China National Energy Strategy and Policy 2020

Chapter VII: Renewable Energy Strategy and Policy

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Abbreviations

CO_2	Carbon Dioxide
ECU	European Currency Unit
GCS	Green Certificate System
GDP	Gross Domestic Product
GW	Gigawatt (x 10^9)
GWH	Gigawatt (x 10^9) hour
IEA	International Energy Agency
IGCC	Integrated Gasification Combined Cycle
kgCE	Kilogram coal equivalency
KJ	Kilojoule
KW	Kilowatt
Mm^2	10^6
MMS	Mandatory Market Share
Mt	Million (x 10^6) tons
Mtce	Million (x 10^6) tons coal equivalency
MW	Megawatt (x 10^6 watt)
PBF	Public Benefits Fund
PR	Proved Reserves
RPS	Renewable Portfolio System
SO_2	Sulfur Dioxide
TCE	Tons coal equivalency
TOE	Tons oil equivalency
TWh	Terawatt (x 10^{12}) hour
VAT	Value added tax
W_p	peak Watt
WTO	World Trade Organization

Executive Summary

RENEWABLE ENERGY DEVELOPMENT POLICY AND STRATEGY

In the last century, two major oil crises shook the economies of western countries, and triggered interest in renewable energy development. Beginning in the 1970's, and in more recent years, renewable energy has gradually become a substitute for fossil fuels and played an appropriate role in the energy system.

In 2001, worldwide development of renewable energies was nearly 2 billion tons standard coal equivalency (tce), about 13.5 percent of the total supply of the primary energy in which 10.8 percent was combustible biomass energy, 2.2 percent was hydropower, and geothermal, solar, wind, tide energy and new biomass technologies account for 0.5 percent. Among all the renewable energies, wind energy is the fastest growing. By 2002, the worldwide installed capacity of wind power had reached 32 KW. The manufacturing capacity of photovoltaic generation had exceeded 560,000 KW and actual installed capacity was about 2.2 GW. The worldwide installed capacity of biomass generation had reached about 15 GW and biomass liquid fuel had exceeded 20 million tons. The ownership of solar water heaters had reached 100 million square meters (nearly 50 percent in China), which had supplied equivalently 14 Mtce. Meanwhile, newest advances have been made in geothermal and tidal energy.

What does the booming overseas development of renewable energy mean for China?

Renewable energy has become a critical choice for countries in implementing sustainable strategies. Energy drives social and economic development. But the consumption of a great deal of fossil energy reveals the lack of sustainability of the economy. Currently, 80 percent of the total energy consumption came from fossil fuels, which has resulted in a series of environmental problems: 85 percent of the sulfur, 35 percent of the suspended particulates, and 75 percent of the CO2 in the atmosphere come from the combustion of fossil fuels. Thus, current energy consumption structure has threatened the realization of sustainability.

The burgeoning renewable energy such as wind, solar and biomass energy are clean, non-polluting, and renewable forms of energy and in line with the goal of sustainable development. To address the environmental problems in their own countries or regions and

by force of international emissions abatement of GHG, the developed countries have designed and carried out a grand series of plans and projects on renewable energies. First of all, supports in policies and legislation have formed the fundamental incentive to impel the development of the renewable energies. Feed-in Law has been promulgated in German and Spain to interest the investment in wind power generation. The early execution of *Non-Fossil Fuel Obligation* (NFFO) in UK has provided a venue for the development of renewable energy. RPS in some states of US, as well as Australia and Japan, has compelled a certain proportion of renewable power in power supply. These countries have compelled the society to accept and exploit renewable energy, and guaranteed the prospect of renewable energy development.

Secondly, historic development plans have been designed to speed the development of renewable energies. The European Union stated in its white paper on energy policy that they have taken renewable energies as the key to realizing three strategic goals: (1) increasing energy competitiveness, (2) securing supply, and (3) protecting the environment. The EU set the ambitious target for 2010 that renewable energy should account for 12 percent of the total energy consumption of EU in which wind power generation should reach 40 GW and photovoltaic (PV) generation 3 GW.

Renewable energy, as a booming industry, has played an increasingly critical role in the economy. The Danish consultants BTM found that worldwide wind power generation in 2002 reached 65 million kWh, accounting for about 0.4 percent of the total power generation and the sale of generation units was 7.4 million KW with the annual production value of over 7 billion Euros and provided thousands of new jobs. It is estimated that by 2020 the world installed wind turbines will reach 1200 GW with the annual income of 67 billion EURO. It is estimated by EU that by 2020 the global PV market will increase from present 3000 MW to 70GW_p, that the commercialized utility of biomass energy will be equivalent to 100 million tons of oil and that the production capacity of biomass liquid fuel will reach 10 million ton level.

Industrialization will provide more job opportunities. Some American scholars have proposed that investment in energy efficiency and technologies such as solar energy will provide twice as many job opportunities as the investment in oil and natural gas. In Europe, a great number of the population is employed in renewable energy industry. The EU

estimates that by 2010 wind, PV, and biomass generation in Europe will be about 40 GW, 3 GW and 10 GW, respectively, solar collectors will reach 100 M m^2, and 1.5-1.7 million jobs will be created. This does not include 17 billion Euros annually in exports and the 35,000 additional and potential jobs created.

Renewables provide market opportunities

In analyzing the recent tendency of developed countries, we will find that they are common in that they are making good use of the technological advantages and the grand industry opportunities to occupy the market, regardless of their difference in the targets and trajectories of developing renewable energy technologies. U.S., Japan and the Europe are leading in renewable energy technologies. They have abundant capital, advanced technology and capability of transforming technology into business, as well as they are out of step with the times in the development ideal. Thus, these developed countries own most advanced renewable energy technologies and occupy the largest market share.

Based on its leading position in electronic technology, Japan has concentrated on developing PV generation products and occupied more than 50 percent of the global PV generation market. And UK, Netherlands, Japan, and U.S. have almost monopolized this market and their export has accounted for more than 80 percent of the worldwide trade in this market. The state-of-the-art wind turbine manufacturing technologies are in Denmark, German, Spain, and US. And US is the only country that has retained the lead in wind generation, PV generation, solar heat generation, geothermal generation, and manufacturing capability of modern biomass utility facilities simultaneously.

Five reasons to encourage renewable energy development in China

Inevitable step in executing sustainable energy strategies

China's energy system is facing severe challenges. There is immense scarcity in high-quality energy resources such as oil and natural gas. Fossil energy resource per capita in China is half of the world average. Specially, oil and natural gas per capita is only the 11.0 percent and 4.0 percent of the world average respectively. The consumption of primary energy per capita is equivalent to 0.7 tons of oil, less than half of the world average[①]. Moreover, outdated energy technology, low efficiency use, and torrid economic growth will implicate that it is more likely that we deplete the resources more rapidly than other countries and the threat of energy exhaustion will come earlier and more seriously.

Overdependence on coal will result in more serious environmental impacts. China is a country that uses coal as its main energy source. Especially in the electricity sector, nearly 90 percent of fuel comes from coal. Due to intense coal use, 66 percent of urban cities had total suspended particulates and 22 percent had SO_2 exceeding China's national class II standard. The concentration of these pollutants is even greater in winter. It is estimated by environment experts that 90 percent of the sulfur and 70 percent of the smoke and dust in the atmosphere come from coal combustion. Coal pollution has become one of the critical environmental problems in terms of sustainable development in China.

The disposal of coal wastes is another problem. A great deal of gangue, corrosive water, slurry, clinker, and flying-ash produced during coal development and utilization have threatened the agriculture and industry production and ecologic environments, and become the key factor that restricts the sustainability of regional development.

Coal makes up 67 percent of China's current energy consumption structure, a proportion that is excessively high. In adjusting the energy mix, reducing the percentage of coal consumption is crucial. Restrained from the volume of oil and natural gas resources, we have to increase the utilization of hydropower, nuclear power, and renewable energy resources to substitute the use of coal. Yet, the lack of a the proper disposal method for nuclear waste restricts the speed of the development of nuclear power. And hydropower resources are concentrated in Southwest China, while the largest demand for energy is in East China. The West-East Power Transmission is also constrained by transmission capacity and grid safety of the receiving areas. In contrast, abundant renewable energy resources in China are distributed widely and in diverse areas and can meet various demands such as power generation, gas, heat supply and liquid fuel production. Renewable energy resources are a good choice to substitute coal, make up for the scarcity of oil and gas, and rationalize the energy structure.

In China the scarcity of oil resulting in the high dependence on export is a crucial problem in the energy supply. Since 1993, China has become an oil net importer with the import dependency of oil increasing sharply. The import dependency was 34 percent in 2001 and will reach 50 percent by 2020. Energy safety has become a predominant problem. Renewable resources are local resources that can be transformed directly or indirectly into

electricity or liquid fuels such as ethanol, bio-diesel and hydrogen. They can mitigate the dependence on oil, help establish a diversified energy structure, and improve the energy supply safety.

Key means to speed the development of rural economy and increase the income of farmers

In China, 60.9 percent out of its 1.3 billion people live in rural areas and consume energy of equivalently 600 million tce, in which about 50 percent is from renewable energy resources but they are utilized by means of traditional means. The outdated energy consumption pattern has resulted in serious indoor pollution, public health threats, and threatens forests and vegetation. If these methods of energy use were all substituted with commercial energy, the supply of fossil energies would face great pressures. In the rural areas of China, especially in western regions, renewable energy resources are abundant. We should exploit wind, solar, hydro and biomass energy according to the local conditions and realize the high quality and clean energy consumption in rural areas step by step. It is not only an effective way to help rural areas alleviate poverty and develop the economy, but also a great step forward in "building a well-off society"[1] and implementing the "Develop the West"strategy.

Development of renewable energy resources in rural areas can not only solve the problem of energy consumption in rural areas but also combine with the agriculture production procedure. For example, we have started to spread the ecological energy patterns, such as integrated biogas energy with animal husbandry in the south and in the north, that utilize biomass energy resources to produce biogas. These patterns can increase the efficiency of agriculture production and the income of farmers.

[1] Building a Well-Off Society in an All-around way (policy)

Electricity access

By 2001, 30 million residents of more than 20,000 villages are without access electricity. Some of them are without the guarantee of basic energy consumption. Most of them live in West China, where renewable energy resources are concentrated. Thus, development of the renewable energy resources in these areas is an effective means to solving the above-mentioned problem as demonstrated by several projects that deliver power to rural areas.

The development of new energy and renewable energy in rural areas can preserve the achievements of the *Grain for Green Project*[2], as well as solve the problem of resident energy consumption. Nowadays, the desertification area is 2.62 million km^2 and the area of water loss and soil erosion is 3.67 million km^2. But the combustion of traditional biomass energy is the primary way of energy consumption in most areas, especially in the areas where the energy supply is short and utilization efficiency is low. Direct combustion has polluted the environments, resulted in the overcut of forest and vegetation as well as the degrading of living environments. And the spread of the alternative technologies such as biogas implication, biomass gasification and small hydropower will consolidate the achievements of the *Grain for Green* project.

New job opportunities and economic growth

Local labor, materials and other resources will be explored during the development of the renewable energy resources, which is important for the development of regional economy. Meanwhile, the booming renewable energy is a new segment to boost the economic growth. The success of small hydropower and solar water-heater in China, ethanol in Brazil, and wind power in the Europe has proven that the renewable energies can form a grand industry and impel the economic development.

Moreover, it is shown that the development of renewable energies can provide a number of job opportunities as well as meet the energy demand. For example, in 1999, the manufacture, maintenance, installation, and consulting services supplied 12,000 to 15,000 job opportunities in Denmark and 6,000 overseas. In Brazil, the ethanol industry has created hundreds thousands of job opportunities. In China, the employees in small hydropower companies have

[2] A national program in which farming on fragile land gives way to afforestation.

exceeded 500,000. With an abundance of labor, China is facing severe employment pressures in China. The development of renewable energy will boost the economic development, drive the development of mechanical manufacturing, construction, transportation, and service industries, and mitigate the employment pressure induced by the population growth.

*Close the gap with developed countries*I

In the renewable energy technology market, China is behind western countries that are still speeding their development. Unlike the ordinary technologies, the renewable energy technologies and the related industrialization need a long-time R&D and market accumulation. A journey of a thousand miles always begins with a single step. Thus, we should increase the investment in the renewable energy industry, advance the competitiveness of the technology and products and take advantageous position for the future development.

It can be seen that renewable energies will become the predominant energy in 21st century. Whoever owns abundant renewable energy resources and advanced technologies of new energy will obtain the first-move advantage in the future international competition.

Enviromental Protection and Greenhouse Gas Abatement

The development and utilization will produce little gas harmful to the atmosphere and avail to the emissions abatement of greenhouse gas emissionss (GHGs) such as CO_2. Take wind power and hydropower as the examples. The intensity of carbon emissions in their entire life cycle is only 6g/kWh and 20g/kWh, respectively, extremely lower than coal with 275g/kWh. As a response to the strict requirements for developed countries in Kyoto Protocol, EU countries have taken the development of renewable energy resources as a vital measure in GHG emissions abatement. By 2020, they plan to have the installed wind turbine capacity to account for 15 percent of the total capacity and by 2050 energy supplied by renewable energy will account for 50 percent of the total energy consumption.

GHG emissions mitigation is a central theme in global environment protection and sustainability. As a rapidly growing economy, China must reduce the proportion of fossil fuels used in energy consumption and GHG emissions to foster a better world image. Hydropower, nuclear power, renewable energy, and new energy are all effective means to mitigate GHG emissionss. Internationally, renewable energy and new energy are both clean energies that do little damage to the environment. Therefore, in terms of maintaining the responsible image of big power country and GHG emissions mitigation, China also should

speed the steps of exploiting renewable energy resources.

Barriers to renewable energy in China

The main barriers for the development of renewable energy in China are cost, market share, and policy.

Cost barriers

Renewable energy has a higher cost and price than traditional energy sources. This is the biggest obstacle to its commercialization and distribution, and the production cost of renewable energy is higher than that of fossil fuels with the same technology. Small scale hydropower is 1.2 times the cost of coal,biogas is 1.5 times, wind power is 1.7 times, and PV is 11 to 18. Therefore, high cost of renewable energy weakens its competitive ability.

Many reasons result in high production cost. Small scale and low production technology are the main reasons.

Market Barriers

The current development of renewable energy is under small scale, full of uncertainty and lack of promotion mechanism.

The current market for renewable energy in China is small and full of uncertainty. Although to some extent, a few technologies, such as small-scale hydropower and solar water heaterS, have realized commercialization after years of building and development, the market scale is still small compared with development potential and market demand. To further expand the market, it should decrease production cost and improve technology reliability. Moreover, developed market can improve system operation reliability and decrease production cost through development of renewable energy. At present, renewable energy needs to avoid the direct competition with traditional energy, but lacking of competition keeps the high price in long term, which will hold back the development of renewable energy. To solve the dilemma, we need property market development mechanism according to China’s situation.

Policy Barriers

Experiences of China and foreign countries prove that policy enactment is an effective method to solve this problem. In the last 10 years, Chinese government has enacted some policies to promote the development of renewable energy. However, with the progress of

system reforms, the administration in charge of renewable energy has been transformed. The result is the elimination of some policies, (e.g., *Wind Power Generation Interconnection Policy*), some policies existing in name only, and some never being implemented because of the difficulty in execution (VAT on small scale hydropower is set at six percent).

Now the development of renewable energy is in a key period in China. The development of renewable energy in the next 20 years to an industrial scale will depend on the support of policies, especially those focused on increasing its market share.

CHINA'S RENEWABLE ENERGY COULD BE DEVELOPED TO AN INDUSTRIAL SCALE

Market Potential

China has a large population but its lack in natural resource and energy supply hinder it from meeting the demands of national economic development. With economic development and the focus on building a "well-off society," more demands will be put on its energy supply. Agricultural products make up a large amount of China's GDP, and 61 percent of population lives in rural areas. Rural areas consume 600-million tce energy annually, and half of this energy is obtained through crops and cutting wood, which harms the environment and results in hunger. Development of solar energy, wind power, and biomass according to local conditions not only can meet local energy demands, but also improve the environment. Therefore, the urgent demand provides a huge market for renewable energy.

