Bureau[2013]No.296		According to the provinces (area, city) submitted to the implementation of the demonstration zone, Haidian District Zhongguancun Haidian Beijing Park and other 18 parks as the first batch of distributed PV application demonstration area。
2013/08	China Southern Power Grid Company Limited	《Guiding opinions on further supporting the development of new energy sources such as			From the aspects of grid services, power purchase and sale of electricity, and grid scheduling management and other aspects of comprehensive support for orderly coordinated

		solar energy》			development of new energy。
2013/09/30	Ministry of finance, the State Administration of Taxation	《Notice on PV VAT Policy》	finance and taxation[2013]No.66	2013/10/01-2015/12/31	Solar power products produced by the taxpayer for sale,carrying out VAT refund of 50%。

3 Management, policies and regulations on China’s wind energy

3.1 RE Legislation

The ‘Renewable Energy Law’ (REL) was published in 2005 and came into effect at the beginning of 2006 (State Council, 2005). This provided a single, coherent framework of government policy for the development of RE. The REL instituted five market interventions for the government: setting an overall target for RE production, mandating compulsory grid connections, introducing a feed-in tariff (FIT), introducing cost-sharing for electricity generated from RE, and establishing a special RE promotion fund (Wang, et al. 2007). The signals sent through these measures were positive national incentives for renewables development.

RE has developed rapidly in China since the implementation of the REL. However, in terms of RE both manufacturers and developers were beyond what was anticipated when the law was enacted, which meant that the REL could not keep up with the actual pace of RE development. So, in 2009 an amended version was enacted to respond to the new emerging demands of RE (State Council, 2009). In the new version of the REL, some of the remaining problems were addressed. Compared with the 2006 version, the 2009 version concentrates mainly on the following aspects of renewables.

(1)Formulating a more scientific approach to RE planning

The new REL highlighted the importance of increasing the use of science-based planning-tools when making large-scale plans for the development and use of RE, so that these are coherent within the framework of the whole energy system. Additionally, the need for coordination between regional and national governments for RE planning was also mentioned in the new REL to help guarantee an efficient allocation of resources.

(2)Power grid connections – quotas for electricity generated from renewables

Because renewable electricity was being abandoned by the grid in serious quantities, the new REL clarified the delineation of responsibility between the state, grid enterprises, and electricity generating enterprises. First, the state determines the share of total electricity to be generated from RE, and guarantees that electricity generated within this target by RE producers will be purchased in full. To reach this target, the NEA and the State Electricity Regulatory Commission (SERC) have identified the responsibilities of grid companies and power generators in the implementation of such measures.

At the industry level, grid enterprises should sign grid-connection agreements with renewable electricity generation enterprises to ensure that renewable electricity is purchased in full, and provide a synchronization service for electricity generated by using RE. In turn, electricity generating enterprises need to meet the grid connection technical standards of the power grid, and have to cooperate with the power grid enterprises in protecting grid stability.

(3)RE subsidies

The new REL also enhanced financial incentives for RE development, emphasizing that 'for the access cost and other relevant costs that cannot be recovered from the selling price of electricity, the power grid enterprises can apply to the RE development fund for subsidies' (State Council, 2009). A RE surcharge of 0.001 yuan/kWh was set from the nationwide sale of electricity with the goal of supporting RE development (NRDC, 2007b). This was increased to 0.004 yuan/kWh in 2010, and further to 0.008 yuan/kWh since the beginning of 2012. But it is still inadequate to cover the cost of the huge additional installation of RE. According to one forecast, a RE surcharge of 0.012 yuan/kWh is required to cover the subsidies actually needed for the development of RE power generation (China Scope, 2011).

3.2 RE policies and measurements

In economic theory, renewable mandates are considered to be "inefficient." Because most utility performance targets have the effect of persuading utilities to purchase higher-cost renewables even at off-peak hours when less-costly alternatives are available (Greenwald, et al., 2013). While the absence of governmental direction will mean that a "market" dedicated to least-cost principles will select proven fossil-fuel technologies rather than RE technologies. RE policies are thus the key to the creation of an enabling environment to allow renewable electricity technologies to compete on a level playing field with alternative options (Berrill, 2012).

According to earlier research, there are direct and indirect policy instruments as listed in Fig. 2-3. The direct approaches are aimed at the RE sector, whereas indirect instruments are aimed mainly at barrier removal 'outside' this sector and at improving the framework for RE (van Dijk, 2003). On the other side, the value chain can be simplified to the following stages: Research and Development, Investment in RETs, Production of electricity, and Consumption of electricity. In this paper, we link the policies with the value chain to reflect the effects of these policies.

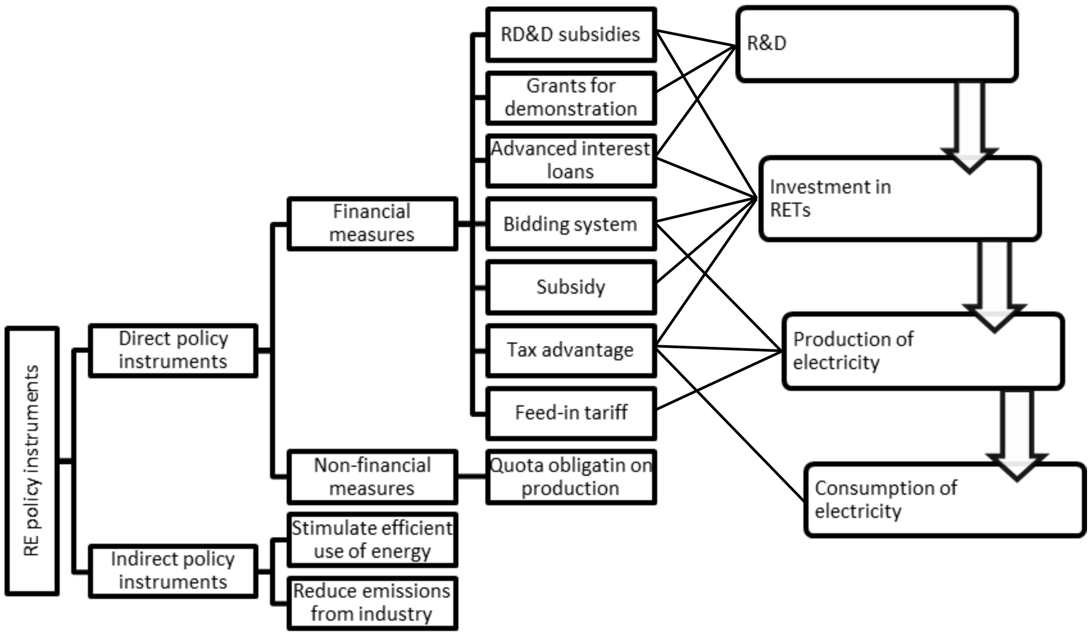


Fig.2-3. The RE Policy System and Targets

3.2.1 R&D facilitation

Direct support for R&D is widely used to stimulate the development and market uptake of those RE sources which are far from commercial implementation. RE research and development has received government support since the enactment of the Science and Technology Law of 1993. Since 2000, national investments in RE R&D have taken an average share of 15 percent of envisaged outlays in MOST science and technology supporting plans. Wind power, solar energy, and biomass have received priority public investment support, accounting for shares of 40, 32 and 25 per cent respectively of total investments in RE technologies (Su, et al., 2008).

R&D facilitation of RE in China has come mainly from government science and technology projects. The lower industry R&D effort reflects the long path to commercial use of these technologies on the one hand, and the weak R&D capacity of the industries on the other hand. Furthermore, the low R&D facilitation of RE also shows that China’s incentives to promote RE are not enough to propel China into global technological leadership, although they are sufficient to allow the country to assume leadership in the manufacturing products.

3.2.2 RE pricing institutions

At present, almost all RE, except for large-scale hydro power, is uncompetitive compared with conventional coal fired power plants, which means that the government needs to set a price mechanism that reflects the externalities of energy (Zhao, et al. 2011). With this background, the NDRC issued a document entitled "Trial Measures for the Management of Prices and Allocation of Costs Electricity Generated from Renewable Energy" (NDRC, 2006a), in which the prices of various RE technologies and the allocation method of costs were set, and different pricing mechanisms were introduced for the development of RE (Table2-2).

