



China's New and Renewable Energy Situation

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Executive Summary

New and renewable energy plays an important role in the energy supply system of China. After the UN conference on Environment and Development in 1992, China formulated the *Ten Countermeasures for Improving Environment and Development*. It was affirmed in the document to make great efforts to disseminate the utilization of new and renewable energy, such as solar energy, wind, biomass, geothermal as well as tidal and ocean energy according to the local resources available, and it was reaffirmed in *China 21 Century Agenda* announced in March, 1994 that the development of new and renewable energy is important to sustainable development.

China is a developing country housing over 1.2 billion population, approximate 900 million of which living in rural areas. Presently, 70% of rural domestic fuel comes from biomass (firewood and straw). In 1996, the consumption of biomass reached 219.33 M tce taking up over 35% of the total rural energy consumption, and the consumption of firewood exceeded 30% the volume of sustainable yield. Now, there is still some rural population living without electricity and under the level of poverty condition. Therefore, the development of new and renewable

energy is not only an important measure for sustainable development; it is also an important way to shake off poverty for rural residents.

New and renewable sources of energy are rich and widely distributed in China (Table1). Since the 1980s the implementation of the principal of *integrated and comprehensive use of various energy sources available locally* has made great progress. (Table2). In 1995, the volume of new and renewable energy supply in Chinese rural areas reached 300 Mtce of which small hydropower contributed 29.20 Mtce, micro hydropower 82.4 ktce, firewood contributed 115.7 Mtce, domestic biogas 1.05 Mtce, district supply biogas 31 ktce, electricity used biogas 1.2ktce, solar energy stove 50.3 ktce, solar energy heating water 642 ktce, solar energy greenhouse 1.22Mtce, solar passive house 277 ktce, geothermal energy for planting and breeding 803.9 ktce, wind energy 15.3 ktce.

The general objective is to improve conversion efficiency, reduce cost, increase the fraction of new and renewable energy in the energy consumption structure, to make innovation in technology and put mature technology into mass production to create a new and renewable energy industry and service system.

Table 1: China's New and Renewable Energy Resources

Name	Theoretical potential	Economic potential
Small hydropower		76GW(less than 25MW)
Biomass:		
Straw and stalks	700Mt	280~350Mt
Firewood	158Mt	158Mt
Industrial organic waste water	22250Mt	
Waste from chick, cow and pig farms	403.36Mt	37.16Mt(dry material)
Solar energy (The average gross of annual solar radiation)	5.02GJ/m ²	
Wind energy	3226GW	253GW
Geothermal energy	200 Gtce	3.16 Gtce
Ocean energy	40~50 GW	21.7 GW

Table 2: Progress in New and Renewable Energy in Chinese Rural Areas in 1991 and 1995

Item	1991	1995	Annual Growth (%)	Energy Provided (ktce)
Small Hydropower (GW)	13.8	19	8.2	29200
Micro Hydropower (kW)	128600	192000	10.5	82.4
Firewood (M ha)	4	5.6	8.9	115700
Biogas Digesters (M households)	4.75	5.7	4.6	1051.7
Big and Middle-size Biogas plants (Households supplied)	68500	84000	5.2	31
Electricity for Biogas (kW)	2288.7	2560.7	2.8	1.2
Solar cooker (unit)	125000	142000	3.2	50.3
Solar water heater (M m ²)	1.28	4.49	36.8	642
Solar greenhouse (M m ²)	255	342.3	7.6	1221
Solar passive house (M m ²)	0.66	3.3	49.8	277
Geothermal planting and breeding (ha)	2227.2	4019.5	15.9	803.9
Electricity for wind energy (kW)	17000	18700	2.4	15.3
Total				300006.6