Abundant Resources

China has various and abundant renewable energy. The recoverable reserve of small-scale hydroelectricity (less than 50,000 KW) is 12 GW, and a quarter of them have been exploited. The annual solar radiant energy in the land equals to 2.4-trillion tce. If only 1 percent of land area is taken use of and the conversion efficiency is averagely 20 percent, there will be 4.8-billion tce energy, which is 3.5-billion more than national energy consumption in 2000 (1.3-billion tce). The reserve of wind power in the height of 10 meters is 3200 GW and 253 GW are recoverable; additionally, the installable capacity of wind power in offshore strip (the water depth is 1-15 meters) is 1000 GW. China has sufficient biomass resource as well, and agriculture waste such as straw is annually about 03 -billion tce and firewood is 013-billion tce. Urban organic waste is 0.7-billion tce. Furthermore, geothermal energy resources and ocean energy resources can be developed at industrial scale in long term.

4.3 Primary development at industrial scale

Since 1990s', development of renewable energy in China has made a significant progress. Developed resources have increased from 17 Mtce to 37.2 Mtce from 1990 through 2000, and average annual increase rate is 8.15 percent. Among various renewable energy resources, small-scale hydroelectricity has been developed steadily and taken the first place in renewable energy supply, accounting for 78 percent. Biomass has developed increasingly, especially biogas. During the ninth-five plan, average annual rate of increase was more than 6 percent, accounting for 8.9 percent of energy supply. Solar energy has made a rapid development, accounting for 10.32 percent of energy supply and taking the second place. Exploitation amount of wind power was small but development speed is high.

4.4 Technological development has made progress.

Renewable energy technology has made great progress. Quantities of national experiment bases have been established, which have fostered large numbers of talented technological persons and greatly improved the ability of independent research, development and innovation. Commercial technologies spring out, such as small-scale hydro electricity, solar water heater, mini-sized wind power generator and geothermal heating. Large numbers of technologies have been the primary stage of commercialization, such as large-scale interconnection wind power generator, middle and large-scale biogas plant and photovoltaic system for one house. Plenty of technologies under R&D, experiment and distribution have developed smoothly and continuously made new achievements.

The whole mentioned above show a good prospect to further development for renewable energy.

RENEWABLE ENERGY DEVELOPMENT STRATEGIES IN CHINA

According to the trend of renewable energy development in the world and domestic research on strategies of renewable energy development, it is forecasted that in 2050 renewable energy will be a leading actor in energy structure, accounting for more than 30 percent. Therefore, the strategies of renewable energy development in China can be conceived as the following four phases.

The first phase: part of renewable energy technologies will have been realized commercialization till 2010. Through expanding experimental bases to demonstration and spreading under policy's promotion, technologies such as small-scale hydro electricity, wind power, solar heating, biogas and geothermal heating, which have been mature or primarily

mature, will have been complete commercialization.

The second phase: large numbers of renewable energy technologies will have been commercialization till 2020. Renewable energy will take up more than 18 percent of primary energy.

The third phase: renewable energy will be realized commercialization in an all-round way and substitute fossil fuel at a large scale. Renewable energy will have taken up more than 30 percent of energy consumption and have been an important alternative energy till 2050.

The fourth phase: renewable energy will have taken up more than 50 percent of energy consumption till 2100. Traditional using measures will ultimately disappear and energy consumption structure will fundamentally change.

TARGET OF RENEWABLE ENERGY DEVELOPMENT IN 2020: INSTALLED CAPACITY WILL BE 90-100 GW AND ENERGY DEVELOPED AMOUNT WILL REACH 400-500 MILLIONS TCE.

Installed capacity of small-scale hydro electricity will be 60-70 GW. Average annual increase rate of small-scale hydro electricity installed capacity was 1-1.5 GW in recent years, and national installed capacity had reached 28.5 GW at the end of 2002. In next 17 years, with further acceptance of sustainable development, the west development and requirements of building a welfare society, it's a reasonable assumption that the average annual newly installed capacity is 2 GW. Therefore, national accumulative install capacity of small-scale hydro electricity will be reasonably expected to reach 60-70 GW until 2020.

Installed capacity of wind power will be 20 GW. Up to now, national installed capacity of wind power has reached 57 $x10^4$ GW. Compared with small-scale hydro electricity, wind power generation has the feature of short-term building period. Thus, construction of wind power generation can be completed in one year with proper policy promotion. Taking consideration of improvement of policy environment, national economy development demand and buildup of overall strength, installed capacity of wind power will possibly annually increase at average rate of 1 GW. Therefore, in next 20 years, national accumulative installed capacity will reach 20 GW.

Installed capacity of biomass will be 1 GW. There are various measures of biomass generation. At present, the main measures are generation with biogas, rice stalks, straw

gasification and waste, and the aggregated installed capacity is about 1 GW. According to the development trend, generation with waste, straw (including remaining of forest cutting and processing) and biogas will increase rapidly. Because of the strict requirement of urban environment protection, installed capacity with waste generation can be expected to increase from 150 x 10^3 KW to more than 2 GW in 2020. Straw generation will increase with the progress of building small-scale town and building a welfare society in the rural, as well as optimizing biomass-using method, value added through processing, and promotion economic development. If the annual increase rate is about 400-500 x 10^3 KW, the installed capacity with straw will increase to 2.8-3.5 GW in 2010 and 6.8-8.5 GW in 2020.

Besides the above, generation with solar PV, geothermal, tide and ocean energy will increase as will. Therefore, renewable energy installed capacity will possibly reach 90-100 million kW in 2020.

The utilized amount of renewable energy will possibly reach 400-500 tce, accounting for more than 18 percent of primary energy consumption. During the Ninth-five Plan period, the annual average rate of renewable energy development has been 11.2 percent and it is expected that the development rate will remain about 10 percent in the next 10 years. If the increase rate in 2010-2020 is the same as that in 2000-2010, the utilized amount will reach 265 Mtce in 2020. Taking consideration of technology innovation, development at industrial scale and driven by requirement of ecology protection, the increase rate will be about 15 percent, thus the utilized amount will reach 386 Mtce in 2020.

Traditional using of biomass has been on a decreasing tread. With the progress of building a well-off society in an all-round way, demand for high quality fuel in the rural will continuously increase, and the decreasing tread of traditional biomass will remain. If the annual decrease rate is about 2 percent, traditional using of biomass in the rural will decrease to 140 Mtce in 2020.

Therefore, the utilized amount of renewable energy will reach 410-525 Mtce (heating utilization will be 300-400 Mtce) in 2020, which is twice of that in 2000. At that time, renewable energy will take up about 18.5 percent of primary energy supply.

TO REALIZE STRATEGIC TARGET OF 2020, NEW GUIDELINES ARE NEEDED

Government support. According to the development experiences of foreign countries and China's situation, laws and policies must support renewable energy. Government promotion means that government should provide strong support in policy, science and technology, and

establishing market. Meanwhile, the government should actively drive the enacting of Renewable Energy Promotion Law to ensure renewable energy development through law.

Competition introduction will depend on market mechanism to reduce renewable energy cost as soon as possible and realize development at an industrial scale. Thus with government promotion, complete competition in the industry can optimize resource allocation and accelerate development of renewable energy.

Innovation encouragement To meet the requirement of sustainable development, renewable energy development must rely on technology innovation and improvement of technology level. Therefore, China should research on renewable energy technologies with autonomous knowledge property right, and the technologies should mainly be on generation, gas and liquid fuel supply.

Large-scale development It is a necessary process for technology development, and a basic approach to reduce cost and realize commercialization as well. Industrialization should be boosted through development at a large scale. For those mature and almost mature technologies, we should grasp every chance to produce at a large scale, and widen application range to make them take roles in practices.

Development framework

- Form a perfect system of law and policy, and establish firm base for renewable energy development.
- Accelerate technology innovation with the government support. To speed up the development of renewable energy, China must strengthen technology R&D, organize multiple subjects to cooperate and tackle key problem, improve R&D ability as a group as soon as possible, and obtain technology innovation achievements with autonomous knowledge property right. As a strategic guideline, China must develop at a high beginning and crossing over periods, concentrate on the importance, and implement the localization strategy.
- Attach importance to market role in resource allocation and strengthen development of renewable energy industry. Through market mechanism, combine technology R&D with projects, and support the technologies with good business prospect to transform technological achievement into productivity and form an industry.
- Use resource comprehensively and intensively, improve profit

and widen market. To accelerate renewable energy development, China need comprehensively use resource through specialization and at a large scale, and improve using profit of technology to attract enterprises and users and widen renewable energy market.

URGENT STEPS NEEDED TO REALIZE THE STRATEGIC GOALS OF RENEWABLE ENERGY DEVELOPMENT

Strengthen legislation and enact the Renewable Energy Promotion Law

Legislation and implementation policies are the successful experiences in the world. After years of effort, renewable energy has developed at a certain extend in China, but the development is always in a small range, a small scale and a natural increasing trend. National long-term plans and annual construction plans have never been accomplished and no one have ever examined them. The main reason is that the development of new energy and renewable energy hasn't been attached importance to by the government, or put into the government's agenda. Renewable energy belongs to high and new technology, which is in the transformation phase of industrialization and commercialization. Thus, the development cost is comparatively high, and it cannot develop at a large scale without the government's support and policy promotion. At present, China neither has special renewable energy law, nor necessary promotion policy. Therefore, it's necessary to strengthen legislation, and carry out promotion policy.

The *Renewable Energy Promotion Law* should fully contain the following:

- The government should encourage mandatory use of renewable energy to ensure its continuous development.
- Carry out the basic guideline for renewable energy development
- Policies that encourage renewable energy technology R&D should be set down through law. These policies include renewable energy technology R&D, fund investment during commercialization process, favorable price, and tax relief.
- Confirm the duty and obligation of regulatory agencies in charge of renewable energy
- Carry out regional policies of renewable energy development. These policies should harmonize with national Develop the West Strategy; be good to renewable energy development and modernization construction in the rural areas and the remote areas.

- Regulate specific incentive and punishment standards and measures.

Legislation is a fixed procedure. It's important to put legislation propose into national plan. At present, the prophase preparation task of *Renewable Energy Promotion Law* should be carefully completed and start up legislation procedure as soon as possible, then try hard to complete the *Renewable Energy Promotion Law* in 2-3 years.

Strengthen policy system building and innovation

While strengthening legislation, it's indispensable to build a promotion policy system. In the long term, renewable energy has always been developed under the mode of government providing projects and government investment. With out question, this mode is no longer fit for the current economic situation of China, nor sustainable. Policy system innovation means that we should research on how to meet the requirement of market mechanism, and promote the sustainable development of renewable energy.

The important things at present include: speed up the progress of wind power demonstration with chartered rights and obtain experience to guide wind power development in the country; improve financial environment, establish straight path of investment and finance, complete the task of investigation, design and application for Public Benefits Fund (PBF), and establish a base for solving the capital problem of renewable energy development; further research on the renewable energy mandatory market share (MMS) policy and experimental demonstration, compare and analysis these three MMS policies (quota system, electricity purchase act and bid system), which have been implemented in foreign countries, and hybid policies, and carry out MMS policy fit for China's situation at proper time.

Increase investment, strengthen design and manufacture of key technology, and realize cross over development.

Since 1980s', China has carried out many kinds of subsidy policies to boost renewable energy development. However, comparing with foreign countries, renewable energy investment is still small. Up to now, renewable energy construction projects haven't been formally put into any level of government's financial budget and plan. Because of little investment and lack of enough capital for R&D, plenty of key equipments have to rely on import, which result in low level of industrialization and commercialization, and slow development speed.

The government should increase investment and support R&D of the following projects:

large-scale biomass liquid fuel project, wind power units with MW installed capacity, oversize PV assembly line development, transmission of electricity to the area without power in the west; 20 GW wind power project, 10 GW biomass generation project and 1 GW PV generation.

During the development process, we should stress innovation, take crossover development as guideline, take the international leadership as target, and try to form influence in the international market.

Renovate concepts, uniform cognition and change the thought that renewable energy can't bear important task.

The first thing for renewable energy development is to open up consciousness. We should treat renewable energy development at strategic level, and combine the development of renewable energy with strategic issues, such as national energy security, sustainable development, new industry pioneer, and market share enlargement. We should change the one-sided view that renewable energy development can only solve the issue of local energy use. Compared with foreign countries, China lags behind in the consciousness, and we should rectify the orientation of renewable energy in time.

Therefore, China should treat renewable energy development at national strategic level of sustainable development, put it into governmental energy development plan and financial budget, work out long-term plan and annual construction plan, and set down elaborate development road map to make it perfectly justifiable.

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Strategy and policy research on China renewable energy development

Chapter 1 International renewable energy development and experiences

1. Current situation and trend

1.1 Renewable energy has been part of energy system in the world

What is renewable energy? To be simply, renewable energy refers to all kinds of energy resources which can continuously rebirth in the nature and can be transformed into useful energy directly or through treatment. It's different from non-renewable energy resource such as coal, oil and natural gas and mainly includes hydropower, wind power, solar energy, biomass, geothermal energy and ocean energy. However, large-scale hydropower and biomass used through traditional measures are usually called as traditional renewable energy in research to distinguish from other new renewable energy, for this new energy development needs more policy support.

Renewable energy is recyclable and clean energy, which is expected to be future energy system and is attached great importance to by many countries. In the last 20 years, with governmental support, all kinds of renewable energy technologies have developed rapidly, developed reserves increasing continuously, which have been a constitute of modern energy system. Up to 2001, renewable energy developed reserves in the world have reached about 2 billions tce, taking up 13.5 percent of primary energy supply of whole world, of which 10.8 percent is traditional biomass, 2.2 percent is hydropower, 0.5 percent is geothermal energy, solar energy, wind power, tidal energy and new biomass.②

The structures of primary energy and renewable energy in the world in 2001 are shown in Fig. 1-1 and Fig. 1-2.

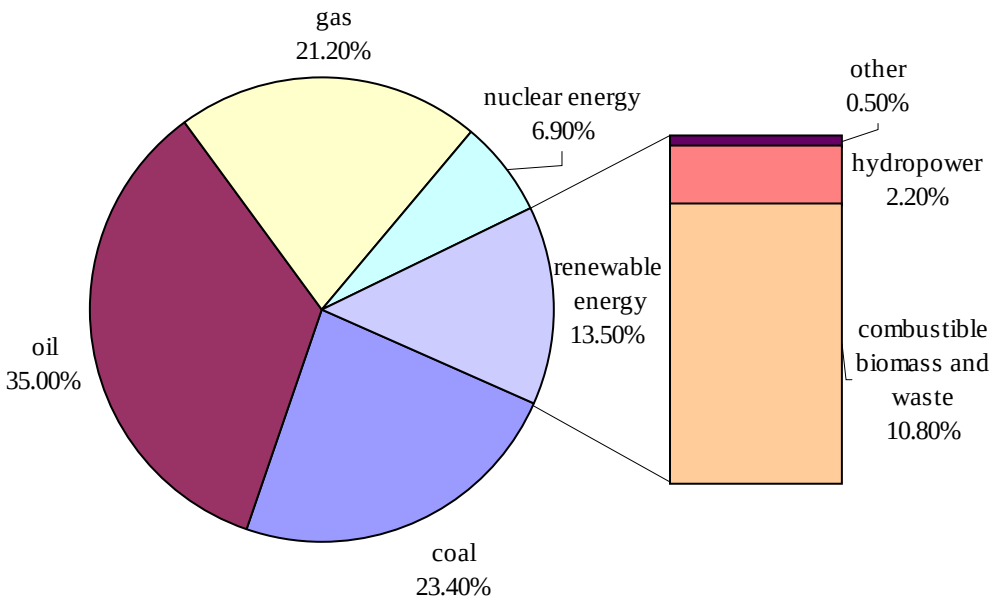

Fig. 1-1 Energy supply structure of in the world in 2001

Source: IEA， Renewables Information, 2003 Edition.