Table 2-2 Pricing Mechanisms for RE

	Pricing	**Comments**
Wind, onshore	Concession bidding (from 2003) to FIT (from 2009)	Benchmark onshore on-grid wind power prices were set from 0.51 yuan/kWh to 0.61 yuan/kWh depending on the specific resource area (NDRC, 2009)
Wind, offshore	Concession bidding/auction (from 2008)	The ultra-low price of the four 2010 projects has been blamed on a faulty bidding process. Low price reflected overly optimistic forecasts of both national incentives for offshore wind development and large scale cost decreases in the future.
Biomass	Price subsidy (2006) to FIT/concession bidding (2010, 2012)	Central government mandated a subsidy of 0.25 yuan/kWh since 2006 (NDRC, 2006a). 0.75 yuan/kWh was set as the benchmark price for agriculture, forest biomass power (NDRC, 2010); while 0.65 yuan/kWh was set as the benchmark price for municipal solid waste power generation (NDRC, 2012b).
Solar PV	Government pricing (2011) + concession bidding to FIT in some provinces (from 2013)	The benchmark price was set to 1.15 yuan/kWh for projects approved before July 1, 2011, while it was decreased to 1 yuan/kWh for projects approved after that date. Lower benchmark prices ranging from 0.90 yuan/kWh to 1.00 yuan/kWh was set for ground-based PV system depending on difference solar radiation intensity; and 0.42 yuan/kWh of subsidy for distributed PV system since September 2013 (NDRC, 2013).
Oceanic power	Government pricing	Set by the government according to the rule of reasonable cost plus reasonable profit (NEA, et al., 2013a)

Government pricing and guidance pricing (the price standard imposed by the price administrative department under the State Council in accordance with the tender price determination) were both introduced into the RE pricing system at an early stage of RE development. Tender price determination means that in each bidding round the most cost-effective offers will be selected to receive the subsidy. This mechanism therefore leads to the lowest cost options.

The table also describes how China's RE pricing gradually evolved from concessionary pricing to the FIT mechanism. We can also see that China's FITs in turn have evolved from technologically neutral flat tariffs to technologically specific graduated tariffs. These adjustments are aligned with what has been identified by leading sources as best practice FIT design in Europe and other developed countries, that is, tariffs that vary according to technology, size, resource intensity, and the degree of technological maturity of the RE projects eligible for FITs.

In conclusion, because the cost of renewable electricity generation is still significantly higher than fossil fuel generation (Cherni and Kentish, 2007; Liu, et al, 2011), both developers and their financial backers need incentives from the government to invest in RE development so that they can compete with fossil fuel power plants on a price for grid access basis (Feng, et al., 2010). However, the decrease in the cost of RE has approved the economic efficiency of RE policies, and the adoption of several pricing methods for technologies at different development phases, has nonetheless realized some success. There is a still long way to go for RE to reach commercial competitiveness in China (Wan and Yin, 2009).

3.2.3 RE subsidies

Subsidies were the earliest incentive used to promote RE, and still play an important role in the establishment of RE technologies and their market development (Lund, 2009; Hirschl, 2009) through helping them overcome the barrier of high initial capital cost. In China, the REL established a long-term, stable subsidization system for setting up a public-financed fund for RE development. The fund is built by charging the public an additional 0.008 yuan on each kWh of electricity consumed, and can be used in two forms (NRDC, 2006b). First, it can be issued as a grant.

Recipients of such grants use the funds for RE research and development. Second, it can be used to subsidize loan interest. Eligible renewable projects may obtain public funds to pay part of their loan interest costs.

Since 2006, eight installments of subsidies with a total of 32 billion yuan have been distributed for RE power generation projects. As a result, the capacity of RE installations has increased from 1414 to 39,313 MW, while the electricity generated has increased from 1044 to 48,438 GWh (NDRC, SERC, 2012). More than 90 percent of distributed subsidies were granted for wind power projects, which is consistent with the big share of wind power in China's RE power market. Six percent of total subsidies were granted for biomass power generation. The share of biomass increased to 12 percent from the end of 2007 to June of 2008, but fell back to 7 percent at the beginning of 2011. The change revealed the blooming of biomass power projects at the beginning of the implementation of incentive measures, with a corresponding decrease later because of a lack of sufficient raw materials and advanced technologies. The structure of RE subsidies also reveals the relatively slow development of solar PV projects and geothermal power projects, which attracted only 1 percent of total distributed subsidies (Fig.2-4).

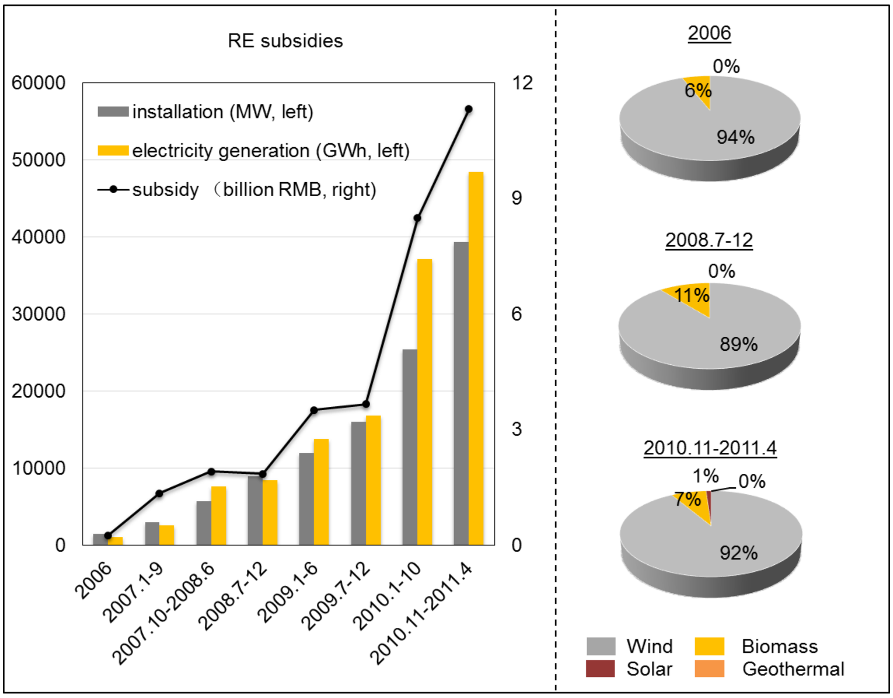


Fig.2-4. The Subsidies for RE Projects.

Huge subsidies have stimulated the development of RE. Figure 4 reflects China's rapid development of RE power installations, especially wind turbines, since 2006. But what should be noticed is the severe subsidy shortage of RE subsidy, which cause negative impacts on RE developers and manufacturers.

3.2.4 Taxation policy

Tax incentives used to promote green electricity are mainly designed as tax exemptions, rebates on taxes, tax refunds or as lower tax rates on activities promoted (KPMG, 2011). Up to now, various taxation policies have been issued to encourage RE development, and the policies have been regularly updated to keep pace with RE development (Li, 2004; Zhao, 2012; Zhang, 2013). In summary, value added tax (VAT), corporate income tax (CIT), and customs duties are the three main categories of taxes in China.

(1) Value added tax (VAT)

At the end of 2008, the National Tax Administration (NTA, 2008a) published the "Circular on Value Added Tax Policy of Comprehensive Utilization of Resources and Other Products", and clarified that VAT paid on the sale of goods produced from recycled materials or waste residuals is refundable. According to the documents, a 50 percent refund of the VAT is paid on the sale of wind power, which means that the VAT for wind power was reduced from 17 percent to 8.5 percent. A 100 percent refund of the VAT is paid on the sale of biodiesel oil generated by the use of abandoned animal fat and vegetable oil and electricity generated by the use of waste, including municipal solid waste, crops, sewage, and medical waste.

(2) Corporate income tax (CIT)

According to the "Corporate Income Tax Law", corporate revenues earned by energy conservation and water saving conservation projects, environmental protection and clean development mechanism projects are eligible for a three-year CIT exemption, followed by another three-year 50 percent reduction of the CIT rate for income derived from qualified projects, starting from the year in which the first revenue is generated. Applicable fields include biomaterial energy, energy cogeneration, the use of methane, and technological innovation in energy conservation and emission (NTA, 2008b).