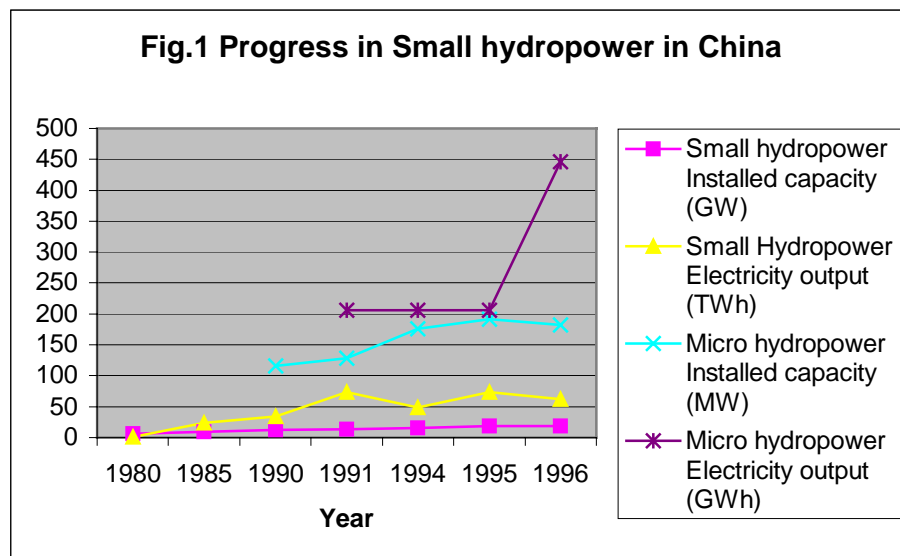
Small Hydropower

There are 76GW exploitable small hydropower resources (less than 25 MW) in China. The development and use of small hydropower resources plays an important role in speeding up rural electrification. The state and local administration assist the construction of small hydropower stations with loans on favorable terms. By the end of 1994, more than 6,000 small hydropower stations had been built with a total installed capacity of 15.5GW, producing electricity 49TWh and accounting for 54% of the rural electric power consumption. 780 counties (accounting for 36% of the total) have power supply mainly from small hydropower in China.

In addition, the micro-hydropower (capacity less than 10kW) develops rapidly in recent years, there were more than 60,000units in 1994 with total installed capacity of 176MW supplying electricity for 600,000 rural households, see Table 3 and Fig.1.

Table 3: Progress in small hydropower in China

	1980	1985	1990	1991	1994	1995	1996
Small hydropower Installed capacity (GW)	6.93	9.52	12.5	13.85 3	15.65	19.0	19.02
Small Hydropower Electricity output (TWh)	1.27	24.2	34.1	73	49	73	61.693
Micro hydropower Installed capacity (MW)			116	128.6	176	192	182 (1997)
Micro hydropower Electricity output (GWh)				206	206	206	446.6



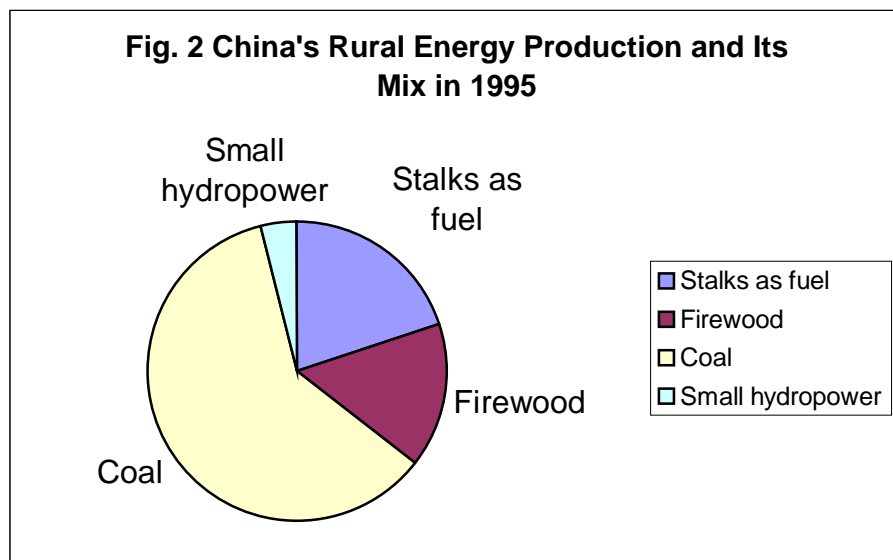
Biomass

Biomass energy supplies a considerable part of Chinese energy consumption especially in the countryside. At present, the total consumption of biomass energy in China, including stalks, firewood and other kinds of organic waste, was equal to about 260 Mtce each year, which make up over 25% of the total energy consumption in the country. In China's rural areas, it accounts for 70% of the domestic energy consumption, or 40% of the total energy consumption, see Table 4, Fig. 2.

Table 4: China's Rural Areas Energy Production And Its Mix in 1995

Unit: M tce

Item	Quantity
Stalks as fuel	150.92
Firewood	115.7
Coal	455
Small hydropower	29.2
Total	750.8



Biomass for Fuels

There are about 900 million people in Chinese rural areas, meeting their need for energy mainly depends on biomass energy. China needs to develop advanced technologies in biomass. In 1997, the Central government announced *prohibition of cutting trees in the area of the Upper Reaches of Yangtz River for the farmers and forest companies*, in 1999, the scope was extended to overall country. How to resolve the problem of rural energy is urgent for Chinese government. Generally speaking, the experts think that the development, demonstration and promotion for high-efficiency and practical biomass technologies is the best way to resolve rural energy problem.

Firewood and straw

Firewood of China may be roughly divided into 5 management categories.