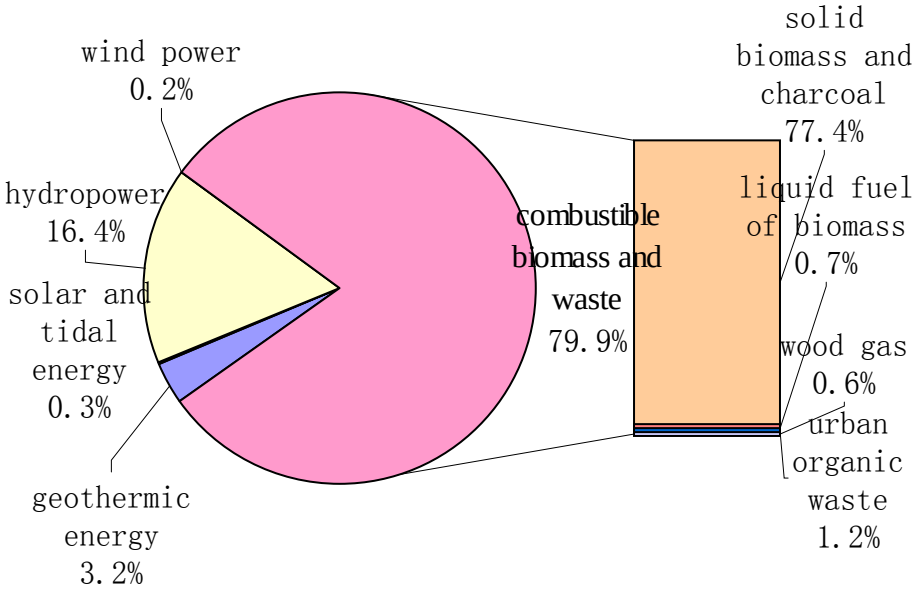

Fig. 1-2 Renewable energy developed reserves and structure in the world in 2001

Source: IEA， Renewables Information, 2003 Edition.

Among all kinds of renewable energy, wind power, solar photovoltaic generation, heating use of solar energy and biomass have developed most rapidly.

1.2 Wind power generation is growing up as a newly emergent industry

Wind power generation began in 1890s'. After years of development, especially after development in the last 10 years, wind power generation has completed development model machine, pilots and demonstration, and batch preproduction. At present, the technology has been grown up and begun commercialization. Wind power installed capacity of the world has increased from 2 millions kW to 32 millions kW[③] since 1990, annual average rate is 15 percent. At the end of 2002, generation cost has decreased to US$0.05/kWh (shown in Fig. 1-3).

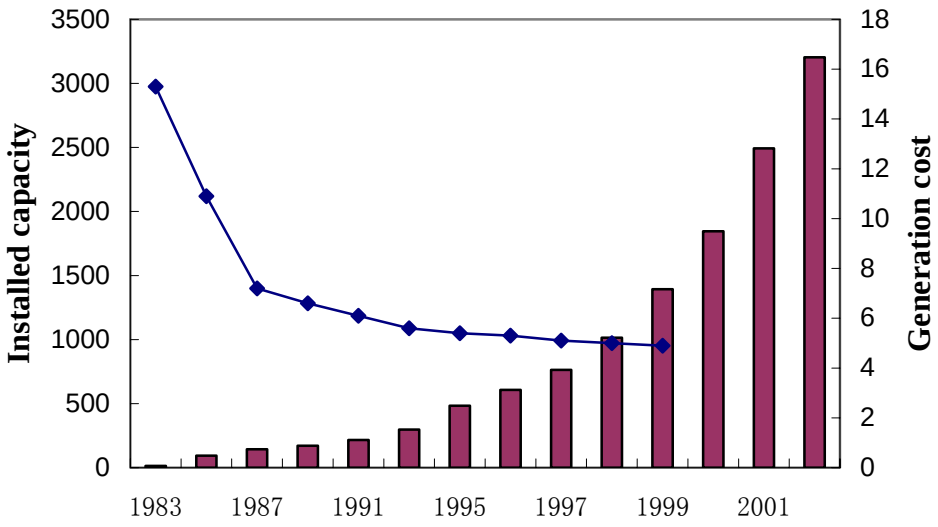

Fig 1-3 Wind power development in the world in 1983-2002

Source: China Energy Seminar, Development Strategy of China Wind Power Generation Symposium, 2003

Wind power installed capacity of Germany, Spain and U.S.A are highest in the world, and that of China takes the 10th place (shown in Table 1-1). The increase rate of Europe is highest, accumulate installed capacity in Europe taking up 85.2 percent of the world in 2002; the second highest is America, taking up 4.8 percent; installed capacity of Asia (most of them is in India) takes up 4.0 percent and other regions takes up less 4.0 percent.

Table 1-1 the top 10 countries in wind power installed capacity in 2002 (10 thousand KW)

	Germany	Spain	U.S.A.	Denmark	India	Italy	Holand	U.K.	Japan	China
In 2002	325	149	43	53	22	11	22	5	13	6
Accumulated amount	1197	504	467	288	170	81	73	57	49	47
Ratio	37.2%	15.7%	14.5%	9.0%	5.3%	2.5%	2.3%	1.8%	1.5%	1.5%

The rapid development in Europe owes to governmental support and improvement in policies. In 1990s', the members of EU have taken wind power as an important instrument to reduce CO2 emissions. Since Kyoto Conference, European Union has put forward new development target that is 60 millions KW of wind power installed capacity in 2010 and 150 millions KW in 2020. In order to ensure development of renewable energy, these countries have not only carried out perfect incentive policies, but also enact promotion law, such as Electricity Law of Germany and Spain.

With progress of wind power technology, wind power has grown up as a new industry. According to the statistics of BTM Co. in Denmark, wind electricity generated in the world was 65 billions KWh in 2002, equivalent to 0.4 percent (16.2 trillions kWh) of total generation in the same year, sold generating units were 7.4 millions kW, annual production value was about US$4 billions, and provided tens of thousand employment.

Making a comprehensive view of wind power development in these countries, we can find the main trend is as the following.

- **Large-scale unit**

Large-scale generator is a common trend in wind power development in the world. In 1980s', generator groups were mainly 50-100 kW, then it enlarged to 300 kW, 400kW, 600 kW and 750 kW. Now generator group with 1000-3000 kW is being developed. Statistics shows that the ratio of large-scale units with MW capacity has increased from 9.7 percent in 1997 to 62.1 percent in 2002.

- **Reliability improvement**

Although wind power generator has made a great progress in recent years, its lifespan is still too short to provide 20-year service life, which is needed for technology

commercialization. Therefore it's necessary to mend reliability of all components, especially that of rotor. This can be realized through optimal design of generator system, choosing better materials, components, variable speed rotor and advanced control device. These mend can not only alleviate load, but also reduce generator's weight and component's cost. More research is needed to make achievement at this facet.

- **Development offshore and at large scale**

Development at large scale is an approach to reduce cost and raise profit, as well as ensure reliability of development and enlarge significance of renewable energy. Many countries have carried out large-scale development plan. Denmark has planed that in 2005 it will build 5 offshore wind power stations, each of them with capacity of 150 thousands kW, accumulated installed capacity over 750 thousands kW added with existing projects, and that in 2030 wind power installed capacity will reach 5.5-6.5 millions kW, equivalent to half of total capacity, half of which will be located at continental shelf of northern sea. The initial pilots will be 100 MW, and adopt generators with 1.5 MW or 9 MW.

1.3 Solar energy photovoltaic generation remains increasing trend at a high speed

In the last 10 years, photovoltaic technology has developed rapidly. Firstly, manufacture technology has made great progress. After years of research, many kinds of batteries have been manufactured, such as single-crystal silicon battery, multi-crystal silicon battery, non-crystal silicon battery, hull cell and compound battery. Conversion efficiency of battery has improved significantly. At present, conversion efficiency of battery used in market has reached 15-17 percent (single-crystal silicon battery) and 14-15 percent (multi-crystal silicon battery). The highest conversion efficiency at laboratory is over 25 percent.

Secondly, production cost is decreasing. In 1995, the price of crystal silicon battery component was about US$6.5/Wp, and in 2000 it reduced to US$5.0/Wp, then in 2002 it reduced to US$3.0-3.5/Wp, which decreased 47-54 percent in 7 years. Experts expect that the price of crystal silicon solar battery will reduce to US$2/Wp in 2010, system price will reduce to US$3.12/Wp, and that electricity price will reach US$0.11/kWh. In 2020, the price of crystal silicon solar battery will reduce to US$1.0/Wp, system price will reduce to US$1.52/Wp, and electricity price will reach

US$0.052/kWh, which is equivalent to other generation methods.

Thirdly, production is increasing. Since 1988, production of solar battery has increased 15 times, and increased from 33.6 MWp in 1988 to 561 MWp in 2002 (shown in Fig. 1-4). Japan has produced most solar battery in the world, 251 MWp in 2002, and production of U.S.A. is the second highest.

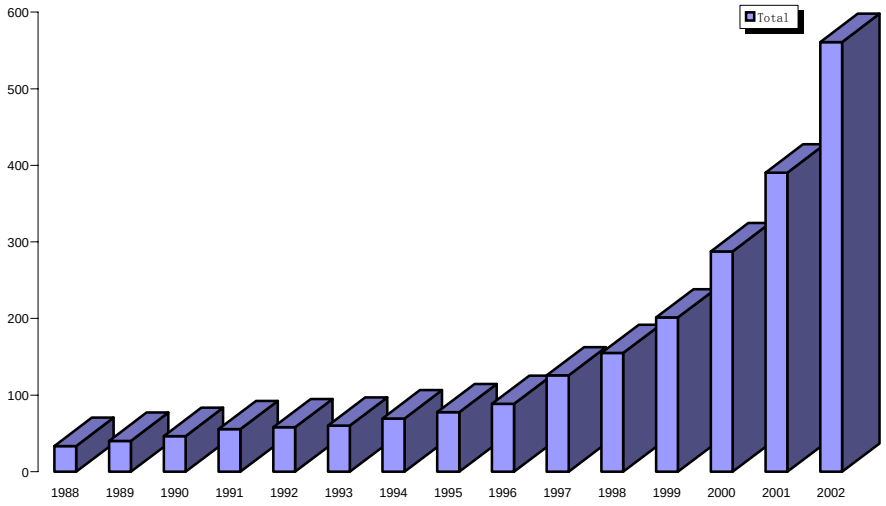

Fig. 1-4 The world Production of Solar Battery Component in 1988-2004 (MW)

Source: China Spanish renewable energy technology symposium

There are more than hundreds of manufacturers who produce solar battery in the world, operating photovoltaic system are about 1 million, and installed solar battery was over 2200MWp in 2002, half of which was used in interconnection photovoltaic system. Market distribution of photovoltaic battery is shown in Table 1-2.

Table 1-2: Market Distribution of Photovoltaic Battery（MWp）

Application fields	2000	2001	2002
Consumer goods	40	45	60
American independent house	15	19	25
Rural independent system	38	45	60
Power supply of communication/signal	40	46	60
Photovoltaic-diesel oil commercial projects	30	36	45
Interconnection photovoltaic system	120	199	270

Large-scale centralized power station (＞100KW)	5	5	5
Total（MWp）	288	395	525

Source: Wang Sicheng, *Solar Photovoltaic Generation*, China/Spanish Renewable Energy Technology Symposium, Dec. 2003.

According to the development trend, R&D of solar energy battery will focus on high-efficient and low-cost battery (including non-crystal silicon and micro-crystal silicon layers thin film battery), and application will concentrate on interconnection rooftop system and large-scale interconnection system.

1.4 The market of solar energy heat use is enlarging.

Solar water heater is one of solar energy heating use technology with most rapid increase speed, widest application fields and largest potential. According to statistics, solar water heater possession of the whole world was over 100 millions square meters in 2002, which provided energy equivalent to 14 millions tce, and half of them are located in China. However, Cyprus and Israel are the top two countries at solar water heater area per capita. In Israel, 80 percent families use solar water heater, and in Japan 20 percent families use solar water heater. European countries are carrying out SOLTHERM Project, whose target is to annually install heat collector 2 millions m2 and the gross area will reach 15 millions m2 in 2004.

Solar energy heat generation is still on the prophase of commercialization. Since 1980, many countries such as U.S.A., Spain and Australia have constructed all types of demonstration devices to boost heat generation technology. There are three types of solar energy heat generation systems: trough line focusing system, tower system and dish system. Installed capacity is over 350 thousands kW. Since 1990, U.S.A. and European Union have carried out " Solar Energy Heat Generation Plan" to promote commercial progress. It is forecasted that solar energy heat generation will realize commercialization in developed countries in 2020 and expand to developing countries step by step.

The most prospective field is solar energy building. At present, developed countries are actively developing solar energy building technology. In 1980s', International Energy Agency organized experts from 15 countries to cooperate on solar energy

building. Germany, Holland, Belgium, Austria, Norway, Canada and U.S.A. have constructed demonstration buildings with comprehensive using of solar energy. The result shows that annual energy consumption of solar building is only 40 kWh/m2, while annual energy consumption of traditional building with the same scale is 172 kWh/m2. Therefore, energy conservation of solar building is very obvious.

1.5 the development of the biomass energy has stepped into a new phase

There are three main ways in the development and utilization of biomass energy: 1) combust biomass directly to heat; 2) biomass gasification to supply biogas or generate; 3) product liquid fuel. Till now, the way of direct combustion is still one of the main ways of biomass utilization, which is till used by 2.5 billion people throughout the world and the annual consumption amount is 1.3 billion ton SCE (see figure 1-1). The development trend of biomass will be optimized utilization such as biomass gasification, biomass generation and product liquid fuel from biomass etc.

- **Biomass gasification and biogas supply**

Biomass gasification and biogas supply is mainly applied in Chinese rural areas, which is seldom in foreign countries. About 500 demonstrations of biomass gasification and biogas supply have been built in China and the annual biogas production is about 0.15 billion m3, these projects are mainly served for the rural cooking fuel and still at the demonstrion level. The biogas technologies in China are comparatively mature and have been applied widely. By now 11.1 million farmers and more than 1300 livestocks have built biogas projects and the annual output is about 4.7 billion m3 (the sociation of China energy research, Energy Policy Research, 2003, 6). These projects are helpful to improve the rural healthy environment and energy supply.

- **Biomass generation**

This technology is applied most widely in foreign countries. There are two ways to generate by biomass: one is combustion directly; the other is to drive gas turbine by biomass gasfication. These two technologies are relatively mature and the former one which has reached the commercial level has been applied to many projects broadly. The U.S.A is still the country that has the most installation with more than 350 biomass power plants. These plants are mainly distributed amoung the industries of pulp, paper and forestry maching with a total installation of 7000MW and offer about

60 thousands employment opportunities. It is expected that 13000 MW installations will be obtained by 2010.

In EU, biomass generation is used to district heat system or cogeneration. Its technic process is: put the collected rural and industrial waste into the incinerator to generate hot water or high pressure steam to heating or generate by driving the gas turbine. There are more than 16.3 thousand sets in Austria by now with total power of 1663MW. The cost of these systems depends on their scale and technology standards level. In a general way, the cost is in the range of 300-1700ECU/KW and the average cost is 589ECU/KW.

Waste generation is another rising field. There are about 114 waste power plants with total installation of 2650MW in the U.S.A; more than 50, total 1000MW installation in German; 149 plants, total 557MW④ installation in Japan. To all generation efficiency, the U.S.A is the most high-level with 22 percent; Gemany is the second with 17 percent; Japan is the lowest level with only 9 percent. From the development trends, biomass gasfication generation in large-scale technology is on research in the world. Commercial IGCC system is developed now meanwhile combustion directly generation technology is generalized.

- **Produce liquid fuel by biomass**

Biomass is the only renewable energy that can be converted into liquid fuel directly. There are all kinds of liquid biofuel because of the various kinds of biomass and conversion technologies. The two kinds of liquid biomass fuel oil of fuel ethanol and bio-fuel conversion technologies have been mature and obtained a considerable scale.