As advanced and new technology enterprises, many enterprises engaging in RE can be granted a reduction in the CIT to 15 percent (usual CIT rate is 33 percent). Applicable fields include solar energy, wind energy, biomaterial energy, and geothermal energy (NTA, 2008c).

Furthermore, 10 percent of the amount invested in qualified equipment is credited against CIT payable for the current year, with any unused investment credit eligible to be carried forward for the next five tax years if such equipment is qualified as special equipment related to environmental protection, energy saving, or water conservation and production safety.

(3) Customs duties

Customs duty exemptions or reductions are also given to the import of RE power generation equipment and to special items considered to be high-tech. According to the "Import tax policy to encourage the development of equipment manufacturing industry", solar and wind equipment were included in the duty-free list. Large scale wind power equipment and some solar PV equipment could be imported without tariff and value-added taxes, so as to stimulate Chinese RE development. However, with the growth of domestic renewable industries, this policy has now been repealed (MOF, 2012). According to the new policy published by the government, wind turbines smaller than 3MW have been removed from the duty-free list, which reflects the advance of domestic technologies.

4 Management, policies and regulations on China's small hydropower industry

China boasts abundant small hydropower resources. The history of the small hydropower industry can be divided into the following stages:

1) At the preliminary stage of the new China when the national economy had just recovered, the Party and the government immediately focused on developing rural

small hydropower. In the national water conservancy meeting in 1955 it was required to actively implement pilot small hydropower stations. The construction principles for small hydropower proposed in the 1958 national rural hydropower meeting convened by the Ministry of Agriculture state: “simultaneously develop power and electricity by emphasizing a comprehensive plan that integrates small-scale, social establishment, production, and pays equal attention to construction and management”.

2) In 1963, the development guidelines for rural electric power at or below county level with power supplied by small hydropower and large power grid were presented by the national electric power working conference, and stipulates: “focus on commodity grain and cotton base, centered on irrigation and drainage electricity consumption and power supplied by the grid, simultaneously promote power supplied by the grid and rural small power stations”. In addition to state funding for water conservancy funds, small hydropower and its supporting grid may also obtain special funds appropriated by the Ministry of Hydropower on an annual basis for transforming and renovating rural grids.

3) From October 20 to November 19, 1969, the business group of the State Council convened the “Symposium on Small Water Conservancy and Hydropower in Southern Mountainous Areas” attended by government heads from 15 provinces and municipalities with the purpose of accelerating small hydropower development. The representatives present at the meeting in Beijing studied the policies and guidelines on speeding up small hydropower, and formulated the construction guidelines titled “Focus on small, self-constructed and independent equipment manufacturing” as well as subsidy policies for funding and major raw materials offered by the state. Since 1970 small hydropower development has been officially included in the national plan.

4) Since the reform and opening-up policy, the Chinese government has introduced a suite of policies to support and encourage local governments and the public to develop small hydropower resources. The policy of “independent construction, independent management and independent use” enforced in 1970 is a widely-known policy on developing small hydropower in China. The Value Added Tax (VAT) of small hydropower in 1994 was 6%, more preferential than the 17% for

large hydropower. Relevant government organizations are also accelerating the introduction of control regulations for rural hydropower. The Chinese government continues to support the planning of new rural electrification in its “Twelfth Five-year Plan” (2011-2015) through RMB 43,520,000,000 ¥ investments for building 300 rural electrification counties, increasing equipment production to 5,156 MW, and increased generated energy to 19.16 TWh. Moreover, the small-hydropower-replacing-fuel project continues to be widely implemented (2009-2015). By constructing 1,022 small hydropower stations with an installed capacity of 1705.6 MW have substituted fuel wood, resolved the power consumption problem for 6,780,000 rural customers, and reduced deforestation across 1,593,333 hectares. In addition, energy efficiency and capacity extension projects are carried out for rural hydropower. There are plans to invest RMB 3,750,000,000 ¥ in transforming 620 rural small hydropower stations with a total installed capacity of 880 MW within two years. The generated energy after transformation will be 1.1 GW. The preferential policies have aroused the enthusiasm of local, collective and individual small hydropower stations.

4.1 Management of the small hydropower industry in China

The management of the small hydropower industry aims at two aspects: First, to implement the guidelines and policies for encouraging and supporting small hydropower by the Party and the state, protect the legitimate interests of small hydropower investors and boost industrial development; second, to ensure the production and property safety of people through strict enforcement of the law and standardized construction procedures for small hydropower. Industrial management mainly concerns the following:

1) Establish and improve laws and regulations, and stringently implement laws and policies. It regularly outlines various problems that emerge in work and cooperation between legislative institutions in improving laws and regulations. Concurrently it should stress the implementation of laws and regulations; 2) Formulate and improve planning. River planning for small hydropower has been revised many times, and to date is sufficiently adequate; 3) Handle administrative

licensing. The administrative licensing of future small hydropower is mainly under the purview of the Development and Reform Commission for project approval of development and construction schemes. The administrative licensing procedures should be simplified and authority transferred to lower levels to shorten the construction period of small hydropower projects, and reduce investment costs; 4) Supervision management during construction. Supervision primarily centers on implementation of a competitive bidding system and supervision system, the qualification of construction organizations, the robustness of engineering quality and safety management rules and regulations. 5) Supervise and participate in the final verification of projects; 6) Supervise safety production, mainly including the robustness and implementation of a safety production accountability system and the regular maintenance of electro-mechanical equipment in small hydropower enterprises.

Over the past decades, significant changes have occurred to the development, investment and management of small hydropower. Prior to 1990, China's small hydropower was principally established upon contribution from central and local governments. Afterwards, following rapid economic development, the gap between power supply and demand increased sharply, resulting in power shortages in many provinces. At this moment, China has begun to reform its investment system to combine government support with market mechanisms, and encouraged all economic entities to invest and develop small hydropower with the aim of resolving the supply-demand issue and the shortage of government funds.

In addition to government investment, a large proportion of private investment has been engaged in the development of small hydropower. During the past ten years, investor groups in newly added small hydropower installations have shifted from central and local investment to companies (including foreign capital), joint ventures and private capital.

Table2-3 Ownership of China's Small Hydropower

Type	Number of small hydropower stations	Proportion (%)

Non-company	2 217	8.94
Enterprise (ownership)	22 585	91.06
State-owned	1 972	7.95
State-owned shares	1 003	4.05
State-owned joint venture	213	0.86
Collective ownership	2 702	10.89
Private and others	16 695	67.31
Total	**24 802**	**100.00**

Furthermore, a complete set of technical standards has been established, including small hydropower planning and design, construction and installation, operations testing and equipment production, providing technical support and service for its development.

4.2 Policies, regulations and standards on China's small hydropower

(1) Hydropower resources management prescribed in national laws and central documents

It is stipulated by the new Water Law promulgated on August 29, 2002 that: "Water resources are owned by the state, and exercised by the State Council on behalf of this country." "The administrative department in charge of water is responsible for uniformly managing and supervising national water resources." "The administrative department in charge of water in local people's government above county level shall uniformly manage and supervise water resources within the jurisdiction."

In the Renewable Energy Law issued February 28, 2005, the legal status of hydropower as a key and independent part of renewable energy was established. Meanwhile, it has designated the renewable energy system under management of the relevant energy authorities.

It is stipulated by the 2007 Z.F. [2007] No. 1 document: "Accelerate the development of rural clean energy. Strengthen the development, planning and management of rural hydropower resources; expand the scope and scale of the small-hydropower-replacing-fuel project, and increase investment and aid support in rural hydropower development in poverty-stricken areas." In the 2008 Z.F. [2008] No. 1 document it states: "Enhance planning and management of rural hydropower resources, promote rural electrification construction, and enlarge the scale of fuel replaced by small hydropower."