1. The type of short-term rotation in a flat stubble operation. It is suitable for various climatic zones and any site condition good for firewood. This operation is characterized by that a part of firewood is cut annually from ground and a rotatory cutting is completed in several years. As far as a certain plot of firewood is concerned, through such an operation of rotatory cutting and further sprouting, the purpose of planting is one time, harvesting in many times and benefiting for long period can be achieved. The production for first time averagely reach 12.45-38.77 ton per hectare. In China, this kind of firewood is usually the species of black locust and eucalyptus.
2. The timber and firewood management type. This type has a wide adaption to various climatic zones, but the site condition should be up to the medium level and the areas should ensure normal growth of plants without irrigation. The specific operations are: the composition for the firewood and timber species should be well arranged in a plot with row and strip intercropping (the timber species accounts for 1/5, while firewood species about 4/5). This type of management takes producing firewood as mainstay and simultaneously producing timber, which would have a promising prospect in the area of shallow hills extremely short of both firewood and timber.
3. The firewood and cash crop management type. It is suitable for various climatic zones. The local firewood species with multi-function will be selected, which produce mainly firewood and simultaneously fruit, seeds, leaves, barks, etc.
4. The firewood and grass management type. It is suitable for the arid and semi-arid areas in Northern China and is a composition of planting trees and grass in an intercropping process of rows and strips.
5. The basal trunk firewood cultivating management type. It is suitable for all the roadsides, the banks of rivers, canals, lakes and ponds, in front of and behind the houses in plain and hilly areas of various climate zones. The specific technical requirements are that the tree species with strong germinating force in the higher position of the trunk and the tree crown stand-able for shearing should be selected, such as williows, Siamese senna, black locust, eucalyptus, London plane tree, etc.

The situation of firewood and straw use in China's rural areas see Table 5, Table 6, Table 7, Fig.3, Fig.4 and Fig5.

With the development of China's economy, the rural areas energy consumption structure is changing drastically; high-quality energy such as electric power, oil, natural gas as well as coal will replace stalks as fuel, so the volume of stalks as fuel used in rural areas will drop gradually.

Table 5: China' Biomass Energy Consumption And Its Forecast

Unit: M tce

Year	Consumption and demand forecast
1979	234
1980	229
1985	245
1990	263
1995	221
1996	219
2000	210
2005	195
2010	181
2015	168
2020	151
2025	137
2030	127

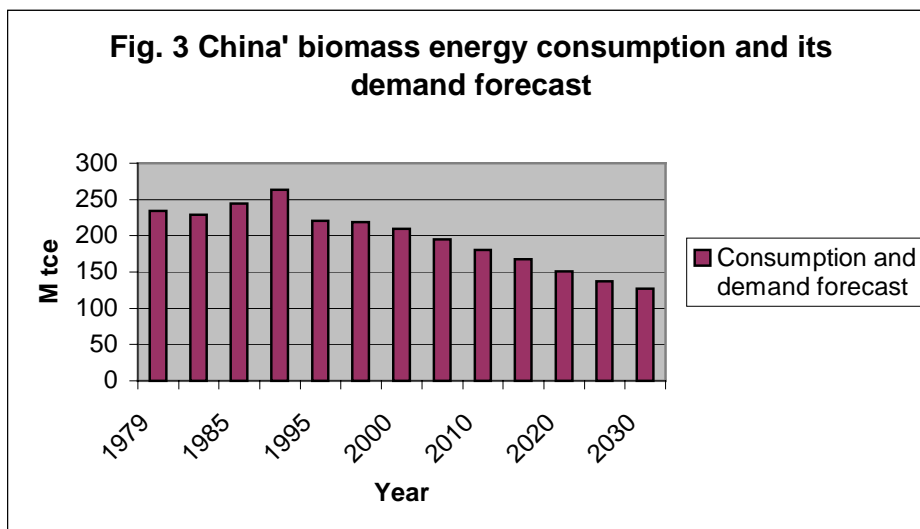


Table 6: The planted area for firewood And Its Production In China During The Period Of 1991-1996

Year	Planted area (M ha)	Volume of cut (Mtce)
1980	3.34	111.20
1985	5.54	121.50
1990	6.26	131.40
1991	4.00	120.85
1992		110.30
1993		106.30
1994	6.00	110.30
1995	5.62	92.39
1996	5.60	120.00