Brazil is the country that implement fuel ethanol program earliest. The materials of fuel ethanol production are sugarcane and granulated sugar. Considering national energy safety and economic development, the first reason that Brazil carries out the fuel ethanol program is that the first oil crisis shocked Brazilian civil economy; the second reason is to promote the agricultural and planting development and protect peasants' benefit; the third reason is to develop native renewable energy and protect environment. The annual ethanol fuel in Brazil is about 8 million ton now which accounts for 1/3 of total oil consumption. Brazil has been the largest ethanol fuel

consumption country with more than 3.7 million vehicles using ethanol fuel. Meanwile, Brizal is the only country that doesn't supply gasoline. Ethanol fuel program has benefited Brizal in three aspects: first, an independent economy-energy operation system was builded; second, the program incentives agricultural and planting development, brings 27 billion USD, and increases employments by 1.5 times; third, improve the environmental and people's living quality and reduces the GHG emissions by 20 percent.

Another country that produces and uses ethanol fuel in large scale is the USA. Different from Brazil, the matirecials is corn in the USA, which comsomptions 7-8 percent of their total national output. The government supports the ethanol fuel development: first, the government provides investment privilege policy that 10 percent makeup for the initial investment and 90 percent credit loan for the alchol plants less than 3000 tons annual output; secondly, the government provides 45 cents/gallon(1498￥/ton) tax derate for the alcohol fuel plants; 10 cents more tax derate for the 3-90 thousand tons production scale. Besides the federal government, the state government probides 10-20 cents/gallon subsidy for corn production; thirdly, the government makes laws of environmental protection such as clean air law modify draft published in 1990 which requires the areas that CO emissions and ozone content overstandars use oxo fuel such as ethanol and MTBE etc. But the congress has forbidden MTBE because it caused groundwater pollution. Ethanol fuel development programs are also under taken in EU and Japan countries.

The government of China has been attaching importance to the development of ethanol fuel, especially for the R&D of the production ethanol from non-foodstuff, which is be included in one of the national science and technology key tasks and 863 plan by Ministry of Science and Technology. Since 1980s, the broomcorn breeding technology and ethanol production technology have been made progress; its trial-produce scale was 5000 tons per year in 2001.

Biomass oil is a kind of "green energy". The production process cleanses environment already, which can obtain 3.2 units energy per unit foissl consumption; the biomass oil is poisonless, high octane number and non-sulf, non-dust, so biomass oil consumption reduces environmentaltoxicity by 90 percent, cancerd rate by 94% compared with the

traditional diesel oil. So the development of biomass oil is regarded high in many countries.

Early in 1970s-80s, special institutes were founded and plentiful manpower material resources were put into the research of biomass oil. Along with the increasing oil resources and environmental pressure, many countries increase their support on the development of biomass oil in 1990s. Decades of settings of biomass oil production have been built in the USA, France and Italy, the largest scale of whose output is 0.57 million tons per year. A plant that cost 50 million marks with 0.1 million annual outputs were built in German in 2001. The sum output of biomass oil in German was 0.45 million tons in 2000.

The booming development of biomass oil benefits from the support from the foreign countries government. Take the USA for instance, the development of biomass oil is one of the main tasks of the RE development stratagem and the federal government leads the way to comsumpt biomass oil. Special technology standard was established and price subsidy was provided to promote biomass oil commercial development. In German, the peasants who plant biomass matericals crops can get 1000 mark per hectare subsidy and the plants that produce biomass oil can get the tax derate privilege.

1.6 The development of other renewable energy

- **Geothermal energy**

Generation and utilization directly are two main ways in the development of geothermal. The total installation around the world has been 7173 MW[⑤] by 1996. The largest sacle is in the USA that is 2800 MW, followed with Filipine and Italy with 1230MW and 632MW. Now the total installation is about 9000MW.

There are various direct utilization ways. The most widely one is geothermal heating by total consumption of 150 thousand tons per second. The total geothermal heating areas is more than 8 million square metres in China.

Geothermal pump technology is under research to increase geothermal resources utilization eff efficiency. It turned out that high-level efficiency causes domestic heating expends to be reduced by 15 percent and refrigeration expends be reduced by

25 percent.

- **Micro hydro-power**

Micro hydropower has been developed well abord. New micro hydropower is 3 million KW yearly in the worldwide, half of which is from China.

- **Ocean energy**

The ocean contains several kinds of energy such as tidal energy, wave energy, tidal current energy, ocean thermal energy and so on. Human being having been researched in the fields of ocean energy and made some kind progress, however, only tidal generation has been formed a considerable scale. The total globle tidal generation installation is about 0.3 millionKW and 80 percent distributed in France. Other ocean energy utilization technologies are still on trial.

In general, renewable energy is plentiful, clean, and renewable. The development of RE will never be exhausted and harmless to environment, so the development of RE is ideal choice for sustainable development energy system. The experts forecast that globle RE development will be advanced further in 21 century and become the main energy supply in the future. Figure 1-5 is the forecast of globle energy development by Shell. Although it is just one example of all kinds of analyse and estimations, it figure vividly the development prospect of RE.

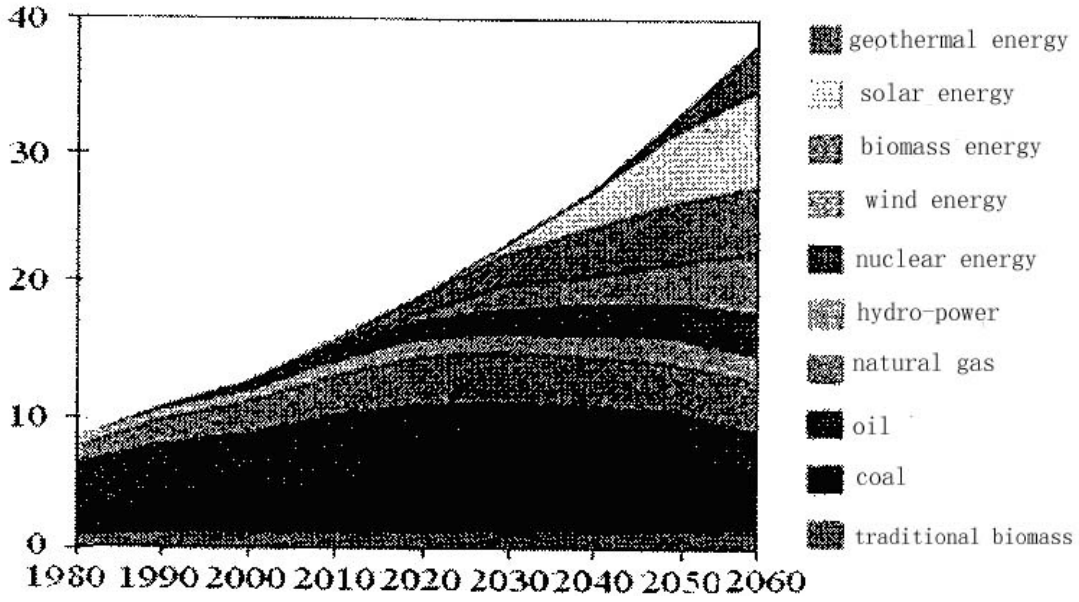

Figure1-5 forecast of global energy development by Shell

source：ABB, “Alternative Energy Solutions”, P7.

2. Development strategy and discussion

2.1 Development objectibes

Meny countries have developed RE a lot, but the objectives are various. The objectives in developing countries are generally the same including China. In the past, the objective is to solve the problems of energy and electricity in rural and jumping-off areas. However, the objective in developed countries is different from the developing countries'. In 1980s, the developed countries were impacted by the oil crisis, so they developed RE to sovle diversified energy supply; in 1990s, the objective became to solve environmental pollution. Whether the pressure is from diverfied energy supply or environmental problem, they all brought market demand for the technology of RE development and promoted the development of RE industrial development.

The objectives are different in developed countries because of their different political preference and public environmental awearness. The developed countries are divided into two parts: one is the European country such as EU. By force of climate change and their promises at Tokyo Protocol, these countries do their best to achieve their political goals that improve environment, reduce pollution and control GHG emissions. At the same time, energy supply safety, lessening rely on fossil fuel and mitigating the polical and martial situation of overdepend on the USA are also be considered. The RE development quantity target is made according to the GHG abatement index in these countries. The RE development targets assure to expend scale rapidly, increase appearance, solve energy supply, insure RE to account for a certain ponderance and promote RE to develop sustainbly, steadly and rapidly.

The other part is North America such as the USA, Autrilia and Japan. These countries' main motive is to fulfil their promises on Climate Change Convention and try to achieve the transition of RE technologies commercialization by market and competition means. The RE developments in these countries appear up-and-down due to the undefined RE quantity target.

The developing countries are divided into two types: one is the country such as Brazil and India. These countries develop RE in order to solve the energy short.

Considerable preferential finical incentive policy is made to promote RE development, trying to solve the energy supply problem.

The other part is the countries such as China. These countries develop RE with mulriple goals. At beginning, the purpose is to solve the problems of energy especially electricity short in the rural and remote areas. The development of biogas, micro hydropower, micro PV system and wind-power can meet their requirements. Afterwards, the target tries to integrat RE development into national total energy development stratagem; keep up with advanced technology trend of wind-power and grid connected PV-power in the world.

2.2 Stratagem status

In order to achieve above targets, the developed countries reattach importance the status and role of RE technology in energy supply stratagem. According to the available information, the status of RE technology has been enhanced more:

- Means to ensure energy security and multi-supply;
- Important measure to reduce GHG emmision;
- Technology choice to reduce urban environmental pollution;
- Alternative energy tevhnology to reduce the external cost caused by fossil fuel and nuclear;
- Motivity to creat employment opportunity and develop mimedium and small-sized enterprise;
- New resource to expand technology and instrument export;

As a result of the important status, energy policies have been remodified in many countries especially in EU, the U.K., the U.S.A., Danmark, and Australia. The energy stratagem with topic of new century, new energy and new policy has been established. Except that the U.S.A. still put the emphases on overseas energy supply and nuclear development, the other countries all give prominence to RE development especially EU. RE technology has been the most important role in total energy supply stratagem in EU. RE consumption will be account for 50 percent in total energy consumption by 2050. “Greem electricity” was put fordward in the USA to increase the green electricity proportion. “Green electricitiy” include wind-power, PV-power, biomass-power and so on; PV-power will account for 15 percent of new installation in

2020. In order to achieve the above target, 3.2GW installation yearly and 36GW accumulative total installation must be assured to guarantee the leading situation in the world.

In despite of different targets and routes, the trend to enhance the status of RE in energy supply to a great extent is the same.

2.3 Specific strategy and development route

Different countries have different specific strategy and development toute:

In Sweden, Finland, France and Austria, native resources such as biomass and hydro resources are developmed on emphases to meet the requirement of energy supply and environmental protect.

In Japan, Danmark, Netherlands, Spain and German, the development route is to build industrial production management system rapidly pushed by native market.

In the USA, the general strategy of RE technology is to locate the frontier of technology development; build a wide market of RE development at the same time. Under this strategy, the USA not only possesses of various research and manufacture capability of advanced RE technologies but also the wide RE technologies application market.

2.4 Policy problem

There are ont only successful experiences but also failing lessons in the RE development in develped countries. As far as their lessons be considered, lack of specific development target, coherent finical incentive policy and public opinion support are the key factors. The successful experiences are as follows:

- Lead by sicience and technology, attract industries to participate in the long-term key technologies' research and development, accelerate the technologies' commercialization, form manufacture industries foundation system. Take the USA for instance, the governments demand the enterprises keep their international leading station in technology research and development and furnishment manufacture capability. The USA work-out the development route of PV-power, wind-power generation furnishment and hydric power technology

development successively, locate most RE technologies frontier and guarantee the leading station of this field.

- Specify medium and long-term target, build a steady market scale, and guarantee the investors' long-term profit. Take German for instance, the government put forward that RE technologies especially wind energy would take the place of nuclear technologies in 30 years. This decision accelerated the step of RE development; in less than 10 years, a system of furnishment manufacture, installation and operation has been built up. By the end of 2002, wind-power installation in German was over 12GW; German became the largest wind-power installation country exceeding the USA.
- Build a policy system based on legislation, guarantee return rate of the investment of RE technology. Various economic incentive policies such as RPS, feed-in-law, green certificate and so on have been carried out since 1990s. Though different policies adapt to different locations, so long as the policies are consistent, the policies are effective.
- Build public opition atmosphere. Long-term propaganda and education in the developed countried make the public accept at large the RE technologies such as high-price and green energy power which are helpful to environment. In the international stockmarket such as Newyork and London, the industries of RE are always blue chip. Public recognization is the motive to promote the government to develop RE. The enterorises such as Shell developed RE technology.

Long-term practices show that the RE technology development progress turned out be a progress of technology innovation, mechanism innovation and the progress of the public participation in the energy decision-making and impletment. In the past 20 years, technologies of wind energy, solar energy, biomass energy and the other renewable energy are developed; different operation and incentive mechanism are trial-built, which promote the formation of RE technologies market. These are all rewarding experience and important reference for our renewable energy development.

Chapter 2 Necessity and Strategy significance to impel the development of renewable energies in China

Energy is the important strategy materials for the national economy and society development; on the other hand, energy is the main pollution source in reality at the same time. China is a big country with big population and rapidly developing economy. With the economy development and WTO goal's realization, in the big country whose energy consumption depending mainly on coal, not only the energy industry face the dual pressure economy growth and environmental pollution, but also the problem of energy security and international competition stands out badly. The renewable energy such as solar energy, wind energy, biomass energy and hydraulic energy is not only the base for energy system in future but also the supplement energy in urgent need for China to use now, for its cleanliness, non-pollution, sustainable exploitation and utilization. So during the time nowadays with problems of the energy, climate, and environment face the big challenges, to impel the development of renewable energies is not only suitable and necessary, but also follow the international development trend.

1. To impel the development of renewable energy is one important content to implement sustainable development strategy

1.1 Sustainable development is paid attention by the whole world

Based on the point of the view for whole world to development together, and the understand course for people to environmental and resource protection, to exploit and utilize clean new and renewable energies is the compulsive choice for sustainable development, which is agreed on gradully.

At the same time, the sustainable development of the human being society has to base on the sustainable development of energy. So, what is the sustainable development energy system? According to the definition and requirements of the sustainable development, it should satisfy the following 3 conditions at the same time: firstly, resources are abundant, sustainable utilized to sustain the energy need of the society and economy development in the long time; secondly, its quality is cleanly low emissions or zero emissions and has no threat for the environment; thirdly, it can be

accepted by the human being society from the technology economy and bring out the actual economical benefit. In a word, a real sustainable development energy system should be systems to help to improve and protect people's happy life and promote the harmonious develop of the society, economy and eco-environment.

China is one of the countries that consume much fossil fuel. The primary energy consumption in China in 2000 is close to 1.3 billion tce, 93 percent of which are fossil energy. The abundant utilization of the fossil fuel not only brings out heavy burden and destroy to the transportation, soil and vegetation, but also heavily pollute the air environment. According to the national environment public report, the air quality of over 2 thirds of cities in China have gone beyond the national air quality level 2. The main reason of the air pollution is the exceeding of the sulfur dioxide and dust concentration in air, especially in the oversize cities with the population bigger than 1-2 million. What's more, with the number of the passenger car increases rapidly, the exhaust air has been an important pollution source. The breathing organ illness related to air quality has become common illness that is threatening citizen's wealthy. The problem of the environment pollution has become a serious restricting condition for sustainable development. So there is no time to delay to alter the energy consumption way, improve life status and implement sustainable development.

1.2 Present energy system's inherent limitation bring out its non-sustainability

Up to now, the fossil energy systems of petroleum, gas and coal are the main three energy stanchions for the world economy. Without one doubt, these fossil energies had made undeniable contribution for human to society progress and material welfare production. But it is proved by the practice; they have some unconquerable limitation and threaten human being society development and security heavily day by day. Firstly it is the resource has limitation. According to experts' research and analysis, there is a coincident conclusion that the exhaust of the non-renewable energies cannot be avoided and it is the problem of when to happen. The following table shows the French experts analysis 20 years early and they are also right even from the today's view.