(2) Establishment of a standards system during small hydropower construction

With regards to legislation, through sixty years of construction, in particular water conservancy and hydropower projects in the recent thirty years, the technical standards for China's water conservancy and hydropower projects are relatively comprehensive. Since previous standards are only applicable to medium and large-scale water conservancy and hydropower projects, small hydropower projects may only use them as reference. After the 1990s, China began to establish a batch of technical standards based on existing small hydropower projects and adequate for small-scale projects, gradually forming a series of standards. This demonstrates the scientific management method undertaken in the standardization of small hydropower projects.

Through its small hydropower construction China has accumulated considerable experience, and has a thorough standards system for planning, designing, constructing and managing small hydropower, covering both planning of rural electrification and construction and management of power stations and grids. Within China's water conservancy technology standards system, the system for small hydropower is composed of eleven parts: integration, planning, survey, design, construction and installation, quality verification, operation and maintenance, safety evaluation, monitoring and forecast, material testing and equipment, encompassing fifty-eight standards with thirty-one already issued. There are four national standards (three recommended) and twenty under consideration (revision).

China has established a complete set of codes and standards in operation, maintenance and management of small hydropower, which few other countries have done. As a result of its development policies and mechanism for distributed power construction China has become a resource and demonstration country globally for small hydropower technology. The industry is at the international forefront.

Few standards systems for small hydropower exist internationally and in other foreign countries. The technical standards and management regulations on small hydropower construction are reflected in related standards for energy, hydropower plants and power systems. At the same time, regarding content division, we have established the following standards nonexistent in other countries: verification standards for hydropower rural electrification, project standards for small-hydropower-replacing-fuel, and site selection standards for developing rural hydropower stations and rural electrification.

Furthermore, China's small rural hydropower technical standards can be divided into regulations, norms, standards, guidelines and specifications, all formulated and released by the Ministry of Water Conservancy of the State Council. While some simply provide guidance, others are compulsory. The standards on small hydropower (or hydropower, electric power) of international bodies and developed countries can be classified as below: ① Code, e.g. National Electric Code of America is coercive. Failing to perform the code means to break the law and will be punished. ② Standard, guideline, criteria and specification, rules and recommendations are all recommended and voluntary. They are established by more than one organ, and are competitive. Their release does not mean there is no other method to produce, test, measure, purchase, sell or supply goods and services in relation to the document. Before the standards are approved and issued, the viewpoints raised shall be modified according to the opinions of the user and existing technical levels. Thus, through its standard system China provides significant guidance for developing small hydropower.

4.3 Interpretation of policies, laws, regulations, standards and impact analysis

On November 29, 2005, the Development and Reform Commission provided provisions for hydropower by printing and issuing F.G.N.Y. [2005] No. 2517 Guidance Catalogue on Developing Renewable Energy Industry.

1) Conform to the planning of river basin development, and the environmental

requirements of various grid-connected hydropower stations.

2) Off-grid small hydropower stations shall be used for local development and nearby power supply, resolving power and energy consumption issues for remote areas.

Localities and communities in China often adopt local development and power supply in small hydropower and grid construction in order to resolve power consumption issues in remote areas. Other grid-connected medium and small hydropower stations already in operation generally meet development, planning, and environmental requirements, and should be included in the preferential policies and implemented in the Renewable Energy Law.

Hydropower is both a crucial part of hydropower resources and a type of renewable energy. In accordance with the Renewable Energy Law, the relevant water department’s responsibilities for hydropower resource development and utilization include: organize establishment of technical specifications for resource investigation; within the scope of responsibilities for resource investigation, prepare development and utilization plans, formulate industry standards as well as operation and management development standards.

In August 2006 the Ministry of Water Conservancy published S.D. [2006] No. 338 document titled Opinions on Enhancing Management of Rural Hydropower Construction, which specified the development and planning of river hydropower resources, project technical review and administrative examination and approval, evaluation and preliminary review system, supervision of construction procedures, project verification, market construction and safety supervision.

1) Strict technical review and administrative examination and approval of projects

Rural hydropower projects invested and constructed within all systems of ownership shall strictly abide by the consent system for hydropower engineering planning, examination and approval system of engineering construction scheme, permit system for water resources and water drawing, examination and approval system of water and soil conservation and preliminary review and approval system of technical documents.

The examination and approval system shall be implemented for rural hydropower projects directly invested by the government as well as those utilizing government investments to construct rural hydropower projects. While the authorization system includes project proposal and a feasibility study report, the relevant water department only needs to examine and approve the preliminary design.

Prior to the authorization of a rural hydropower project the relevant water department shall handle the preliminary design approval and planning consent in accordance with flood control requirements, approval document on engineering construction scheme, the reply to water resources objections, approval document on water drawing permit and examination and approval document on water and soil conservation.

2) Rigorously implement the engineering verification system

After acceptance of a rural hydropower station project a verification system is carried out. The verification before closure and verification for significantly concealed projects and foundation reinforcement engineering and unit projects are borne by the project entity and joined by the responsible water department; verification for environmental protection facilities will be the responsibility of the environmental protection department and relevant water department; verification for engineering impounding shall be organized by the relevant water department; verification for units startup shall be jointly organized by the project entity and the manager of the connected grid, and joined by the relevant water department; the relevant water department is also responsible for preliminary completion verification. After the project meets qualifying standards, the relevant water department shall award a use permit. The power station can be put into operation after the water drawing permit is issued by the water drawing approval authority.

3) Strict supervision for safety and market construction

Each relevant water department shall take charge of supervising and managing the safety production of rural hydropower engineering within the jurisdiction; carry out and execute the construction market access and clear system in accordance with the law. The survey, design, environmental assessment, supervision, construction, equipment manufacturing and bidding agency unit shall all be conducted within the designated range of responsibilities for corresponding operation activities. No exceeding of authority or arbitrary expansion of scope of operations is allowed. Organizations lacking appropriate qualifications and experienced personnel are prohibited from entering the construction market of rural hydropower engineering.

5 Biogas Management and Relevant Policies and Regulations in China

The Chinese government has been paying much attention to the development of biogas. In the promotion process of biogas, the attention and continuous investment from the Chinese government played a crucial role.

5.1 Biogas Industry Management in China

With the consistent attention of the Chinese government, there have been well-established working systems for the biogas industry across the country. They include a complete set, a series of packaged working systems for administration, technology promotion, research and development, design and construction, equipment manufacturing, quality supervision and testing, vocational skill training and assessment, consulting and technical service, etc. There are professional teams of biogas construction technicians holding certificates granted by the Ministry of Agriculture and Ministry of Labor. There are biogas spare parts and manufacturers. By the end of 2009, there were 12795 biogas management and promotion institutions across the country, and 40106 people worked for them.

A relatively sound quality supervision and testing system is available for the biogas industry in China. In Chengdu, there’s the Biogas Equipment Quality Supervision and Testing Center of the Ministry of Agriculture. In Hebei and other provinces, provincial biogas equipment quality testing centers have also been established to be responsible for participating in the development of technical standards and the product quality supervision and testing, and checking on quality products meeting the standards. China Association of Rural Energy Industry, China Biogas Society and other institutions are in charge of the development, revision, planning, organization and coordination of standards in the biogas domain, as well as the propaganda and implementation after the release of the standards. Quality testing centers not only conduct quality supervision and inspection for the products traded in the market, but also perform performance testing of new products.

5.2 Biogas Related Policies and Regulations in China

In the process of biogas development, the government's encouragement policies and fiscal/tax policy supports have played a crucial role. Policies, regulations, government's attention and support to biogas projects serve as the foundation and driving force for the fast development of biogas projects in China. China have enacted the Energy Law, Energy Conservation Law, Renewable Energy Law, Animal Husbandry Law, and Circular Economy Promotion Law, which contain special provisions to encourage and support the vigorous development of biogas and comprehensive utilization of crop stalks, livestock excrements, agricultural and sideline products, waste agricultural film, etc., development of biogas and other biomass energy in rural areas, facilitate the construction of socialistic new countryside, and drive the harmonious development of urban and rural areas.