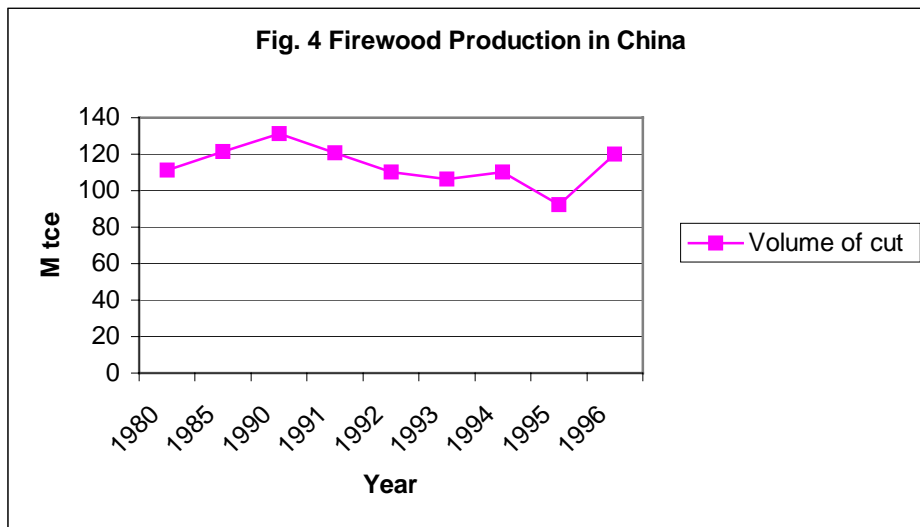
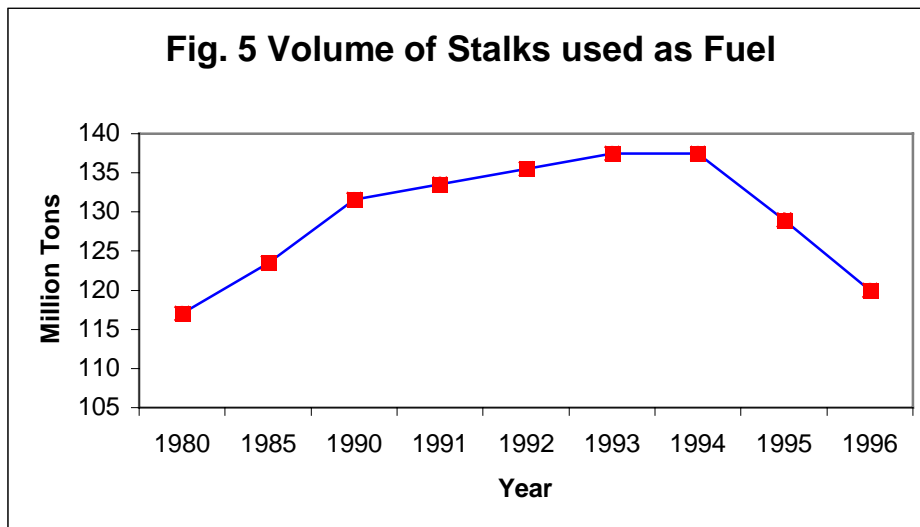


Table 7: The Volume of Stalks used as Fuel In Chinese Rural Areas During The Period of 1980-1996

Unit: M tce

Year	Volume of Stalks used as Fuel
1980	117.00
1985	123.50
1990	131.60
1991	133.55
1992	135.50
1993	137.45
1994	137.45
1995	129.00
1996	120.00



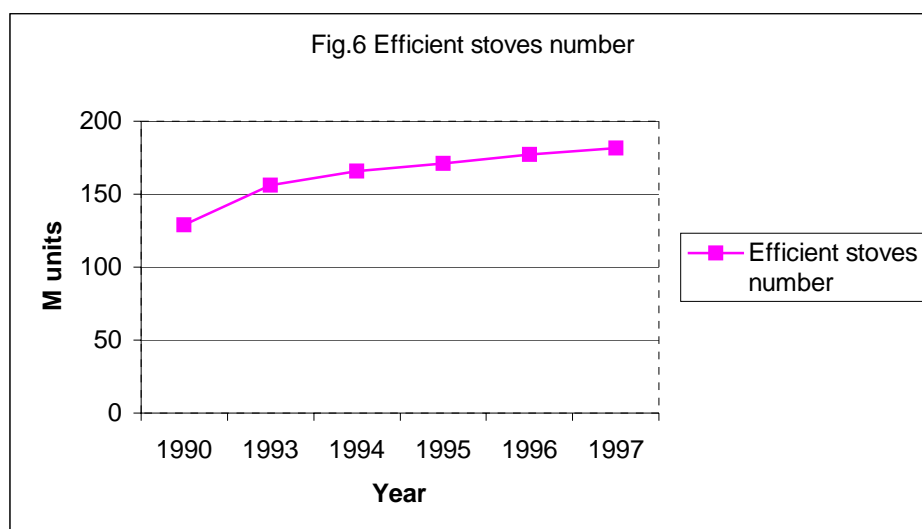
Efficient Stoves

In recent years, Chinese government spares on efforts to disseminate efficient stoves in rural areas and has got fruitful results. By the end of 1997, there were 182 million rural households using efficient stoves, accounting for 80% of the total. The thermal efficiency of the new stoves was above 20%, doubling that of the old ones, see Table 8 and Fig. 6.