Table 2-1 Estimate for he energy exploitation time limit in the world

Sort	Proved up Reservation（PR）and Assumption Reservation（AR）	Used up day

Coal	900(PR) 2700(AR)	About 2200
Oil	100 (PR) 36 (AR)	Before 2020
Natural gas	74 (PR) 60 (AR)	About 2040
Uranium	According to the thermal reactor calculation 60 (PR+AR) According to the breeder reactor calculation 1300 (PR) 1600 (AR)	According to the thermal reactor calculation 2073; According to the breeder reactor calculation 2110-2120
Total Non-renewable Energy	1100 (PR) 300 (AR)	About 2200

Source：J.R.Frisch，Resource Crisis in the Future，French，1982

Secondly, there is harm to environment. Fossil fuels especially coal is the dirty energy, with pollution from the exploitation to transportation, to finally utilization. Many researches prove that over 80 percent air pollution and 95 percent Greenhouse Gas is caused by burning of the fossil fuel. They also bring a series of pollution to the water body and soil. The pollution has serious influence to people's healthy and cannot be despised. It is shown in the following table.

Table 2-2 the concrete situation of the global environmental eco-environment deterioration

Item	Deterioration situation
Soil desertion	10 hectare /minute
Forest decrease	21 hectare /minute
Grassplot decrease	25 hectare /minute
Plow land decease	40 hectare /minute
Species extinction	2 /hour
Soil sweeping	3 million/hour
CO2 emissions	15 million/day
Garbage brought	27 million/day
People death due to pollution	100 thousand/day

Total wastewater emissions	6000 billion ton/year
Total loss due to natural disaster	120 billion USD$/year

Source：Zhang Wudi，“the utilization of the biomass energy”，solar energy，2000 , 1

For China, the threat of drying up the energy is likely to come sooner. Even though China has abundant fossil fuel energies resource gross, the level of resource per capita is the half of the global average level due to China’s big population. The resource per capita of oil and natural gas are 11 percent and 4 percent of the global average level⑥. Now, the primary energy consumption per capita in China is only 1.2tce, which is 1/2⑦ of the global average level. China’s population is 1.3 billion, China is the most rapidly economy growth in world. The increasing of the population and the purpose to well-off society and rapid economy growth are need to supported by the energy supplying. According to the newest projection from ERI, SCDR, whole national energy demand will get to 2.7 billion tce in 2020 (the source is same as 9), among that, the available energy supplying including coal, oil, natural gas, hydraulic energy and nuclear energy is 2.4 billion tce with the gap of 0.3 billion tce; in 2050, the energy demand will get to 4.0 billion tce with the gap of 1.0 billion tce. It is 25 percent shortage. What’s more, the energy utilization technology is laggard, efficiency is low and consumption is high. Based on the economy stable development, the consumption rapidity of fossil fuel may become bigger. Because of the not abundant oil, gas resource, their dry up rapidity for China will be quicker than other counties and the threat of the energy dry up will be earlier and heavier. So to fully utilize the not used up renewable energy and let it be an important part in the energy supplying is a necessary choice for the sustainable development.

1.3 Renewable energies suit for the basic requirement of the sustainable development

1.3.1 Abundant resource, abroad distribution are the good conditions to substitute the fossil fuel

Take China for example, just in the present technology level, the available resource from solar energy, wind energy, hydraulic energy and biomass energy resource can be 7.3 billion tce (table 2-3), which is about the 5.6 times of China’s energy consumption in 2000:1.3 billion tce and 8.3 times of China’s coal consumption

Table 2-3 Projection for new and renewable energy resource availability in China

	China	Note
Solar energy (Mtce)	4800	Calculate by 1% land area, 20% conversion efficiency
Biomass energy (Mtce)	700	Including village waste material and city organic garbage
Hydraulic energy (Mtce)	130	Including all possible dam site (including micro scale hydraulic)
Wind energy (Mtce)	1700	According to the exploitation quantity in the sea and land wind resource, 2300h, 0.36kgce/kWh
Tide energy (Mtce) Geo-Thermal energy (Mtce)	Omitted now	
Total (Mtce)	7330	

Source：Estimated by authors

The abroad distribution of the renewable energy resource set the very convenient condition to implement decentralized energy. This is an unbeatable advantages compared with the fossil fuel.

1.3.2 the technology become mature, the effect stands out increasingly

The main features followings are:

- The energy conversion efficiency is increasing gradually;
- The technology reliability has been more improved;
- The stability and continuity have been enhanced with more perfect system;
- There is a set of commercial technology with the industrial development.

1.3.3 Economy feasibility has get more and more improved

It should be known that most of the renewable energy technologies not low-cost technology. If we only calculate the energy economy benefit, many technologies now can’t reach the conventional energy technologies level and they are short of competence in economy; but in certain districts and applying fields, there are different conditions, some technologies have shown a certain degree market competence, such

as micro scale hydraulic electricity, geo-thermal electricity, solar water heater, geo-thermal technology and mini PV system.

The above facts show that, the renewable energy technologies not only to be part of the sustainable development energy system, but also to be an essential part in the present energy system. So it is a must to accelerate its development with any necessary measures.

China government pays attention to sustainable development at all times, and sets it a basic national policy. In 1992, China signed the <UNFCCC> and brought forward 10 countermeasures, and definitude that “to exploit and promote the new energy such as solar energy, wind energy, tide energy and biomass energy”; in 1994, China drew the “Agenda of 21st century in China” to emphasize the importance of development of new and renewable energy to China’s economy sustainable development and environment protection. In the global sustainable development summit, Premier Zhurongji expatiate China’s principle and position again deputy of Chinese government and made formal promise. This showed the decision and confidence for Chinese people to implement the sustainable development strategy. But proved by facts, there are many things to do so as to turn the thinking of sustainable development to action, to realize the sustainable development energy building, to promote the renewable energy development.

2. To impel renewable energy is an important measure to insure China’s energy security

2.1 Optimize China’s energy structure and improve energy distribution

Now, China is during the rapid economy development period and the energy construction has heavy duty and many works to do especially direct by the goal of completely construct well-off society. But in China, the energy structure has been based on coal and it is the main reason of low energy efficiency and environment pollution. To optimize energy structure and improve distribution is one of important goals for the China’s energy development. To utilize and exploit new and renewable energy is an important way to promote diversified energy structure without doubt.

2.2 Enrich energy supply, improve energy supplying diversification level

China became net import country for oil production in 1993 and for crude oil in 1996. In 2000, the oil import dependence has reached 20%. With the continuous growth of the national economy, the ratio of the oil imported in the total oil demand will increase from 34% in 2001 to 82% in 2030. Natural gas has broad market perspective with the import dependence is 6% in 2000 and will be 20% in 2010. With these import dependence become bigger and bigger, the stability of China's energy supplying can't be influenced by international situation changes. Renewable energies are local resources, which are utilized and exploited domestically and can't influenced by exterior condition; through technologies, the renewable energy be converted to not only electricity but also liquid fuel such ethanol fuel, biomass diesel oil and hydrogen fuel to supply energy for the mobile equipments. So to exploit China's abundant renewable energy to construct diversified energy structure not only satisfy the demand of energy for economy growth and do well in enriching energy supplying and improving energy supplying security.

3. There is actual promoting influence to solve the problem of agriculture, rural and peasant, ant completely construct well-off society

3.1 It is an important means for promoting rural economy development and increasing peasant's revenue to impel renewable energy development

There is special but actual meaning for China's rural economy development to develop renewable energy. China has 1.3 billion people among which 0.8 billion are living in rural district. They consume 0.6 billion Tce energy, half of which are supplied by traditional biomass energy. There is abundant renewable energy in China's rural area especially in west rural district. They are not only the traditional biomass energy but also abundant micro scale hydraulic electricity, wind energy and solar energy. The level of rural district and peasant utilize energy and their utilizing way reflect the development situation of the rural district directly, so solve the rural district energy utilizing problem and construct perfect rural district energy utilization mechanism, is one of the focus problems of Chinese government. Under the call on of national full construction for well-off society, to exploit and utilize renewable energy such as biomass energy, solar energy, wind energy can supply clean and high efficiency energy for peasants for they to improve life condition, and promote the

sustainable development.

To impel renewable energy in rural district cannot only solve the life energy, but also be related closely to the agriculture structure adjustment to effectively promote agriculture revenue increase and peasant revenue increase. For example in southern district we can promote the ‘pig-biogas-fruit’ to use biomass material to generate biogas; in northern district we promote the ‘four parts in one body’ energy zoology model to help crop, breed through biomass residue bottom fertilizer, and get the obvious revenue increase through increasing 9% wheat, paddy production and 15% for corn.

To alter traditional rural district energy utilization way, such as develop biogas, micro scale hydraulic generation, straw gasification and solar boiler can bring the development of the rural district building materials and transportation industries and cultivate the service team for energy construction and maintenance. It can increase rural district employment opportunity. So to exert integrated benefit advantage of renewable energy, can promote the development of the industries of agriculture, breed, crop, and increase peasant’s revenue to increase rural district resident consumption and promote he rural district economy development through pulling the interior demand.

3.2 It is a practical means to solve remote resident electricity.

There were 1061 counties, more than 20 thousand villiages, more than 7 million household to live without living electricity at least. These distribute in the west of ourcountry where contain abundant RE resources. Developing RE is the most practial and sustainable means to solve the electricity in these off-grid areas. RE development can provide clean energy, improve their living condition and increase their income.

3.3 It is an effective means to improve rural living environment and sustain rural ecoconstruction.

Now, firewood is still dominated in the rural living energy in the middle and west of our country. Rural firewood energy consumption accounts for 50% of total national foresty resources, which impacts our eco-environment. The spread of biogas plants, solar stove and micro hydropower can hold back chopping woods in disorder and

solidify the eco-construction. Take micro hydropower for instance, 1000kWh installation can replace 1-2 tons firewood, 1.8 units of area forest can be protected per year. 5.4 units of areas forest will be protected in 3 years.

4. RE industry is an important new economy increasing fields.

4.1 RE development can narrow the gap in RE technology between abord and ours', locate an advantaged station.

RE is not cheap and effective energy yet; but it has huge potential and wide prospect. Along with the wider market and more mature technologes, the RE technologies will be more and more competitive and will have an important impact on national income.

In the past, our country lack dynamics with economic strength, scientific and technological foundation, fund input, support policy, etc. respect, cause the renewable energy not to develop fast, even with having greater disparity foreignly on some key technology, make most renewable energy technologies unable to reach the degree popularized in commercialization, form more perfect industry; It is the products depending on foreign import that there are much some existing renewable energy projects, it has been unable to form the market with certain scale all the time .

But according to trend of the energy development, it is a common and irresistible trend in the world to develop renewable energy; the development trend of renewable energy has already been no longer only served for the rural and remote district, but should move towards commercialization progressively, play more roles in national economy and people's lives. So on the question of renewable energy development, the situation faced at present is: in the market of our country has already lagged behind, renewable energy technology and market which others have already led, such western countries as America and Europe, etc. are still developing with higher speed, this may make them continue leading; In this cases, if we do not follow the development trend of the world tightly, increase the input into renewable energy industry, the future not so far, not merely the space which we gave play to will be smaller and smaller in the field of renewable energy technology, will also surrender submissively our own renewable energy market after many years.

4.2 Developing renewable energy can increase the social employment opportunity; it is a need of opening up the new field of economic increase.

American scholar thinks that it is probably 2 times of petroleum[⑧], natural gas to invest in such employment opportunities that technology create as the energy efficiency and solar energy, etc. Several pieces of new energy of European Union and professional committee of renewable energy have similar views, according to the estimation by them, European wind-power electricity generation reaches and invites 40GW, solar cell 3GW, biomass energy to generate electricity when 10GW and solar energy collect hot device 100Mm2 in 2010, total can offer 1,540,000-1,670,000 employment opportunity, and this return not including have 17 billionECU commercial extra potential 350,000 employment opportunity that export create every year. The renewable energy industry is verified by practice of our country the contributing of employment too. Only taking the small power station and other renewable energy as an example, there are more than 20000 enterprises of small power station of our country in 2000, fixed assets nearly 300 billion, obtain employment worker 520,000 people (materials source is the same with 10), in order to arrange for the surplus rural labor force to make enormous contribution; Solar energy enterprise, wind energy enterprises, biomass energy enterprise add up to more than 2100, if each enterprise counts according to 20 people, national employees are above 40,000 people.

5. It is an important means to reduce GHG emmission and prevent globle cilimate change.

The countries all over the world have already noticed the development renewable energy there are enormous benefits at present, development and utilization of renewable energy hardly discharge no gas danger to atmosphere, this is very favorable to reducing the discharge of such gas of the greenhouse as the carbon dioxide, etc. Take wind-power and hydropower as an example, carbon discharge intensity amoung the whole life cycle of them is only 6g/kWh and 20g/kWh, which is far lower than intensity 275g/kWh generating electricity with coal[⑨]. Under the require to developed country strictly to make in " Kyoto Protocol ", the country of European Union has already regarded development and utilization of the renewable energy as the important measure of reduction of greenhouse gas discharge, they plan by 2020

wind-power electricity generation hold confidential more than 15% which account for the whole of European Union's generator installation, the energy that the renewable energy technology offers will occupy 50% of the proportions in the whole energy composition by 2050.

Our country makes great efforts to reduce the proportion of fossil energy consumption in the energy consumption structure, try our best to reduce the discharge of the gas of the greenhouse. It is essential to establish the good national image.

Chapter 3 the Current State and the problem of the renewable energy development in China

1. The current state

During the course of research and exploration for so many years, the technology of renewable energy in our country has much advance, and the whole level has been improved in a high step, all we can summarize two aspects as follow:

1.1 The technologies have been made a great improvement, bursting out of a set of commercialization and pre-commercialization technologies, but many of them are under the stage of research and development or the stage of demonstration pilot.

Small hydroelectric power plant is the earliest technology that has already achieved the commercialization, whose installed capacity reaches 2850 MW and plays an important role during the course of electrification in the rural ties of China.

Wind power technology is developing fast, and nearly going to the phase of commercialization. The technology of micromachine and 1-200KW wind-electric machine becomes matured day after day and is made of a series of 100 200 300 and 500W equipments which has been popularized to use more than 170,000; our country's autonomic development equipments of 100KW 200KW 300KW and 500KW have reached the level of batch production and over MW level is still on the research.

Among the technologies of solar energy application, solar hot water heater has already achieved commercialization, the annual output is around 10 million m2 and the sum of installation is 40 million m^2, the top of the world; photovoltaic technology developed faster in recent years, the efficiency of home-made silicone single crystal photovoltaic cell reached 14-15%, the same with the foreign level and the calculated installation number in our country is nearly 40 thousand KW by the end of 2002; the technologies of solar air condition, solar building, solar drying ,new type of high efficiency cell and so on are still during the course of research and demonstration pilot and the technology of solar thermal power is blank now.

Biogas as a relative mature technology is widely applied in the whole nation. Now there are over 10 million biogas digesters, above 1900 large and medium biogas plants, annual biogas output 4.7 billion m3; at the same time, research and demonstration is widely going on in the aspects of biomass gasification and air supply, biomass generation and biomass liquefaction. Currently, the capacity of biomass generation is about 1 million KW, in which the capacity of bagasse generation is over 800 thousand KW; the rest is rice hull and other agricultural waste, forestry waste, biogas and garbage power. Ethanol fuel output is nearly 1 million T, the research of bio oil and fuel crop is in the plan, in which the production scale of experiment of sweet sorghum alcohol abstraction has reached annual output 5000 T, own the primer terms and conditions of commercialization.

1.2 Industrialization has started its way, but the market share is limited.

With the technological improvement and development, the renewable energy industry in our nation developed step by step and became a certain scale. On the side of energy, the current new renewable energy can apply for 49 million tce energy annually, 32 million more than that in 1990; but compared with the whole energy system, its market share is narrow, only 2.8 percent of the national primary energy consumption quantity in 2002, reference the table 3-1 and table 3-2.