In addition to encouragement policies, the government also spent a large sum of money supporting the biogas projects. In the 6th Five-Year Plan period, China allocated subsidized loans of RMB 40 million every year to support the biogas projects in rural areas. In recent years, China increased its subsidies to biogas projects in rural areas year by year. The amount of such subsidies in each of the previous years: RMB 100 million in 2001, RMB 300 million in 2002, RMB 1.0 billion/year in 2003-2005, RMB 2.5 billion/year in 2006-2007, RMB 5.5 billion in 2008, of which RMB 3.0 billion was added for boosting domestic demands, and RMB 5.0 billion in 2009. At the same time, the Management Regulations for Rural Energy Construction were introduced in succession in different provinces and municipalities to put into practice the national policies for encouraging and supporting rural biogas projects. Investment in biogas projects was increased.

Chapter 3　Renewable Energy Technologies Types Transferrable from China to Ghana

Following years of development, China is increasingly advanced with regards to renewable energy technology. This chapter elaborates on the renewable energy technologies that may be transferred to Ghana, in particular for solar energy, wind energy, small hydropower and biomass.

1 Solar energy Technologies Types Transferrable from China to Ghana

The suitable solar energy utilization technology that China can transfer to Ghana:

(1) Large scale photovoltaic power plant survey, planning, design, operation, equipment supply.

(2) Distributed photovoltaic power plant survey, planning, design, operation, equipment supply.

(3) The daily application of photovoltaic, such as photovoltaic street lamp, solar flashlight.

(4) Application of low temperature in solar thermal, can provide design, equipment supply, installation, etc for such as solar water heating, solar heating, solar drying, solar oven, etc.

(5) Survey, planning, design, operation and equipment supply of solar thermal power station.

2 Wind energy Technologies Types Transferrable from China to Ghana(TBD)

3 Small hydropower technology models transferrable from China to Ghana

China has achieved significant progress in using renewable energy technology in rural electrification. Moreover, the successful experience of China is applicable to Ghana. Through the “China-Ghana Renewable Energy Technology Transfer Project”, the renewable energy technology, policies and experience may be transferred to Ghana. Meanwhile, South-South strategic cooperation can be enhanced. Although China is extensively experienced in cooperating with African countries, this South-South cooperation mechanism varies significantly from previous models.

3.1 Typical technologies in developing and constructing China’s small hydropower

Through years of small hydropower construction, China has formed a mature equipment technology system and engineering development mode, including technology for river basin planning, design and construction of hydraulic structures, manufacturing of small hydropower units, monitoring of power station computers, automatic power scheduling and Power Transmission and Distribution. Currently, China has an intact equipment industry system for small hydropower technology consisting of scientific research institutions, academies and enterprises, covering research, trial-manufacture and production, boasting powerful technology and product strength. The following article mainly gives an introduction to the key factors and experience in developing and constructing small hydropower.

River basin planning technology mainly includes development of small watershed cascade, leading reservoir and cross-basin of high water head power stations. By systematically studying the river basin as an organic whole, the most suitable scheme is identified that maximizes hydropower utilization rate, generation, social and environmental benefits. At present, small hydropower river basin planning technology continues to develop rapidly and is extended to the national development of small hydropower.

Fleet cascade development is a key feature in China’s small hydropower development, which can fully utilize the hydropower of a river. Reservoir built upstream can regulate the flow for downstream areas. Rural electrification planning based on small hydropower contains hydropower resource development, balance of electric power and energy and economic calculations. Since the load in the small hydropower supply area changes drastically between the rainy and dray season and for peak and low loads, it is proposed to simultaneously plan the power source construction and power consumption load, and consumption standards with Chinese characteristics for initial rural electrification. These initiatives are the first of their kind in the world. This achievement has been awarded first prize for scientific-technical progress by the Ministry of Water Conservancy.

The hydraulic structure of small hydropower mainly includes (1) a water retaining structure such as concrete gravity dam, stone-laying arch dam, small stone-laying arcade buttress dam, concrete arch dam, rubber dam, concrete faced rock fill dam and earth dam; (2) diversion structures such as generation, inter-basin water diversion and hydrocone type. While investment for small hydropower hydraulic structure is relatively large, its engineering schedule is restricted. As a result, hydraulic structure technology can effectively reduce engineering investment and speed up the schedule. China has many new technologies, materials and achievements in hydropower construction, which are all pioneer work in small hydropower engineering, e.g. laminating enrockment concrete face, laminating concrete dam and filling rubber dam have all been tested and promoted within the small hydropower industry. Local materials and non-pressure diversion structures scarce in large power stations are applied in small hydropower, including: low damming, non-pressure water inlet, desilting facilities, diversion canal and forebay. Furthermore, automatic start-stop hydrocone inlet, forebay design specification, as well as sand prevention and disposal have all been researched, developed and promoted.

Currently, small hydropower equipment technology has transformed from conventional to micromodule. The automatic control system enters computer digital control stage. Economically advanced regions have adopted advanced scheduling automation systems and comprehensive automation systems in transformer substations. Partial hydropower stations and transformer substations have realized “no-man on duty” operations. Furthermore, technical reform and energy saving technologies have been widely applied. Some small hydropower stations have adopted highly-efficient rotors, new excitation devices and other new technologies and devices, improving efficiency and obtaining considerable economic benefits.

In China, optimized operation of hydropower stations and optimized scheduling of drainage basins continues to develop quickly. The computer monitoring system for cascade power stations adopts a layered and distributed structure and water regimen system interface which can automatically receive the upstream rainfall and reservoir water level so as to optimize the scheduling.

The supporting grid of small hydropower tends to be adequate, with greater layout reliability and flexible operation. Meanwhile, the supply capacity and quality has been significantly improved. The low-voltage circuit loss per unit has decreased from 25% before reconstruction to about 12%. It has now partially achieved automatic regional scheduling or county-level scheduling. The function meets the SCADA technical requirements and practical standards. At the same time, China vigorously promotes automatic substations. The rural 35kV and 110kV substations are adopting comprehensive micro automation systems, partially realizing operations requiring no or few personnel. Based on vast engineering experience and technological achievements, the Ministry of Water Conservancy has published technical standards concerning planning, designing, construction, quality, management, test and equipment of small hydropower, thus forming a small hydropower technical standard system with Chinese characteristics.

Over several decades of development, the technical features of China’s small hydropower can be summarized as below:

1) Openness. As an important rural energy, small hydropower is especially suited to a wide variety of rural areas; thus small hydropower technology is open, may easily be assimilated by people, facilitates the utilization of local human resources and

available materials, and permits independent development and management of local small hydropower resources. Based on the concept of self-reliance, it gradually resolves the power supply issue in China's mountainous area.

2) Adaptability. Small hydropower technology is also adaptable. Based on local economic and social development, mature and practical small hydropower technologies with local characteristics may be selected.

3) Economic efficiency. Small hydropower technology is of high economic efficiency due to reduced development and operation cost. In addition to local participation and full utilization of local materials and domestic equipment, it requires that development and operation management technologies unique to small hydropower construction and of high quality-price ratio will be adopted for all stages from site planning to power generation. Small hydropower equipment technology clearly reflects unique industrial features of simplification, standardization and automation.

3.2 Small hydropower technologies suitable for Ghana

(1) Development model of China's small hydropower

Based on many years of exploration and development, small hydropower development in China has achieved great success and its development mode and experience can be learned by Ghana. Small hydropower development may simultaneously provide three benefits. The varied expectations of investors (including government, economic organizations and the private sector) largely determine the development model of small hydropower:

1) Ecological development model. It refers to rural hydropower development aimed at ecological construction with the objective to produce ecological benefits. As a clean and renewable resource, small hydropower can be developed and supply locally. Replacement of small hydropower for fuel enables protection of forest resources, reduces harmful gas emissions and improves ecological environments. Combination of rural hydropower and ecological environmental protection has become a new development model.

A major theme within the ecological development model is the SHP Replacing Firewood Ecological Protection Project approved by the country. Following project implementation, firewood consumption will be greatly decreased, protecting the environment and generating ecological benefits.