Table 8: The Efficient Stoves Number used In Chinese Rural Areas during The Period Of 1990-1997

Unit: M household

Year	Efficient stoves number
1990	128
1993	156
1994	166
1995	171
1996	177
1997	181



Biomass Gasification

China is the biggest biogas consumer in the world. In 1994, 5.43 million domestic biogas digesters (180,000 more than that in 1993) producing biogas 1350 million (heat value 21-23 MJ/) served cooking fuels in rural areas. 583 medium/large biogas supply systems using organic wastes as raw materials supplied biogas for 84,000 households in towns and small cities as daily cooking fuels. 154 units of biogas-powered electricity generating systems had been built with a total installed capacity of 3 MW. Using anaerobic digestion technology, 30,000 units of sewage treatment system have been built in a few small towns for 2.9 million people's waste treatment, see Table 9, Table 10 and Fig. 7.

In recent years, the use of digested sludge as fertilizer has been disseminated and got economic, environmental and social benefits. For example, in Liaoning province, there are 62,800 households having biogas digesters built in greenhouses integrated with pigsties/toilets. 62,000ha of land are cultivated with seeds soaked with the digested slurry and got 5% increase of grain output.

Thermal biomass gasification equipment using waste to produce clean gas for timber and agricultural products drying, heating and cooking, has been put in trial production, at present, its annual sales volume is only 100 and more, and there are 800 units with 200-600 kW or so/ unit in service.

Table 9: Biogas Production and Number of Biogas Digester in Chinese Rural Areas During the Period of 1980-1997

Year	Biogas output (M)	Number of households using biogas (M households)
1980		6.62
1988	989	4.62
1990		4.76
1991		4.75
1993	1180	5.25
1994	1350	5.43
1995	1477.3	5.69
1996		6.02
1997	1780	6.38

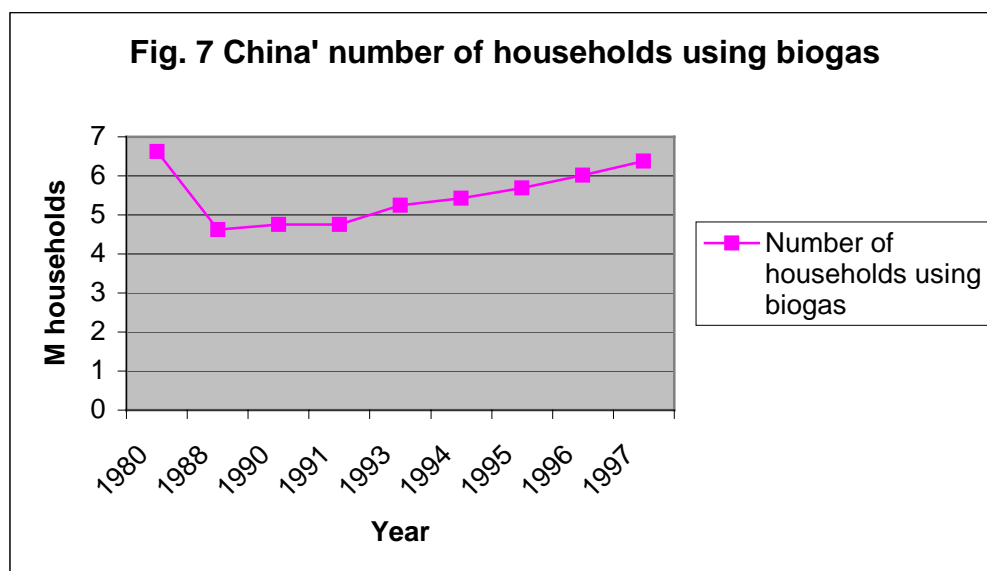


Table 10: Biogas Production and Number of Big and Middle-size Biogas Plants in Chinese Towns During the Period of 1995-2015

Year	Production (M)	Number of big and middle-size biogas plants
1995	40	540
1996		592
1997	132	703
1998	380	740
2015	4000	2500

Source: "Development Planning for New and Renewable Energy Industries between 2000-2015" formulated by the State Economy and Trade Commission

Solar Energy

China has rich sources of solar energy with an average gross amount of annual solar radiation of about 6 GJ/m² and the solar thermal application is being widely launched. Presently, solar energy mainly used for supplying heat and electricity for households in remote villages and small towns.

Solar thermal utilization

The quantity of solar water heaters and passive solar houses in service in China ranks first in the world.

In 1998, the aperture areas of installed solar water heaters were above 15 million m². The performance both of domestically produced heat pipe evacuated tubular solar collector and SUNSTRIP flat plate collector reach international standards. For example, a solar water heater with 1.1m² (aperture area) of heat pipe evacuated tubular collectors can supply 50 kg/d of 45°C hot water in winter. At present, about 2000 companies have been engaged in developing, producing, marketing and installing solar water heaters, with an annual production of 4Mm² and output value of 400 M US dollars. (Table 11 and Fig 8).