Table 3-1 various renewable energy development volume in China in year 2002

	Volume	**Mtce**
Large and medium Hydro Power	184.3TWh	67.2
Biomass conventional Combustion	255.5	279.8
New renewable energy		48.9
Small hydro power	31.0GW, 103.7TWh	37.8
Biomass energy		4.08
Biogas digester	11.0 Million Doors, gas-generation 3.7 billion m3	2.64
Large and medium biogas	More that 1300 plants, gas-generation 1 billion m3	0.71
Straw gasification	488 plants, gas-generation 150 million m3	0.02
bagasse generation	800MW, 2000GW	0.71
Solar Power		5.86
Water Heater	40 million m^2	4.80
Passive Solar House	26.60 million m^2	0.80

Solar Cooker	478 km^2	0.24
PV Cell	25MW, 50GWh	0.02
Geothermal		0.65
Direct Utilization	0.6Mtce	0.60
Power	28MW, 140GWh	0.05
Wind power		0.45
Wind Turbine in Grid	460MW,1245GWh	0.44
Small and Micro Wind Turbine	33MW, 34GWh	0.01
Total		395.90

Note:

i Power generation calculated from coal consumption in coal-fired power plant by TCE.

ii Heat produced by Solar water heater annually is 120 kgce, passive solar house 30 kgce annually and solar cooker 5000 kgce.

iii heat value produced from biogas and straw gasification are 0.714 kgce/m3 and 0.157 kgce/m3 respectively.

iv data resources: Institute of China Energy Research, energy policy research, 2003.6

Table3-2 The Proportion of Renewable Energy to total primary energy consumption in China

	1990		2000		2002	
	Mtce	%	Mtce	%	Mtce	%
Coal	752.1	60.2	861.3	56.3	978.3	55.2
Petroleum	163.8	13.1	320.5	21.0	346.3	19.6
Natural Gas	20.7	1.6	32.6	2.1	40.0	2.3
Nuclear Power	0	0	6.3	0.4	10.4	0.6
Renewable Energy	313.3	25.0	309.4	20.2	395.9	22.3
In which：large and medium scale hydro-power	34.3	2.7	53.1	3.5	67.2	3.8
Traditional utilization of biomass energy	362.0	21.0	219.1	14.3	279.8	15.8
modern renewable energy utilization	17.0	1.4	37.4	2.4	48.9	2.8
total	1250.0	100.0	1530.1	100.0	1770.9	100.0

Note: same to the above

2. Problems and Barriers

Although the renewable energy resources probably have great development, some technologies has commercialized and industrialized to some extent; there are large gaps in terms of technologies, industries scale and developing speed comparing to those in developed countries. The development of renewable energy has to face a lot of problems and barriers as follows:

2.1 The power generation costs of most of renewable energy technologies are too high and the market volumes are too narrow, which are the key barriers in the process of renewable energy development in China.

As we all known, exclude the small-scale hydro-power, the power generation cost of renewable energy is far higher than the normal energy resources in China. For example, the initial investment of Grid wind power is 8000 yuan/kw, unit power generation cost is 0.33 yuan/kwh, the Grid price (including VAT) is 0.52 yuan/kWh. The cost of PV power generation even reaches 40000 yuan/kw, the unit power generation cost is as high as 2.38 yuan/kWh. Thus, the unit investment cost of coal (an evidence of 300 thousand kW without the desulfurated equipment) is 5000 yuan/kW, the unit power generation cost is only 0.21yuan/kWh, the grid price (including VAT) is 0.33 yuan/kWh, much lower than wind power and photovoltaic power.

In addition, most renewable energy industries develop slowly and don’t change the situation that is that the market is relatively narrow, scant demand, cannot promote the related technology and its industry. The result is: the dominance of upgrading and reducing cost by rapidly developing new energy technology isn’t incarnated well; the low rapid of commercializtion cannot help the industry development; the development of new domestic technology lacks momentum, has to depend on the supportive policy of government.

Obviously, the high cost will inhibit the enlargement of the renewable energy market capacity. Per contra, the narrow market will block the cost reduction of renewable energy, becomes a vicious cycle, lets the development of renewable energy go to hardship and has bad effect on the courage of government, bank and private enterprise who maybe invest the renewable energy. More standing by than activity, less

investment.

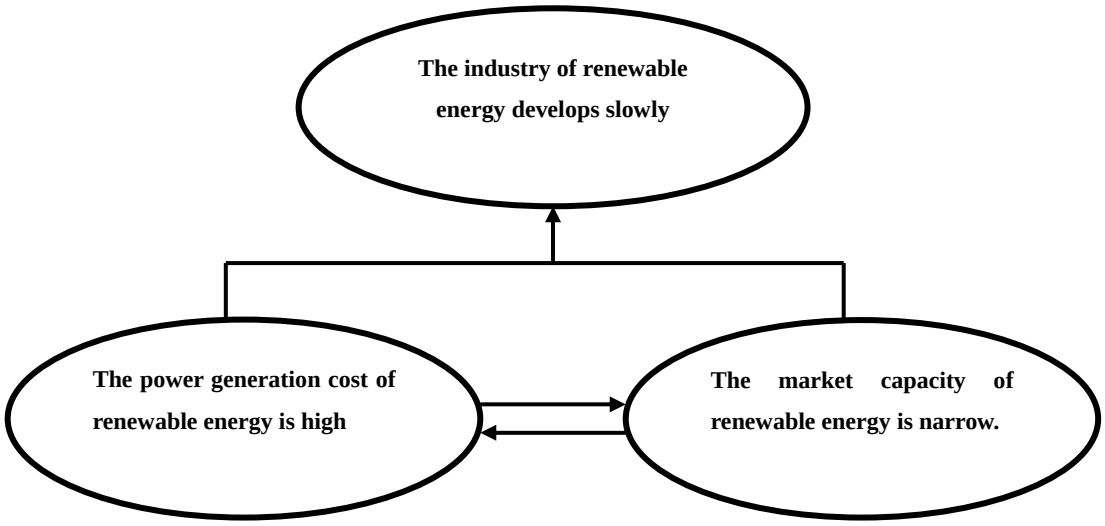

Chart 3-1 cost and the market mechanism

2.2 Lacking the special law is the hardpan of renewable energy developing lowly in our country and falling in a subsidiary situation in a long time. The position of renewable energy isn't established in law that made the trade in development discomfiture.

The experiment of foreign renewable energy development is proved that the obligatory law is one of the successful experiments that can guarantee the aim reality of renewable development. For example, in 1978, the USA federal energy commission brought forward and executed "*Public Utilities Regulatory Policy Act*". On April 1st 2003, Japan executed "*Special Measure Act on Electricity Power Corporation Adopting New Energy*". In 1990, Germany disciplined Feed-in law. The laws mentioned above have an obvious effect on promoting renewable energy development. However, China has already given out some related policies and regulations but not promulgated a special law that made the policies of renewable energy weak and lack some power, cannot give much help of promoting it. Then, to discipline renewable energy law must be added in the development schedule.

2.3 Related puny manufacturing made a difficulty of localization and commercialization in renewable equipment produce. And this is also one of the reasons why the cost of renewable energy is too high and the market is build-up lag. On top of this, the puny manufacturing may build an impediment of technology commercialization; become the phenomenon that there is only technology but not industry.

As the foreign experiments show, powerful manufacturing is the important bases of renewable energy industry development in Germany, Nether land, Denmark or the USA, the fast development of domestic renewable energy industry depends on the mighty technology power and powerful manufacturing besides the related policy and law. An important guideline of weighing the growth speed of manufacturing is the continuous growth of investment. In the USA, the growth rate of wind machine manufacturing increased annually by over 15% between 1990 and 2000, which ensured the domestic generating capacity to reach 2500 MW in 2000. However, because of the shortage of investment in most of new and renewable energy factories for a long time, it brought such results that there is no professional manufactory, the production capacity is small and divergent, centralization degree is low, the technology is far behind the advanced technology, the production quality isn't instability, the economic performance is poor and the ratio of localization product is low. All above made a difficulty reduce the construction cost and supply the awaiting parts in time.

2.4 There is no concrete measure or there is no corresponding implementation mechanism to achieve the policy goal, which has seriously decreased the policy effect and been called the problem of 'there is policy and there is not effect'.

In the past, the implementation effect of the renewable energy policies was not good. It is mainly due to that there is no corresponding mechanism for the established policy; especially it is the key problem that there is no implementation mechanism oriented by market. For example, due to the shortage of the goal mechanism, the government institute can't draw the long term and stable development plan so that the project developing enterprises' investment confidence is restricted. Due to the shortage of he competition mechanism, there is no pressure for the present renewable energy price to be low and it is hard for developer and grid to reach a agreement on the electricity supplying. Due to the financial mechanism, the investment channel in this industry is

not diversified and the government is the main investor, only the finance input can't satisfy the investment demand for this industry. So, in China, a series of implementation mechanisms including goal mechanism, competition mechanism, financial mechanism, compensation mechanism, transaction mechanism and administration service mechanism should be constructed.

2.5 There are many branches to set policies which can't implement without effort due to the low harmony among these branches.

For long time, China's management works of new and renewable energy are decentralized in a lot of government branches. The Ministry of Agriculture, the Ministry of Water Resources, the former Ministry of Electricity and the former Ministry of Forestry all have set particular branches or department to be deputy on a part of task. Especially between the former State Committee Economy and Trade and the former State Committee of Planning, their functions were intersected partly and there was the situation of many branches manage one things, the investment fund is scattered, the construction is repeated partly. This heavily weakened national macro coordinating and controlling strength. There are many branches to set policies and there is low harmony among these branches. The management situation is disordered. In addition, the series of methods to be applied in the renewable energy development are very complex and involve many different institutes. These schedules set overabundant obstacles for the project develop and restrict the both developer and investor to enter the market.

Chapter 4 Chinese strategies, objective and measures on renewable energy development in new situation

1. The framework

Under the new situation of building a well-off society in an all-round way, the framework of Chinese renewable energy development should meet three requirements.

1.1 Meet the energy demand to realize a well-off society in an all-round way.

To realize the objective of building a well-off society in an all-round way in 2020 advanced by the 16th CCP Congress, the increasing energy supply is a key support. Firstly, energy demand will increase through trebling GDP. In spite of industrial structure change and adoption of advanced and efficient techniques, energy demand will be increasing at Chinese current situation. Secondly, a well-off society is more than an economic concept, and has intensive social meaning. While the People is increasing their income, they will also improve living condition, especially for the rural residents who will be not satisfied with traditional renewable energy and need more good quality energy. Thirdly, a well-off society in an all-round way means social equity. The living condition of all of the People should be improved and modern energy should be supplied for the residents in the remote areas.

1.2 Establish a sustainable and safety energy supply system

The coal consumption in the rural area accounts for over 30% of national consumption, and traditional biomass fuel takes up more than 60% of rural living fuel. The coal supply will face a great pressure if living energy use in the rural area turns to fossil fuel. China has been a net import oil country and is facing a serious issue of oil security because of the rapid increasing demand for liquid fuel. Therefore, in long term, China should develop renewable energy to establish a sustainable and safety energy supply system.

1.3 Protect environment and implement sustainable development strategy

Chinese environmental pollution is emergency and China will take the first place in greenhouse gas emissions in the near future. It’s imperative under the situation to

develop alternative energy and reduce fossil fuel consumption. Therefore, clear renewable energy development is an instrument to protect environment and implement sustainable development strategy.

2. China has the fundamental conditions to develop at a large scale

2.1 Sufficient resource

China has various renewable energy resource including small-scale hydropower, solar energy, wind power, biomass, geothermal energy and ocean energy. The recoverable resource is show in Table 4-1. The table shows that the developed resource is few but renewable energy resource potential is great. Resource potential with mature technology, such as small-scale hydropower, wind power and biomass, is 2600 Mtce, while the potential solar energy, geothermal energy and ocean energy is greater.

Table 4-1 Chinese Renewable Energy Resource and Development Potential

Variety	Recoverable Resource	Developed amount in 2000	Undeveloped resource
Small-scale hydropower	1.Small-scale hydropower under 25MW is 75GW, generable electricity is 240TWh, equivalent to 87.1Mtce 2.Micro-scale hydropower under 0.1-10kW is 80GW,g generable electricity is 125TWh, equivalent to 45.3Mtce Subtotal: 132.4Mtce	Installed capacity of small-scale hydropower is 24.8GW, taking up 33% of recoverable resource; installed capacity of micro-hydropower is 167.7MW, taking up 0.2% of recoverable resource, generated power is 261.9GWh;subtotal is 29.1Mtce, development rate is 22%	Small-scale hydropower: 50.2GW; micro-scale hydropower is 79.8GW Subtotal: 103.3Mtce
Solar energy	Two thirds of land has sufficient solar energy, annual radiate amount is over 6GJ/m^2.	Water heater, passive solar house, solar oven, and photovoltaic battery. Total: 3.84Mtce	Development potential is huge

Wind power	Wind resource above 10m height is 253GW；offshore wind resource is 750GW；wind resource above 50m height is 1000GW；Total: 2000GW，4700TWh，equivalent to 1706.1Mtce	Installed capacity of interconnection wind generator is 344MW，generated power is 930GWh；small and micro-scale wind generator is 17MW，generated power 35GWh. Developed rate is 0.018%	Developed amount is small and undeveloped amount is more than 2000GW，equivalent to 1700Mtce
Biomass	Resource is about 700Mtce，crop and straw is 120Mtce，fuel wood 90Mtce，livestock and birds feces, the waste and organic waster water are 390Mtce. With agricultural development, improvement of living condition, and implementation of large-scale project of returning land for farming to forestry，resources of straw, fuel wood, faces, waste and energy crop will increase, and will reach 900-1000Mtce in 2020.	Biomass through traditional measures is 219.1Mtce（straw and fuel wood），accounting for 104.3% of total resource（excessive consumption）；biomass through new technology is 3.3Mtce，accounting for 0.8%	With the development of new technology, biomass through traditional measures will decrease. the potential of biomass through new technology is large, and can reach over 800Mtce in 2020.
Geothermal energy	Recoverable geothermal energy resource is 3158Mtce/a，geothermal energy spots are over 2900	Generation and heat use of geothermal energy are 0.65Mtce	Development potential is huge
Ocean energy	Recoverable resource is abundant and over 48.58GW，tidal energy is 21.79GW，wave energy is 12.85GW，tidal flow energy is 13.94GW	7 small-scale tidal energy generation stations with 6MW；1 tidal flood energy generation station with 5MW，total is 11MW	Development potential is huge

2.2 The market potential is huge

China has a large population but insufficient resources, and energy supply can't fully meet the demand of national economic development. With further development and progress of building a well-off society, there will be new requirement for energy supply. Meanwhile, 80% of population lives in the rural areas, and annually consumes more than 600 millions tce, but half of them is obtained through straw, crop and woods, which destroys ecological environment and results in desert. Therefore,

renewable energy development according to local conditions, such as solar energy, wind power and biomass, can not only meet the demand to living energy use from the rural residents, but also improve ecological environment. The imperative demand provides huge market potential for renewable energy development.

In addition to the increasing demand to energy, there will be three change related with renewable energy development.

Energy demand resulted from transportation increases rapidly. With the increase of income, the private possession of urban car rises up greatly. This trend will result in the increase of oil production demand. Renewable energy development, especially biomass, can provide an alternative fuel for transportation, which is an important instrument oil security.

The rural energy demand is changing from traditional biomass to commercial fuel. This is shown in Table 4-2 and Fig. 4-1.

Table 4-2 The Rural Living Energy Use from1991 to 2000

	1991	1995	2000	Increase rate in 1991-1995 %	Increase rate in 1995-2000 %	Increase rate in 1991-2000 %
Commercial energy, Mtce	90.5	109.7	160.0	4.93	7.84	6.53
Non-commercial energy, Mtce	285.7	266.6	219.1	-1.71	-3.85	-2.90
Total, Mtce	376.2	376.3	379.1	0.01	0.15	0.09

Remark: non-commercial energy consumption includes a little of producing energy use in the rural areas.