Given that the small-hydropower-replacing-fuel project mainly aims at integrating ecological, economic, and social benefits, government investment should serve as the primary support, while encouraging public investment participation. Diversified investors requires clarification of project property rights, enterprise-like operations, and assurance of reasonable investment returns (adopt low payback). For example, for the pilot small-hydropower-replacing-fuel project in China, the government will provide 30% to 50% of total investment and the remaining will be borrowed from banks. The small-hydropower-replacing-fuel project should meet the following conditions: First, financial internal rate of return should be above 10%, ensuring normal operation of the project, repayment of capital and interest, as well as preservation and appreciation of state-owned capital. Second, the electricity price should not be too high and should be affordable for the farmers. To meet the conditions, according to local economic conditions, the electricity price shall be determined initially and the investment funds required by the government then calculated. The investment model for small-hydropower-replacing-fuel project development incorporates government investment, bank loans, and end-user participation.

2) Rural electrification development model. Through rural hydropower development, power supply and grid construction, rural electrification is constantly improved. Aimed at promoting electrification construction, it advances economic and social development through electrification and producing significant social benefits. In spite of the considerable success of rural electrification construction in China, the development model also applies to conditions unique to Ghana such as low electrification levels and low rural power utilization per capita. China's rural electrification

development model thus may also serve as a main model in Ghana for future small hydropower development.

Rural electrification construction is a long-term process, requiring the establishment of a scientific, effective and stable investment construction mode. Firstly, rural electrification area, as well as the main development and construction entities, should all be fairly stable. Economic entities, rather than administrative departments, should be the main sournce for development and construction. Secondly, specify contributors of the state-invested rural electrification fund, verify assets and capital as well as clarify property rights of economic entities like local hydropower and rural electrification companies undertaking rural electrification construction, and specify the responsibilities of rural electrification construction and operation. State-invested electrification funds should provide a reasonable payback (low return). Implement roll-over development for guaranteed appreciation. In conclusion, the investment mode for rural electrification projects incorporates government investment, bank loans, and investment from electrification implementation entities.

3) Private sector development mode. The objective of this mode is to realize economic benefits and maximize capital profits. It has served as an important development model for rural hydropower in the new era. Under prevalent market economic conditions, equal emphasis is given to public and private investment, and active guidance of various market players in entering the rural hydropower market thus accelerates rural hydropower development and utilization and benefits rural communities. Recently, private investment in rural hydropower development has very popular. Experience has demonstrated that private investment will accelerate development, relieve government financial stress, promote local economic development, increase financial income, and create more job opportunities while also providing investors with reasonable benefits, thus realizing multiple social, ecological and economic benefits.

The private investment development mode relies on the market mechanism and encourages private sectors to invest in rural electrification development. First, the ownership and right of use of the resources should be specified. The country owns the ownership while the right of use is transferred to the user, which should be confirmed through a contract. The investor develops and operates independently, and is thus responsible for any profits or losses. A market price mechanism should be formed, through which the electricity price is determined and reasonable investment return ensured. In addition, the investor should be compensated for social and ecological benefits generated during the hydropower resource development. The investment mode for private development includes private investment and bank loans.

(2) Analysis of key points of small hydropower development

1) Favorable cooperation with local demands

Since small hydropower resources are distributed across rural areas, and in particular mountainous areas, small hydropower development in China is suitable for distributed development, and local network and power supply. This distribution integrates well with local economic development, allowing each locality to independently develop its resources, form its assets, occupy markets and build its industry.

2) Combine with local economic development

China boasts abundant small hydropower resources, with 62.1% concentrated in the southwest area. Rich hydropower resources are a priority for exploring and promoting local economic development. Therefore, we should learn from the comprehensive drainage basin international development experience and adopt diversified investment modes. The close combination of small hydropower with tourism resources allows mutual promotion and produces a win-win situation.

3) Path for merger and acquisition

The power sector in China is naturally monopolized and the normal state for market competition pattern is oligopoly competition. However, due to complex investment entities within China’s small hydropower enterprises, a large number of old, small and self-generation power plants, and low market concentration, the few large enterprises face a huge gap between them and domestic and foreign large power enterprises. Moreover, most small hydropower enterprises affected by outdated equipment, high production costs, excessive duplication of construction, poor anti-risk capabilities and low competitiveness. However, of particular interest to investors is their favorable location. Stable water resources ensure normal power generation and supply, creating a key point for merger and acquisition. Through strategic merger, investors can enter the small hydropower industry, adjust its operation structure and even the entire industry chain structure, speed up technical reform and operation process reengineering, and thus more quickly achieve the objective of enhancing enterprise strength, and of growing and strengthening enterprises.

With consideration of national conditions, national policies, water power resources and resource development in Ghana, select a mature and suitable technology model for small hydropower development in the country. Through South-South cooperation of China-Ghana renewable energy technology transfer, transfer the technology to Ghana and help to improve small hydropower development and construction capacity.

4 Biomass Energy Technology That Can Be Transferred from China to Ghana

Ghana is one of the relatively developed countries in West Africa. Since 2000, it has averaged economic growth 6.4% annually. However, the country is still suffering poverty and high unemployment rate. In Ghana, wood fuels account for over 70% of total primary energy supply and about 60% of the final energy demand. The demand for wood puts Ghana’s forests under tremendous pressure and has severe consequences for the ecosystem as a whole. Deforestation rates (3% per annum) in Ghana are amongst the highest in Africa. Therefore, Ghana needs to develop more forms of energy. In terms of biomass energy, the country needs to improve the energy utilization efficiency, ant take full advantage of agricultural and forestry wastes instead of forest timbers. As agriculture is the leading industry in Ghana, numerous agricultural wastes are produced every year. For example, there are 553,000t corn stalks and 19t rice husk per year. There are also many livestock excrements and municipal wastes produced every year in Ghana. These raw materials can be used to produce biogas to be used as cooking energy for farmers. China has a long history of biogas development, boasting mature technologies and rich experience. Especially, the household biogas digester is a biomass energy technology that is appropriate to be transferred to Ghana.

Chapter 4 Barriers and Solutions to China-Ghana Small Hydropower Technology Transfer

1 Barriers of China-Ghana Small Hydropower Technology Transfer

Even though we have accomplished significant achievements in developing and utilizing renewable energy, and constantly improved related regulations and policies, renewable energy development still cannot adequately meet sustainable development needs, primarily because:

1) Poor policy and incentive measures. Under the existing technical merit and policy environment, only hydropower and solar water heaters are capable of market competition. Most renewable energies nonetheless bear high development and utilization costs. In addition, the distributed resources, small scale, discontinuous production and absence of competitiveness under the present market rules all require policy support and incentives. Currently, the policy system for wind power, biomass energy and solar energy is not adequate; the economic incentive is weak; the policies are barely coordinated and unstable; and there is no long-term mechanism supporting the sustainable development of renewable energy.

2) The market security mechanism is incomplete. For a long time, China has lacked explicit development goals for renewable energy and there is no continuous and steady market demand. Although support for renewable energy has grown, there are no compulsory market security policies, stable market demand or market drive. Consequently, renewable energy technology develops slowly in China.

3) Poor technology development capacity and weak industrial system. With the exception of hydropower, solar energy and biogas, the technology of other renewable energies is at a low level, and lacking technical R&D capacity. At the same time, the equipment manufacturing capacity is poor. For that reason most of the technologies

and production equipment are imported. The technical level and production capacity lags far behind that of foreign counterparts. Meanwhile, the evaluation, technical standard, product testing and certification systems of renewable energies are defective; personnel training fails to meet the demand of rapid market development; and there is no technical service system supporting the industrial development of renewable energies.

Despite the generally favorable regulatory and institutional environment, there are specific challenges hindering Ghana's progress towards achieving universal access to energy, ensuring a more developed and widespread use of energy for local economic development, and in this specific case, pushing forward the renewable energy sector:

At the upstream level, there are still gaps in the overall regulatory framework:

1) The Government is yet to develop a Renewable Energy Master Plan to design specific actions to put the Renewable Energy Act into implementation.

2) The established Renewable Energy Fund is yet to be resourced and detailed strategies to mobilize the necessary funding are yet to be defined.

3) The Renewable Energy Authority, necessary to form partnerships with private operators for PPP implementations, is yet to be established.

This situation, together with serious challenges related to the financial solvency of the power sector (the generation, transmission and distribution utilities), is hampering the involvement of the private sector in the renewable energy sector, despite the high level of interest shown both by national and foreign investors.