In 1997, there were 8.2 million m² of passive solar houses built in China, in which 5.37 distributed in the rural areas of Hebei, Liaoning, Inner Mongolia, Gansu, Qinhai and Tibet, see Table 12. 400 primary and high schools building in Liaoning province are in passive solar design. Generally, a passive solar building can save 20kgce coal per m² (floor area) in heating season.

Up to now, the quantity of solar cookers in use is around 140,000units. A solar cooker can save at least 300kgce of cooking fuel every year, with the payback of 1-2 years, see Table13.

Table 11: Total Area of installed Solar Water Heaters in China during the Period of 1990--2000

Unit: M m²

Year	Volume of Solar Water heater
1990	0.99
1991	1.28
1992	1.78
1993	2.30
1994	3.60
1995	4.90
1996	8.50
1997	12.00
1998	15.00

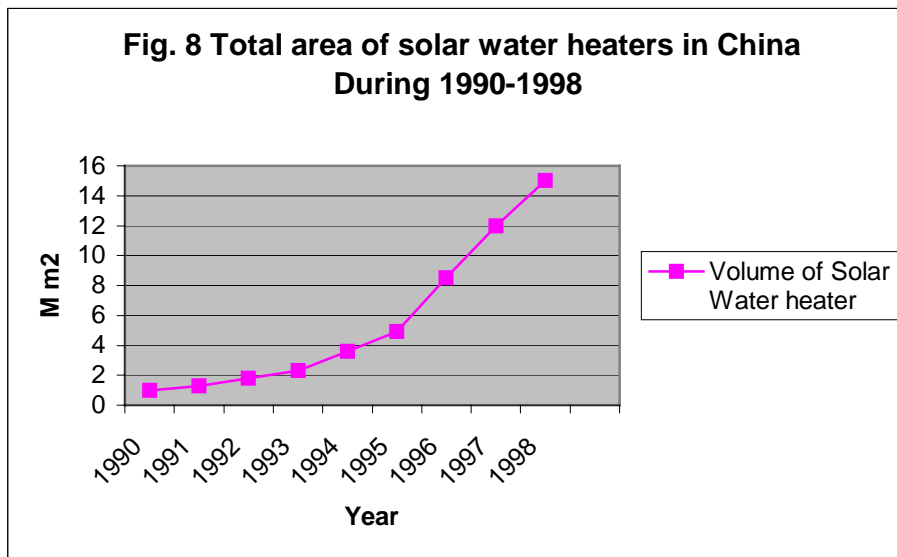


Table 12: Area of Passive Solar Houses in China during the Period of 1990-2000

Unit: M m2

Year	Area of passive solar houses
1990	0.352
1991	0.66
1995	3.42
1996	6.00
1997	8.20
2000	10.00
2010	50.00

Table 13: Total Number of Solar Cookers operating in China during the Period of 1990-2000

Year	Number of solar cookers (Unit)
1990	117900
1991	125000
1993	140000
1995	142000
1996	150000
1997	224000

Solar photovoltaic power source

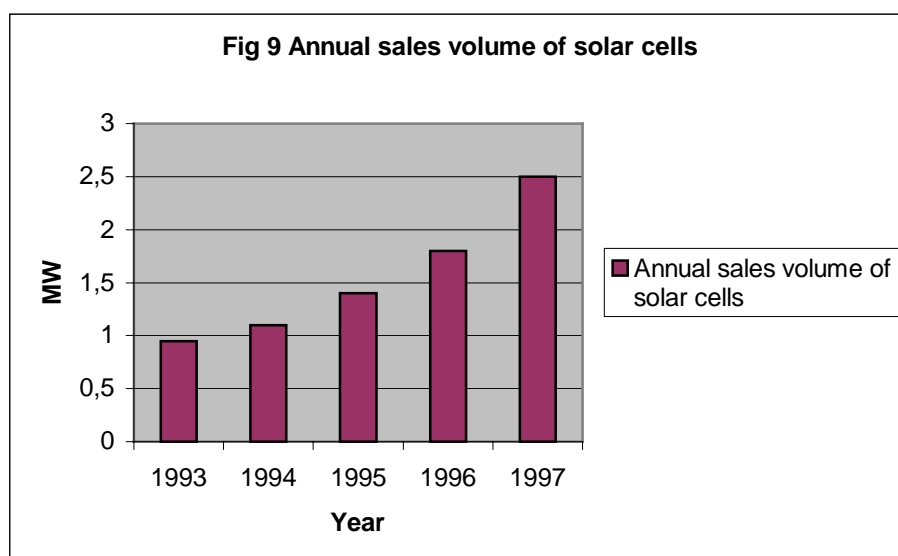
At present, solar PV in China is mainly used as power source for microwave communication systems and stand alone power systems for remote homes. In 1994, the sales volume of solar PV panel reached 1.1 MW, and total installed capacity reached 6 MW. (Table 14 and Fig.9). In Tibet, 7 solar PV power stations of 10kW, 20kW, 25kW and 30kW have been built, and another five are under construction. According to the state development plan on PV, 2 solar PV power stations of 500kW are under construction, 5 solar PV power stations of 1MW will be constructed by 2020.