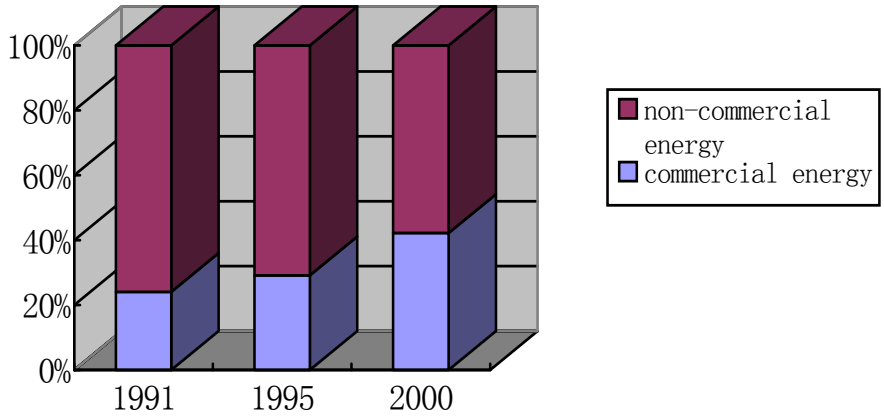

Fig. 4-1 The change of rural energy consumption

Families using good quality living fuel are increasing in the rural, and the peasants need convenient and clear fuel. From 1990-2000, the rural families using liquefied petroleum gas have increased from 4.7 millions to 35.5 millions, increasing 6.55 times, and annual average increase rate is 22.4% with a linear trend (shown in Fig. 4-2).

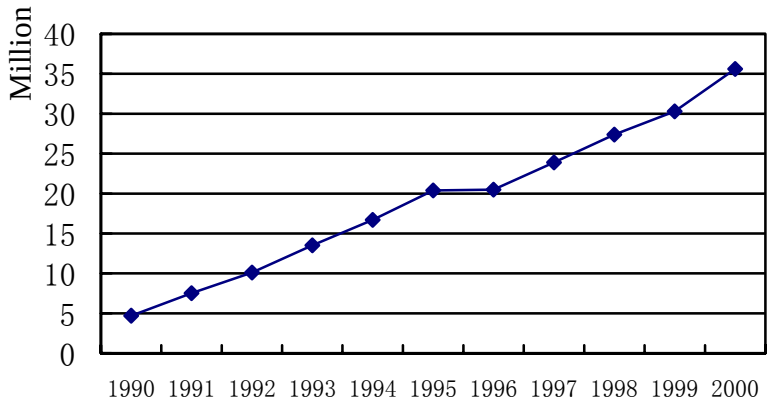

Fig. 4-2 The Rural Families Using Liquefied Petroleum Gas

An instrument to realize social equity. China has 26 millions rural residents living under poverty condition, and 35 millions living in the rural without electricity. To realize a well-off society in an all-round way, China must provide electricity to the poor peasants. The population without electricity lives in the remote mountain areas and pasturing areas, which are far away from the national grid, thus they have to rely on renewable energy generation.

2.3 Renewable energy has primarily formed industrial base and has good development trend.

Since 1990, renewable energy development has made a great progress in China (shown in Table 4-3). From 1990 to 2000, the developed amount has increased from 17 Mtce to 37.2 Mtce, annual average increase rate 8.15%. The annual average increase rate is 11.18% from 1995 to 2000, which is 2.15 times of that from 1990 to 1995. The renewable energy developed amount in 2000 is shown in Fig. 4-3. The table and figure suggest that:

- Small-scale hydropower is increasing steadily, and takes the first place in energy supply, accounting for 78%.
- The development of biomass, especially biogas has the increasing trend, and annual increase rate is over 6% in the ninth-five plan period, accounting for 8.9% of energy supply.
- Solar energy is developed rapidly, and takes the second place in the energy supply, accounting for 10.32%.
- The development rate of wind power is rapid, but the developed amount is still small; the same with geothermal energy.

Table 4-3 The Development of Renewable Energy Technology in 1990-2000

	1990	1995	2000	Annual increase rate in 1990-1995 %	Annual increase rate in 1995-2000%	Annual increase rate in 1990-2000 %
Small-scale hydropower, GW/TWh, Mtce	13.2/39.3	16.6/55.3	24.8/80.0 29.0	4.69	8.36	6.51
Biomass, Mtce			3.31			
Families using biogas, thousand/million m^3	476/700	570/1470	764/2590	3.67	6.03	4.84
Large-scale biogas station, unit/million m^3	535/360	540/420	1000/1000	0.18	13.12	6.45
Straw gasification, unit/million m^3			388/1500			
Bagasse generation,			800/2000			

MW/GWh						
Solar energy			3.84			
Water heater, million m^2	1.0	4.5	26	35.10	42.02	38.52
Passive solar house, million m^2	0.35	3.34	18	57.01	40.06	48.29
Solar oven, thousand unit	118	142	332	3.77	18.51	10.90
Photovoltaic battery, MW/GWh	1.78/3.3	6.63/12.2	19/35	30.08	23.44	26.72
Geothermal energy			0.65			
Direct using, Mtce			0.6			
Generation , MW/GWh			28/140			
Wind power			0.35			
	4.0/10.8	36.1/97.6	344/930	55.27	56.97	56.12
Interconnection generator, MW/GWh						
Small-scale generator, MW/GWh	12.9/26		17/35			2.80
Total /Mtce	17.0	21.9	37.2	5.20	11.18	8.15

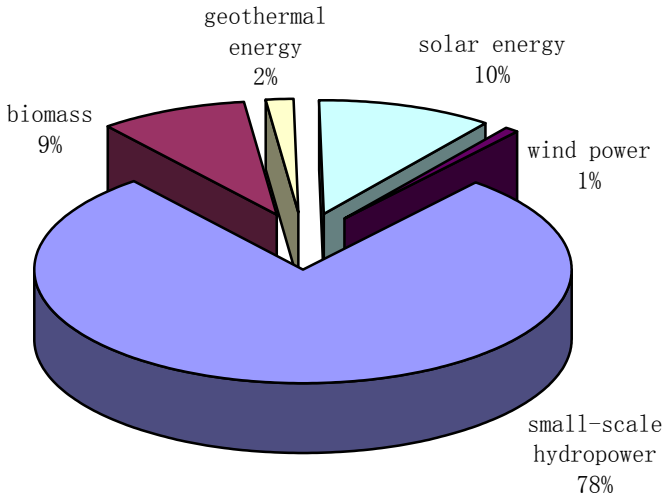

Fig. 4-3 Renewable Energy Development Structure

2.4 Technological development has made progress and competitive ability is strengthening.

Renewable energy technology has made great progress. Quantities of national experiment bases have been established, which have fostered large numbers of talented technological persons and greatly improved the ability of independent research, development and innovation.

- Most of solar energy technologies have been mature, and water heater has realized commercialization.
- Efficiency of single-crystal silicon battery has reached 14%-15%, equivalent to the international level. Component cost has reduced to about 20 yuan/Wp, and the price 30-35 yuan/Wp. It is forecasted that the price will be 10 yuan/Wp and generation cost is 0.5-1.0 yuan in 2020.
- The technology of micro-scale wind generator with 50-300W has been mature, and is able to annually produce 30 thousands units. R&D on large-scale wind generator has made a series of achievements, and more than 90% components of wind generator with 600kW can be produced in China. It's forecasted that wind generation cost will be 0.32 yuan/kWh in 2010, and wind power can compete with coal generation.
- Many kinds of biomass technologies have been developed. Biogas technology is on the international level and utilization scale has increasingly enlarged. Biomass generation technology has succeeded in demonstration, and has economic potential. With policy driven, biomass generation cost can compete with coal generation in 2010. The technology of liquid fuel preparation such as grain alcohol through biomass has made primary progress, and is turning to development at an industrial scale.
- Technologies of geothermal energy heat use and generation, and tidal generation have been mature, and can be developed speedily with capital investment.

3. The strategies of renewable energy development in China

According to the trend of renewable energy development in the world, China has made a lot of research on strategies of renewable energy development, taking consideration of the current situation that coal is the main energy resource and oil is short, and the increasing demand for energy from economy development. "Chinese strategy research on the follow-up energy development" by Ministry of Science and

Technology has forecasted energy demand in China in the middle of this century. The forecast result shows that with ecological driven case, renewable energy will be a leading actor in energy structure in 2050, accounting for more than 30%. Therefore, the strategies of renewable energy development in China can be conceived as the following four phases.

The first phase: part of renewable energy technologies will have been realized commercialization till 2010. Through expanding experimental bases to demonstration and spreading under policy's promotion, technologies such as small-scale hydro electricity, wind power, solar heating, biogas and geothermal heating, which have been mature or primarily mature, will have been complete commercialization.

The second phase: large numbers of renewable energy technologies will have been commercialization till 2020. Attach more importance to R&D, and focus on generation, production of liquid fuel and gas fuel. New renewable energy technology, such as photovoltaic generation, biomass gasification and generation, and biomass liquid fuel, will be able to compete with traditional energy. Renewable energy will take up more than 18% of primary energy.

The third phase: renewable energy will be realized commercialization in an all-round way and substitute fossil fuel at a large scale. Renewable energy will have taken up more than 30% of energy consumption; new renewable energy except hydropower and traditional biomass will have taken up over 20%, and have been an important alternative energy till 2050.

The fourth phase: renewable energy will have taken up more than 50% of energy consumption till 2100. Traditional using measures will ultimately disappear and energy consumption structure will fundamentally change.

4. Development target in 2020: annual developed amount will reach 400-500 tce.

4.1 Overall objective

In the next 20 years, the objective of renewable energy development is the following.

- Enlarge the application range and development scale for renewable energy, and

promote mature technology at large scale to make renewable energy take a significant role in renewable energy supply and do more contribution for building a well-off society.

- Speed up technology innovation, greatly improve technological level to reduce cost, ultimately change the situation that key technology is lagged behind, make most of renewable energy technology reach international level and realize industrialization.
- Focus on development and spread the modern technology of renewable energy, advance the change of rural fuel structure, and gradually make rural energy more modern and good quality to protect environment and boost rural society and economy development.
- Make fully use of solar energy, wind power and micro-scale hydropower to ultimately solve the issue of lack of electricity in the remote areas.

4.2 Quantity objective

During the Ninth-five Plan period, the annual average rate of renewable energy development (with new technology) has been 11.2% and it is expected that the development rate will remain about 10% in the next 10 years. If the increase rate in 2010-2020 is the same as that in 2000-2010, the utilized amount will reach 265 Mtce in 2020. Taking consideration of technology innovation, development at industrial scale and driven by requirement of ecology protection, the increase rate will be about 15%, thus the utilized amount will reach 386 Mtce in 2020.

Traditional using of biomass has been on a decreasing tread. With the progress of building a well-off society in an all-round way, demand for high quality fuel in the rural will continuously increase, and the decreasing tread of traditional biomass will remain. If the annual decrease rate is about 2%, traditional using of biomass in the rural will decrease to about 140 Mtce in 2020.

Therefore, the utilized amount of renewable energy will reach 410-525 Mtce in 2020, which is twice of that in 2000.

4.3 development objective as two phases

The above objective of renewable energy development can be conceived as two phases. The first phase is from the present to 2020, and the second phase is from 2011 to 2020 (shown in Fig. 4-4).

4.3.1 Development objective in 2000-2010

In the first phase, the development objective and focus are the following.

- Through pilots and demonstration, enlarge the spread range of mature technology such as heat using of solar energy, wind generation and biogas to form commercial production system and make renewable energy take their role in energy supply.
- Attach importance to technology development, speed up the update of biomass technology and take modern use of biomass. Ultimately focus on R&D on renewable energy to catch up advanced level in the world and make a base for large-scale development.
- Make use of solar energy, wind power and micro-scale hydropower to ultimately solve the issue of lack of electricity in the remote areas.
- The developed amount of new renewable energy will reach 100 Mtce in 2020 at 10% annual speed. In addition of traditional biomass (170 Mtce), which are decreasing annually at 2.5% speed, the utilized amount of renewable energy will be 280 Mtce.

4.3.2 Development objective in 2010-2020

In the second phase, the development objective and focus are the following.

- Widely spread application of renewable energy technology and annually increase renewable energy at about 15% speed.
- Further improve technology to reduce cost, most of renewable energy technology are used commercially, form competitive products and technology in international market, and establish renewable energy industrial system and research system with Chinese characteristics.
- The utilized amount of renewable energy will reach 410-525 Mtce and make a firm base for larger-scale development.

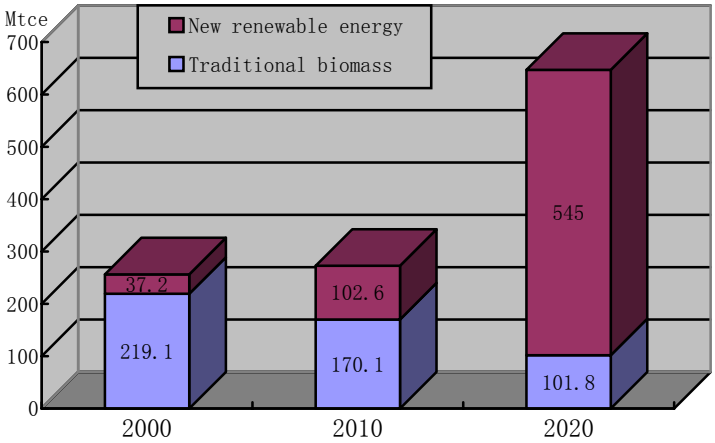

Fig. 4-4 Development Target of Renewable Energy

5. Industrial target: renewable energy generation installed capacity will be 90-100 millions kW, and heat use will be 300-400 millions tce in 2020.

5.1 Generation installed capacity will be 90-100 millions kW.

5.1.1 Small-scale hydropower will be 60-70 GW

According to continuous and steady development rule, that is the annual average increase rate is 4-4.5%, the installed capacity of small-scale hydropower will reach 39 GW in 2010, and 60-70 GW in 2020, when 80-93% will be exploited.

5.1.2 Installed capacity of wind power will be 20 GW

Generation cost of wind power will be decreased with the development of domestic large-scale wind generator. Taking consideration of policy and system improvement, wind generation will develop at a high speed. It's expected that installed capacity of wind power will reach more than 4 GW in 2010, and over 20 GW in 2020 (annual increase rate is 30-35%).

5.1.3 Installed capacity of biomass will be 10 GW

Three possible pathways will boost biomass generation development. Firstly, with continuous modification by developed countries and R&D by China, biomass technology will be advanced. Secondly, biomass generation is an effective method to change rural energy structure from mainly using traditional biomass to modern pattern, which is an instant requirement to build a well-off society in an all-round way. Thirdly, abundant biomass should be developed to boost economy development. Therefore, the installed capacity will be 3 GW in 2010 (annual average increase rate is about 15%), and 13-20 GW in 2020 (annual average increase rate is 15-20%).

5.1.4 Installed capacity of other renewable energy will be 1 GW

Solar energy generation: solar energy generation technology is still on the early commercial application phase in China. Since 1990, the application of photovoltaic technology has developed rapidly, and the annual average increase rate is over 25%. With the increasing demand for electricity from remote rural areas and the

governmental support, solar energy generation technology will be greatly developed. Installed capacity will be 0.3 GW in 2010 and 3.8-8 GW in 2020 (annual increase rate is 30-35%).

Geothermal power generation: although the geothermal power technology is on the commercial phase and China has abundant resource, the development amount will not be great in the future because of the limitation of exploitation condition, market demand and environmental protection. Installed capacity will be 110 MW in 2010, and 0.5-1 GW in 2020.

Ocean energy: large-scale tidal power station will be possibly constructed in 2010. Wave and tidal stream generation still need more research and pilots, and it won't be developed at a large scale. Installed capacity will be 0.6 GW in 2010, and over 3-5 GW in 2020.

5.2 Heat usage of renewable energy will reach 300-400 millions tce.

5.2.1 Rapid development of modern biomass

Biomass should be priority to renewable energy development strategy, and it should be developed as commercialization and modernization. There are many methods for biomass transformation, and development level of technologies varies greatly. While we spread the mature technology speedily, we should do our best to research on new technology and improve technology level and commercial degree. In 2020, biomass used through modern technology will be more than that used through traditional measures.

- Biogas. According to the development trend during the ninth-five and the tenth-five, increase rate will be over 10%. It will provide gas 9.3 billions m^3 in 2010 and 24-37 billions m^3 in 2020.
- Other measures. Besides biogas and generation, development measures for biomass include gasification, liquefying fuel, biological oil, energy crop and contour charcoal.

To meet the demand for good quality fuel from the rural residents, we need to speed up the development of biomass, to adapt agricultural structure change, increase peasants' income and take the place of oil. We will develop good quality biomass 30 Mtce (not including biogas and generation) in 2010 and 13-20 Mtce in 2020 (annual average increase rate is 15-20%).