At the downstream level, there are several gaps, including:

1) Poor business development capacity of key project implementers/managers, service providers and beneficiaries of renewable energy projects

2) Limited business-oriented models and robust results-based planning, monitoring and evaluation indicators and targets for renewable energy projects to ensure their long-term impact and sustainability.

3) Inadequate use and leverage of technical and research institutions.

4) Inefficiency in the operation and maintenance of machinery and equipment,

and in the adoption of technological improvements and upgrades.

5) Cultural constraints – e.g. many rural communities still regard renewable energy an inferior forms of energy.

6) Difficulty for investors to identify matured bankable projects with proper documentation and scale potential.

A key challenge, affecting in particular small and medium size private investors, is the inability to obtain credit or loans to finance their investments in the sector. This is partly due to the fact that the financial sector does not have strong risk mitigating instruments such as partial risk guarantees and renewable energy payment agreements to provide the needed assurance. An important factor in engaging the two sectors is the need to equip the private sector and especially the financial sector with knowledge of the renewable energy industry. This would be crucial in developing and offering the long-term financial products required by the sector.

2 Experience of solar energy development and utilization in China and related suggestions to Ghana

2.1 The phenomenon of abandoning light exist

Source property constraints: photovoltaic power generation with random, intermittent and Volatility;

Resources and load centers are in a reverse distribution: China's solar energy resource rich regions are often far away from the load center power, the developed area of power load is large, while wind energy resources are relatively scarce; the wind energy resources of the northern part is rich, while the power demand is small. Ghana needs to consider the relationship between resources and load.

Peak capacity is insufficient: The system leads to the power structure Chinese coal based regulation means is single, "Wind, light" enrichment of the north area of a larger proportion of heating units; pumped storage, gas stations and other flexible adjusting power is insufficient.

Net source construction is not synchronized with the ability to send out: the new energy construction cycle is short, the power grid supporting projects and new energy projects are not synchronized; partial wind power in the region to send channel blocking, the grid structure is weak; the provincial and inter regional power grids need to be further strengthened.

2.2 The quality problems of engineering and equipment cannot be ignored

The new energy project construction period has the characteristic of "short, flat, fast", There’s problem on rush deadlines while ignoring the quality .

Engineering design, construction, supervision and management of the unit engineering quality is uneven, it is difficult to guarantee the quality

The quality of photovoltaic components is uneven frequent fan pour tower, blade rupture, photovoltaic components decay rate is too high, the photovoltaic component of spontaneous combustion and other quality problems; lack of enough attention in the engineering quality management.

2.3 Renewable energy tariff subsidy funds management work should be strengthened

At present, the national renewable energy development fund has a single source, additional tax subsidy is difficult, and the subsidy funds are lagged. Some wind power and photovoltaic power generation development enterprises have the problems such as cash flow difficulties and losses.

The new energy project approval decentralization, the local government will take the local new energy development as the center, to further accelerate the pace of the construction of local new energy projects, new energy enterprise capital demand will be greater, the existing subsidies will be more difficult to meet the needs, the new energy industry may face a severe shortage of funds

In 2020, photovoltaic power generation and grid sales price considerable development goal bring great challenges for the healthy development of power and the price mechanism reform of the "Thirteen five period" PV.

2.4 The current energy system cannot meet the rapid development of the new energy industry

The existing energy management and operation mechanism are established according to the characteristics of conventional energy, and the regulation and operation management mechanism can regulate the conventional energy, which has poor adaptability to the changes of wind power and solar power.The technology management system is not conducive to accommodate large scale renewable energy source.

The existing power exchange mechanism, the electricity price mechanism, the electricity management and so on is good for the conventional energy, it is difficult to adapt to the large-scale development and utilization of renewable energy.

3 Barriers to wind energy Development

There are multiple barriers to making and enacting RE policies, including lack of information and awareness about RE resources, technologies and policy options; lack of understanding about 'best' policy design; difficulties associated with quantifying and internalizing external costs and benefits; and a lock-in to existing technologies and policies. The outstanding barriers to RE development in China are described in the following section.

3.1 Weak and incomplete incentive and supervision mechanisms

The most burning issues facing RE development in China are technical and economic challenges. Although RE has experienced rapid technological innovation and has become increasingly economically competitive, it remains at a stage where technological development is rapid, but costs remain relatively high (except for hydropower and SWH).

China's energy authorities implemented subsidies, tax and R&D policies and various other measures to encourage the development of RE, as mentioned in the RE Law, but related supporting policies have not been worked out. With the rapid growth of RE, investment in R&D, and subsidies increased as well, however the fact that electricity generators have been getting the subsidies two years after the increased capacity came into operation shows that financial and managerial instruments are not yet effectively in place.

3.2 Lack of policy coordination and consistency

In a patter which is different to the traditional energy system, responsibility for China's RE business is divided among a number of sectors, making it difficult to have a consistent energy policy and to plan for RE in the total energy system (Zhang, et al., 2009). This has at times yielded rather irrational development patterns of Chinese RE resources and has resulted in the rapid growth of abandoned RE power. For example, wind power and solar PV manufacturers are two very representative industries, which experienced from the beginning rapid development, but then to serious overcapacity (IEA, 2012; Li, 2012; Cleantech, 2012). In 2011, one-third of Chinese PV manufacturers closed down, and, out of a total of 11 Chinese PV manufacturers listed on US stock markets, nine suffered huge losses (ifeng.com, 2013). Also, part of the electricity generated in Inner Mongolia has to be transferred to the North China grid because of limited local consumption capacity. However, with the construction of the HeBei wind power plants there is no room on the North China grid to accept more electricity from Inner Mongolia, which further undermines the market for Inner Mongolian wind power. And the often long distance between RE resources and electricity demand markets also exacerbates the urgent need for policy coordination.

3.3 Conflicts between renewable power generators and grid

companies

In China, electrical system operation and management has focused mainly on large electrical generating sources and large grids, and is therefore not well-suited for integrating renewable but intermittent power systems. The challenge for power system operation has increased with the growing scale of RE development. According to SERC (2011), a total of 2,800 GWh of wind-generated electricity went unpurchased during the first half of 2010. The reasons for this could include the lack of regulating methods for implementing the government's mandatory quotas of RE carriage for power grid companies; the fact that no transparent and powerful supervision instruments are in place (Chen and Zhu, 2012); and the mismatch between wind power and other power resources in Northeastern China.

On the last point, a high proportion of co-generation facilities are used to supply both electricity and heat in the winter season in Northeast China (e.g. 72% in Jilin Province). These units basically do not have peaking capacity during the winter season; while the middle and small thermal power units with peaking capacity have been gradually shut down since the beginning of the 11th Five-Year Plan period. Against a background of serious shortages in power peaking capacity, grid management entities in Northeast China have been forced to restrict wind power generator access to the grid to protect electricity network stability and residents' heating supplies.

3.4 A lack of innovation in R&D and regional policy

China has established an industry system through introducing, assimilating and absorbing technologies from abroad. Most of the core technologies are therefore imported. Independent innovation, technology upgrading and talent-grooming are crucial to the internal industry. Both the government and the industry must increase its R&D contribution to RE so as to improve technological levels.

Furthermore, measures have yet to be adjusted to local conditions in terms of existing regional RE policies. Because of the large differences between the different regions of China, the state's macro policies are not equally applicable for each region. Local governments are uniquely positioned to develop a campaign that more directly resonates with local citizens because it can be tailored to the local circumstances (Busche, 2010). The national government should therefore enhance the regulatory capabilities of provincial authorities and switch from nation-wide policies to policies that target measures to the different regions based on local conditions.

4 Obstacles and countermeasures for China-Ghana transfer of renewable energy technology

The Republic of Ghana, with a population of 24 million, is listed as a middle-income country with per capita gross domestic product (purchasing power parity) of USD $2,500. Located near the coast, it is close to Ivory Coast and Togo. Since 2000, the country has witnessed an annual economic growth of 6.4%, even exceeding 7% in recent years. However, a high unemployment rate still prevails in the country, particularly among its young people. Poverty still presents a substantial development gap the north and south areas.