China has 6 companies producing solar cells with the annual production of 4 - 4.4MW and actual sales volume of 2.0—2.5MW at the price of 3 US dollars/ W.

Table 14: The Annual Sales Volume Of Solar Cells in China during The Period of 1993-1997

Unit: MW

Year	Annual sales volume of solar cells
1993	0.95
1994	1.1
1995	1.4
1996	1.8
1997	2.5



Wind Energy

China is a country with rich wind energy resources. The available wind energy resources reach 250 GW. The wind zones can be roughly divided into two kinds, one is coast wind zone, with available wind energy density of more than 200 W / m² and available wind energy occurrence percentage of 80% -90%; the other is northern wind zone of Xinjiang- Gansu- inner Mongolia, with available wind energy density of 200-300 W / m² and available wind energy occurrence percentage of 70% or so.

China has set up wind energy fields at the beginning of 1986, had 24 wind farms with the total installed capacity of 262 MW/594 sets in 1999, see Table 15 and Fig 10. Investment and cost for generating electricity in wind farm in China see Table16 and Table 17.

Table 15: Total installed capacity for wind farms and its forecast in China

Year	Installed capacity (MW)	Number of installed sets (Unit)
1990	12	
1993	13	
1994	26.2	
1995	57	
1996	57.4	
1997	166	
1998	223	533
1999	262	594
2000	1000	
2005	3000	
2010	4900	
2015	7000	

Source: "Development Planning for New and Renewable Energy Industries between 2000-2015" formulated by the State Economy and Trade Commission

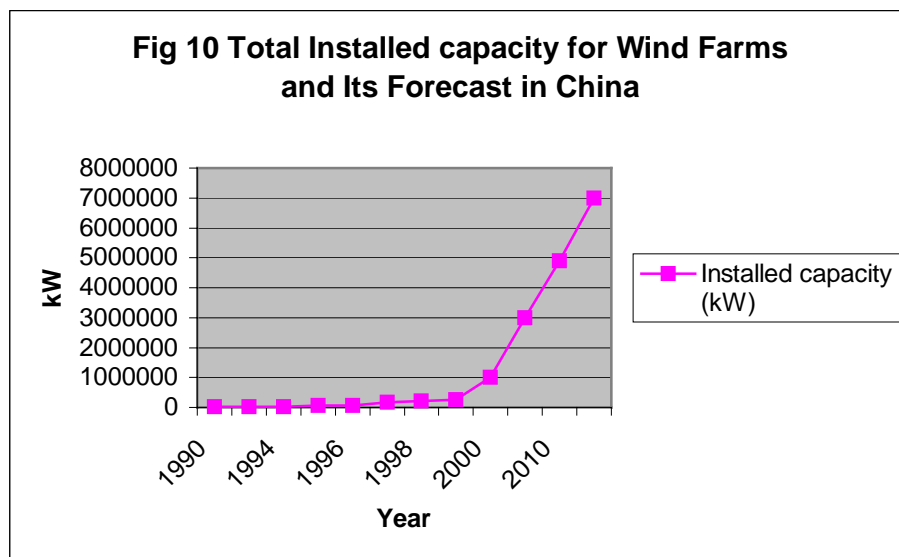


Table 16: Investment And Cost for Generating Electricity In Wind Farm

Item	Huitenxine wind farm (in inner Mongolia)	Nanao wind farm (in Guangdong)
Generator model	2~40/500	
Total installed capacity	19.8 MW	11.2 MW
Investment per kW	1,166.07 US dollars	1,591.13 US dollars
Annual electricity output	67.01 M kWh	38.01 M kWh
Generating electricity cost per KWh (excluding tax)	0.0658 US dollar	0.0878 US dollar
Value-added tax and local surtax per kWh	0.01220 US dollar	0.01585 US dollar

Source: Chinese middle and long-term energy development strategy research

Table 17: Investment and generating electricity cost forecast for Chinese wind energy

Year	Wind energy generating electricity system investment (US dollar/kW)	Wind energy generating electricity cost (excluding tax) (US dollar/kWh)
1992	804	0.0329
2000	684	0.0268
2010	563	0.0232
2015	507	0.0207

Source: Chinese middle and long-term energy development strategy research

The main barriers of wind energy development:

1. Backward in technology development
2. High cost, because of need to import wind energy generators
3. Shortage of incentive policies
4. Shortage of standard sale electricity contracts
5. Long-term financing problem needing to be resolved

Development direction in wind energy technologies

1. Developing small-size wind energy generators for the users in remote regions and islands, further improving the quality of small-size wind energy generating systems.
2. Focus on developing wind energy farms connected to the national grid, which are an important possibility for replacing conventional energy in the future.

The general goal of developing wind energy in China

1. Increasing the diversification of energy supply, improving energy structure and reducing the dependency on coal.
2. Enlarging independent energy supply in remote regions and promoting their economic development.
3. Striving to promote commercial development in wind energy generating technologies and domestic made equipment.
4. Electricity production for wind energy accounting for 10% of total electricity yield in 2050

Geothermal Energy

China is rich in geothermal resources. 2,500 hot springs and 270 reservoirs have been found with hot water (more than 150°C) theoretical potential of 6,744MW. The total proven geothermal economic potential reaches 462.7 Gtce.

At present, there are 1,100 places, mainly distributed in Tianjin, Beijing, Hebei, Jiangsu, Jiangxi, in direct use of low temperature geothermal energy for plantation, aquaculture, space heating, and health care supplying approximately 400,000 tce. In 1994, the scale of using geothermal for plantation and aquaculture reached 3,328 ha, and space heating floor area reached 1.3 million m², hot spring sanitarium, 200places.

The capacity of geothermal power generation reached 28.6 MW, The Yangbajing geothermal power plant in Tibet has got a capacity of 25.2MW and generates 97 GWh of electricity per year, accounting for 50% of power supply in Lahsa. In the end of 1993, the temperature was measured as high as 329.8°C at 1850 m depth of the first geothermal well in north Yangbajing district.

Ocean Energy

China has rich ocean energy resources reserved in the extensive sea area in 32,000 km of coastline, of which 18,000 km is along continental, and the others are along 6,500 offshore islands. The tidal resources (economic potential) are estimated as 21.7 GW, mainly distributed in Zhejiang and Fujian provinces, see Table 18.

Till now, there are seven small experimental tidal power stations with a total installed capacity of 6 MW. There are five bulb turbines, 3.2MW capacity in total, has been in installed in the Jiangxia tidal power plant in Zhejiang. China made small wave powered devices are in practical use, such as more than 300 units supplying power for navigation lights. Another three wave power stations are under construction with the installed capacity of 40 kW in total.

Table 18: China’s Tidal Power Stations

Unit: kW

Name	Address	Design Capacity	Remark
Jianxia	Wenling, Zhejiang	4000	
Baishakou	Rushan, Shandong	960	
Xinfuyang	Pingtang, Fujian	1280	
Shashan	Wenling, Zhejiang	40	
Yuopu	Xiangshan, hejiang	300	
Haishan	Yuhuan, Zhejiang	150	
Guozhishan	Qianzhou, Guangxi	40	
Liuhe	Taicang, Jiangsu	150	
Ganzhitan	Xunde, Guangdong	5000	
Total		11920	

New And Renewable Energy Development Strategy

General development goal

The general development goal for new and renewable energy is as follows:

1. Speeding up the promotion and utilization of technologies and products
2. Enhancing ability to manufacture equipment and production capacity
3. Building service system of the rationalization of industry
4. Perfecting law and regulations, and economic incentive polices and realizing commercial development in new and renewable energy exploitation and utilization
5. Before 2015, new and renewable energy amounting to 43Mtce and taking up 2% of China’s energy consumption (if including small power, it will account for 3.6%)

6. New and renewable energy industry being a new that of national economy, which will pull out and push the development of relative industries, such as machine, electrics, chemical and material industries, etc.
7. Distinctly relieving air pollution and improving environmental quality, reducing CO₂ emission of 30 Mt and SO₂ emission of 2 Mt; providing near 500 thousand jobs and providing electricity for 5 M households in remote regions (close to 25 M population)

Implementation of development strategy

In order to reach the above-mentioned objective, new and renewable energy industry development plan can be divided into the following stages:

1. 2000~2005

Gradually setting up economic incentive policies and administrative management system suitable for market economy

Building and implementing quality control, monitoring and service systems

Strengthening of supporting industries and products, in order to promote industry development

New and renewable energy taking up 0.7% of China's commercial energy consumption, amounting to 13Mtce

2. 2006~2010

Building industry support and service system and further regulating market development

Setting up full scale economic incentive policies and legal regulation

New and renewable energy amounting to 25Mtce, taking up 1.25% of China's commercial energy consumption

3. 2011~2015

Carrying out large-scale dissemination and application of new and renewable energy technologies

Promoting the commercialization of most technologies

Improving new and renewable energy industry system and making it a new important industry of China's nation economy with an annual gross output value of 8 billion US dollars by 2015

New and renewable energy amounting to 43Mtce, taking up 2% of China's commercial energy consumption by 2015

Source: "Development Planning for New and Renewable Energy Industries between 2000-2015" formulated by the State Economy and Trade Commission