By May 2013, Ghana had 2,578 MW of installed power capacity mainly composed of hydropower and thermal power. In 2013, the peak power demand was 2016 MW, and growing at an annual rate of 8%. Due to fuel supply and hydropower generation limits, as well as difficulties in hydropower generation equipment maintenance, the existing power plants are not equipped with sufficient power generation capacity.

In the following section we will analyze the key features and differences between hydropower development and operation in China and Ghana which may bring about obstacles to the technology transfer, and suggest potential countermeasures.

4.1 Obstacles for China-Ghana transfer of renewable energy technology

Currently, final energy consumption in Ghana is very low, with over 56% originating from traditional wood fuel. Fuel for cooking mainly consists of firewood, charcoal and natural gas, while electricity consumption only accounts for 8.4%, resulting in substantial environmental and human health impacts. Moreover, while Ghana has made extensive efforts to supply power to the country and achieved a national electrification rate of 70%, a 40% electrification rate in rural areas severely hinders local development. Electricity provides lighting, commercial opportunities, access to water and medical care, and connects rural communities with urban centers through information technology. However, the rural power network is faced with geographic barriers and financial limitations. The government of Ghana aims to achieve overall electrification by 2020, among which renewable energy (including small hydropower less than 100MW and excluding large hydropower higher than 100MW) accounts for 10% of the total installed capacity. In addition, hydropower provides a favorable price advantage with the electricity price of hydropower stations at 4-8 cents/KWH; in comparison, diesel oil and light crude generation costs are at 25-40 cents/KWH, thus not suitable for rural electrification; the cost of natural gas is 8-12 cents/KWH, and requires dependency on the natural gas transmission of the West African natural gas pipeline that limits reliability. Thus, the demand in Ghana for renewable resources, especially hydropower, is huge.

The government of Ghana has attached great importance to hydropower resource development with a 2,420 MW potential installed capacity that may be developed by hydropower technology. Currently, hydropower generation capacity accounts for 67.5% of the total generation capacity, with most deriving from the two established large power plants. Large and small hydropower developments vary greatly in basic objectives, technology and fund requirements, environment and social impact. Moreover, Ghana lacks requisite experience for small hydropower construction, as well as relevant technology, equipment, professional talents and supporting policies. The installed capacity of small hydropower in China accounts for half of the global capacity and thus China has accumulated abundant experiences in planning, design, engineering construction, equipment manufacturing, operation management and supportive policies.

Ghana has 22 micro-hydropower sites (less than 1MW) that can be developed and between 5.6 and 24.5 MW of power generation potential. Most sites are located on rivers with high lead. Among them, most of the areas depend on the tourism industry as the main economic source. Therefore, river development aimed at power generation will undoubtedly affect managers of the tourism industry, making the combination of hydropower generation with the existing tourism industry a key issue. Nevertheless, some potential hydropower sites located downstream possess favorable head and embankment conditions. The rivers can be better managed with barrage construction, facilitating operation of the hydropower plants.

Main obstacles of small hydropower development in Ghana:

1) Lack of data sources required for small hydropower station development;

2) Lack of preferential financing policies for private developers of small hydropower;

3) Ghana has many rivers with substantial riverflow for developing small hydropower stations, while large runoffs have stream flows that change according to the season with the potential that small rivers may dry up.

4.2 Insights from China's experience for small hydropower development in Ghana

Small hydropower promotion projects in China, such as "Send Electricity to Villages", "SHP Replacing Firewood Ecological Protection Project" and "Rural Hydropower Electrification" are of direct relevance for Ghana. China aims at achieving 75,000 MW of installed hydropower capacity in rural areas by 2020. Through the "Lighting Up Rural Africa" project, China has shared these achievements and experiences in many African countries. Based upon successful experiences developing small hydropower in China, and aimed at future small hydropower development in Ghana, suggestions are hereby put forward from the dual perspectives of national policies and financial mechanisms.

Development of small hydropower will generate multiple benefits, and concern economic and social development, environment improvement, energy construction and investor relations. For future development, the following policy issues should be handled with priority.

1) Implement a unified management system for water resources. In spite of its renewable status, total amount of water resources is limited. Thus, they should be scientifically and responsibly developed and utilized with high efficiency and energy conservation. In particular within a market economy, the participation of various investors in rural hydropower markets may lead to haphazard development resources waste. The government should formulate unified management policies, including management ownership, planning ownership and procedures, a development permission system and market access system.

2) Formulate preferential tax policies. Preferential tax policies should be implemented for small hydropower development to encourage private sector investment. Reference can be made to Chinese policies for hydropower development including "two-year exemption and three-year half-taxation of hydropower enterprises for corporate income tax" and "VAT of 6% for rural hydropower enterprises". Meanwhile, actively formulate energy and environment tax policies, and set emission charges for environmental pollution especially emission of greenhouse gases like CO2 during power generation; feeds collected will be used for subsidizing rural hydropower and other clean renewable energy construction.

3) Formulate financing policies conducive to small hydropower development. Firstly, given of the public welfare benefits of small hydropower, the government should support small hydropower construction from the aspects of financial budgeting, financing channel and credit loan. It is suggested to include investment for small hydropower construction into the financial budgets of various levels, and to direct financial funds primarily towards fund allocation and technology upgrades. Open the market to absorb social, foreign and private investment, securing diversification of investors and comprehensively financing small hydropower construction from multiple channels. Secondly, financial institutions should provide rural hydropower

construction with preferential soft loans. Large national banks should set loans designated for small hydropower, expand credit scale, extend repayment terms and implement subsized or low-interest loans.

5 Suggestions on Biogas Technology Transfer from China to Ghana

China's biogas industry has undergone more than 80 years of research and production application. China-style biogas technologies and development models have taken shape. Based on the national conditions in Ghana, we suggest as follows with respect to China's transfer of biogas technologies to Ghana:

1) To strengthen dissemination. It is necessary to teach the government staff about the function and significance of developing rural biogas, improve the awareness of government staff at all levels; teach the farmers about the benefits of biogas and how to use it, enhance their consciousness and initiative of developing biogas; let all social circles know that biogas can really solve the farmers' and rural benefit issues, and accept such new energy.

2) Improve policies and regulations. The government of Ghana shall introduce encouragement and fiscal/tax policies and regulations. Especially at the initial stage of development, financial support is essential. Due to the widespread poverty in rural areas of Ghana, ordinary farmers cannot afford the lump-sum construction investment of biogas digester. The government of Ghana shall present special funds to support the construction of biogas digesters. Along with the development of biogas, the government may encourage and guide social organizations to participate in the rural biogas construction, while offering support to these social organizations in respect of policy and tax.

3) Establish perfect biogas management and promotion system. Based on China's experience in biogas development, the management of biogas industry is very important, especially the maintenance management. In the initial period of construction, it is necessary to consider the post-construction maintenance issue, set

up special service stations, and offer training for service personnel to ensure any problem of the biogas digester can be solved without delay when it occurs, and improve the public's confidence in using biogas.

4) Carry out demonstration first in Ghanaian areas with political stability and better economic development, summarize and extend the experience of successful demonstration households and villages to more areas. Priority should be given to simple household biogas to facilitate the cooking and heating of common people; when the simple household biogas can be applied maturely, efforts can be further made to develop comprehensive utilization technology, then develop medium- and large-sized biogas projects.

5) Improve local technical innovation level. Many practical technologies of biogas fermentation include fermentation process, fermentation principle, raw material treatment process, raw material ratio, fermentation dynamics, fermentation equipment, gas transmission and distribution equipment, supporting equipment, and biogas combustion equipment, etc. Considering the long-term development, the technical competence of local people should be improved for biogas to develop in Ghana in a sustainable way. The government of Ghana shall integrate colleges and universities, research institutes and producers into a technical cluster, build a strong technical team, make greater efforts to the development and application of biogas production, conversion, utilization technologies, and constantly improve the independent innovation capacity for rural biogas development.

6) Set up the China-Ghana biogas technology transfer platform. In the initial period of development, qualified Chinese organizations or companies can be selected through the platform, to visit Ghana to offer assistance for biogas digester construction and personnel training. Through the platform, China's biogas equipment and other products can be exported to Ghana, which then can be produced locally in Ghana. This platform will help strengthen the cooperation between research institutes from China and Ghana, especially, the technical training offered by China for Ghana.