5.2.2 Speed up the development of solar energy heat usage.

The development of solar energy has good prospect in China. In the last 10 years, solar energy heat usage has developed at 40% speed rate. With the progress of technology and mature of industrialization, development of solar energy will remain the speed rate and take an important role in future renewable energy supply.

- **Solar energy water heater.** It can be expected that solar energy water heater will reach 105 millions m^2 in 2010 and 420-650 millions m^2 in 2020 (increase rate is 15%-20%).
- **Solar house**. With progress of building a well-off society in an all-round way, solar house will be constructed at high speed. It is expected that it will reach over 70 millions m2 in 2010 and 290-400 millions m2 in 2020 (annual increase rate is 15%-20%).
- **Other solar energy heat usage**. Solar heat usage including solar oven, solar dryness, greenhouse, heat supply and refrigeration has spread in living and production. It's forecasted that solar energy will be developed rapidly, and in 2010 the developed amount will be 0.7 Mtce and 2.8-6.4 Mtce in 2020.

5.2.3 Development of geothermal energy

Direct using of geothermal energy includes heat supply, planting, livestock breeding and hotspring. With the development of geothermal energy, direct using will remain high speed. It's expected that the developed amount will be 2 Mtce in 2010 and about 8 Mtce in 2020.

Summate up the above industrial development target, we will get renewable energy development forecast in China in 2010 and in 2020 (shown in Table 4-4).

In 2020, traditional using amount of biomass will reduce to 130-140 Mtce, reducing by 35%-40%. The ration in renewable energy will decrease from 85.5% to 26%-31%. In 2020, renewable energy will be mainly used through new technology, among which small-scale hydropower will decrease from 78% in 2000 to 18% though its accumulated amount is increasing, biomass will increase to 45%, and the ratio of solar energy will be more than that of small-scale hydropower (shown in Fig. 4-5).

Table 4-4 Renewable Energy Development Target in 2010 and 2020

	2000	2010	2020 BAU	2020 Rapid scenario
Small-scale hydropower/Mtce	29	39.348	60.813	68.283

Small-scale hydropower /GW	24.8	36.710	54.340	59.797
Micro-scale hydropower /GW	0.17	1.053	6.517	9.803
Biomass/Mtce	222.41	210.977	258.516	313.543
Traditional using/Mtce	219.1	170.094	146.273	138.979
New technology using/Mtce	3.31	40.883	112.243	174.564
Biogas/billion m3	3.59	9.3115	24.1517	37.6704
Generation/GW	0.8	3.236	13.093	20.039
Others/Mtce	0.02	30.000	77.812	121.367
Solar energy/Mtce	3.84	15.331	63.970	100.715
Water heater/Mm^2	26	105.185	425.530	651.275
Solar house/Mm^2	18	72.820	294.598	414.687
Other heat usage/Mtce	0.17	0.688	2.782	6.405
Generation/GW	0.02	0.276	3.801	7.975
Wind generation/Mtce	0.35	4.262	17.153	26.222
Interconnection generation/GW	0.344	4.742	19.185	29.363
Small-scale generation/GW	0.017	0.044	0.072	0.072
Geothermal energy/Mtce	0.65	2.224	7.670	10.726
Heat usage/Mtce	0.6	2.037	6.914	8.985
Generation/GW	0.028	0.113	0.458	1.055
Ocean energy/Mtce	0.006	0.600	3.715	5.588
Generation /GW	0.006	0.600	3.715	5.588
Total/Mtce	256.3	281.668	411.838	525.077

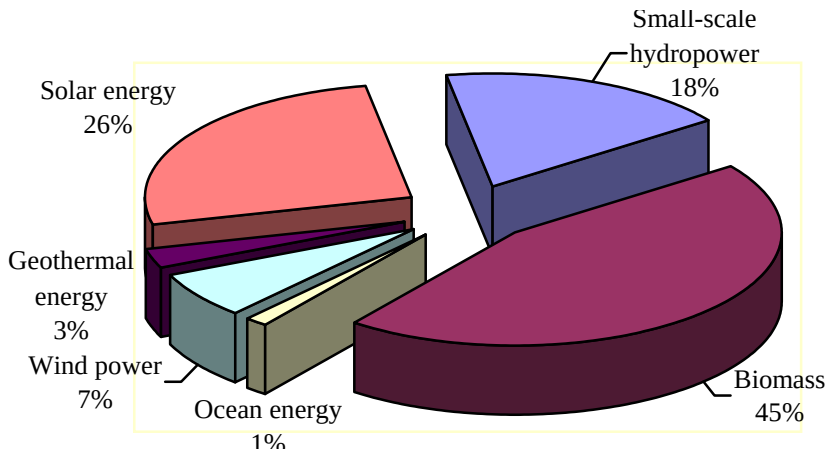

Fig. 4-5 The Development Ratio of Renewable Energy (New Technology) in 2020

6. The strategic guidelines to realize development target of renewable energy: government promotion, competition introduction, innovation encouragement and development at a large scale.

Governmental promotion: according to the development experiences of foreign countries and China's situation, development of renewable energy must be supported by law and policy. Government promotion means that government should provide strong support in policy, science and technology, and establishing market. Meanwhile, the government should actively drive the enacting of Renewable Energy Promotion Law to ensure renewable energy development through law.

Competition introduction: it will depend on market mechanism to reduce renewable energy cost as soon as possible and realize development at an industrial scale. Thus with government promotion, complete competition in the industry can optimize resource allocation and accelerate development of renewable energy.

Innovation encouragement: to meet the requirement of sustainable development, renewable energy development must rely on technology innovation and improvement of technology level. Therefore, China should research on renewable energy technologies with autonomous knowledge property right, and the technologies should mainly be on generation, gas and liquid fuel supply.

Development at a large scale: it is a necessary process for technology development, and a basic approach to reduce cost and realize commercialization as well. Industrialization should be boosted through development at a large scale. For those mature and almost mature technologies, we should grasp every chance to produce at a large scale, and widen application range to make them take roles in practices.

In these strategic guidelines, governmental promotion is the base, development at a large scale is the principle, and competition introduction as well as innovation encouragement are instruments. These four guidelines are united as one to form a comprehensive strategic guideline to renewable energy development.

In practice, these guidelines are embodied at the following facets.

6.1 Form a perfect system of law and policy, and establish firm base for renewable energy development.

Speeding up the enacting of Renewable Energy Promotion Law is the key to form a system of policy and law. Therefore, China should start the legislation procedure as soon as possible and try to finish it in 2-3 years.

6.2 Accelerate science and technology innovation with the government support

Multiple subjects should cooperate to improve R&D ability as a group and obtain technological innovation achievements with autonomous knowledge property right. Firstly, develop at a high beginning, cross over periods, and focus on the advanced level in the world and try to obtain more technological innovation achievements with highest level. Secondly, concentrate on the importance. Chinese input in energy R&D is less than the developed countries (shown in Table 4-5) because of the economic strengthen, and the expense on renewable energy R&D can't increase greatly in short term, thus we should focus on the significant technology to tackle key problem in short term. Thirdly, implement the localization strategy.

6.3 Attach importance to market role in resource allocation and strengthen development of renewable energy industry.

Through market mechanism, combine technology R&D with projects to transform technological achievement into productivity.

Table 4-5: Ratio of Energy R&D Expense to GDP in 1997 (%)

	Energy R&D expense to GDP	Energy R&D expense to gross R&D expense
China	0.0013	0.20
U.S.A.	0.032	1.27
Japan	0.092	3.09
Germany	0.015	0.66
France	0.039	1.69

6.4 Use resource comprehensively and intensively, improve profit and widen market.

To accelerate renewable energy development, China need comprehensively use resource through specialization and at a large scale, and improve using profit of technology to attract enterprises and users and widen renewable energy market. Development patterns include: development at a large scale, multiple energy complementary system, such as wind-photo complementary system, hydropower-wind complementary system as well as solar-biomass comprehensive using pattern (shown in Table 4-6), and comprehensive using of resource, such as livestock biogas plant (shown in Fig. 4-6).

Table 4-6: Four as one energy pattern in North of China (yuan)

Component	Investment and operation cost	Annual revenue	Profit
Biogas pool and system Green house Pigpen Guarder house	Investment: 23874 Operation cost: 10054	Total revenue: 20108 Biogas: 430 Vegetables: 18508 Pigs: 1170	Annual net profit: 10054 Payback period: 2.4 years Rate of return: 42.1%

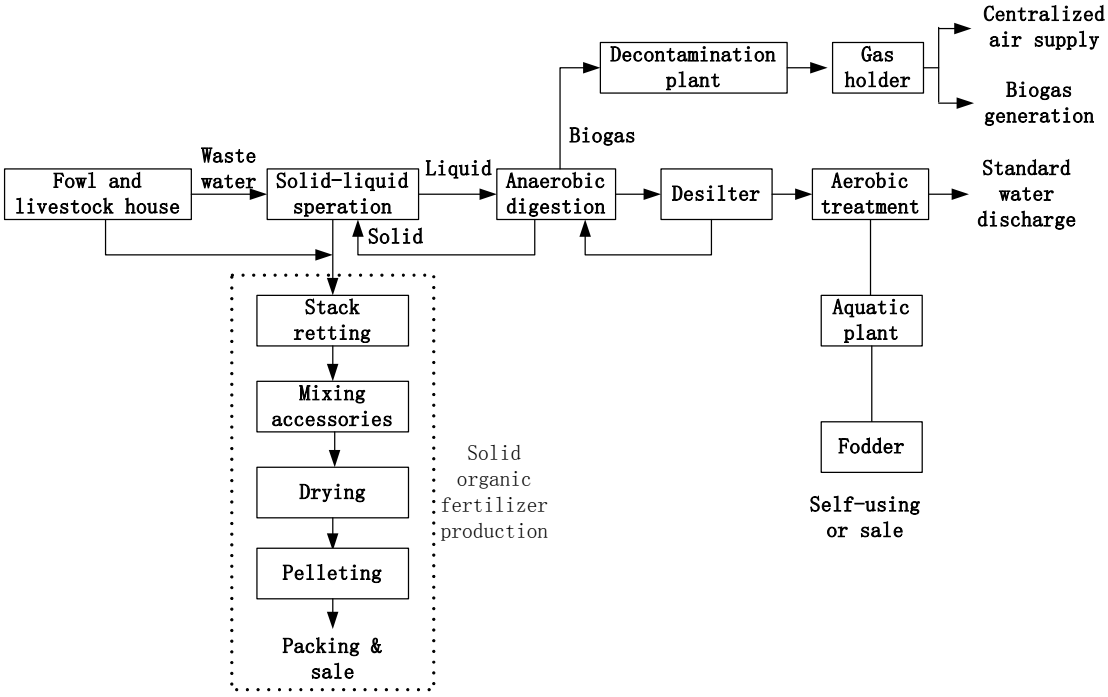

Fig. 4-6 Biogas technology and comprehensive using system

7. Renewable energy will make great contribution to Chinese social and economic development.

7.1 Renewable energy will take up over 18% of primary energy supply in 2020.

Renewable energy supply is increasing continuously. It's forecasted that it will take up 13.2% of primary energy in 2010, and 18.5% in 2020 (shown in Fig. 4-7).

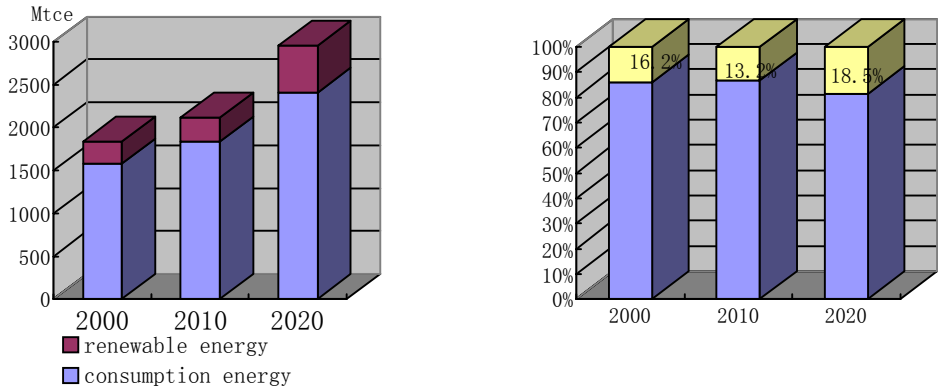

Fig. 4-7 The Rate of Renewable Energy to Primary Energy

Through technological achievements, development crossing over periods and industrial progress, renewable energy will have good condition to develop at a large scale and establish sustainable energy system.

7.2 Improve living condition and boost building a well-off society in an all-round way in the rural areas.

Renewable energy generation can provide electricity to more than 7 millions peasants living in remote areas where the national grid can't cover. The commercialization of traditional renewable energy will greatly change the rural energy consumption structure, and the ratio of commercial energy to traditional energy will increase from 40:60 in 2000 to 60: 40 in 2020. Rural energy consumption will mainly are clear and efficient energy.

It is forecasted that in 2020 renewable energy industry will provide more than 2 millions employments for the rural, and create GDP for 100 billions yuan. Meanwhile,

during the development of renewable energy, agricultural structure will be changed and income of peasants will be increased through development of energy industry, for instance, plant of energy crop, treatment of energy product, and development of energy ecology economy.

7.3 Protect environment and promote sustainable development

It's a necessary choice for sustainable development that clear renewable energy take the place of fossil fuel. In 2020 when exploitation of renewable energy will be 300 millions tce, it will reduce consumption of raw coal 400 millions tons, reduce SO2 emissions 6 millions tons, reduce smoke dust 5 millions tons, reduce CO2 emissions 220 millions tons, and keep within limits series of ecological and environmental issues resulted from coal exploitation, transportation and usage.

Meanwhile, since the issue of rural energy usage is solved, ecological and environmental issues resulted from rural energy usage will be solved gradually. Especially it will take an active role in reducing soil and water loss, vegetation cover loss, and land deterioration.

Chapter 5 Countermeasure in Exectuting the Stragies of Renewable Energy

In the first 15 years of 21 century, the mission of exploiting the new energies should focus on the R&D of key technologies that will play a crucial role in the national economy and ecology as well as their extension and commercialization. In order to fulfill this mission, the following policies should be suggested.

1. Expend the market scale and driven by the development goal

First of all, the government should complete the 10th and 11th five-year plan of the new energy and renewable energy industry as well as the mid- and long term plan. They should not only distinctly describe the development direction and tendency, but also specify the quantity explicitly. These plans should based on the actual resources and technological potential, take account of the national plans in the energy and electricity sectors and analyse the relationship between new/renewable energy and the whole energy sector. Secondly, the responsibility of executing these plans should be assumed to a specific department. The national plan should be supported by the plans of every province, every relevant industry, and even every technology in order to avoid the situation that these plans are put aside on the shelf. Thirdly, there should be a well-known timetable to specify the target, the execution scheme and monitoring methods in each stage. Last, the completion of new/renewable energy plan should be incorporated into the legislation process. Only establishing the compulsive target can attract more investment into renewable energy industry, which can help aquire the scale economy and boost the commercialization.

2. Enforce the legislation to ensure the realization of the goal

1）Make prepare for the “Law of encouraging new energy and renewable energy” and related administration codes. The goal of legislation is to guarantee the orderly development of new/renewable energy as well as their share in energy and electricity supply. 2）the path to implement should follow the four principles, or codes followed by laws, experiment units followed by spread, voluntary followed by compulsory, local followed by nationwide. On the one hand, we should modify and improve the

industry codes and develop them into laws; on the other hand, we should take specific measures to form an integrated and functional policy system. 3）Investgate the feasibility of MMS in renewable energy generation.

3. Impel the formation of industry clusters

The government should support the development of the key manufacturers to cultivate the production capacity in large scale. Moreover, the government should establish a relevant industry service system including developing the project construction units, set up the technology service system, promulgate quality standards or relevant codes and establishing an integrated monitoring system.

3.1 Promote the capacity building

Increase the input in resource survey and project plan and make stage development plans of new/renewable energy both in the nation and province level.

Increase the input in the innovation of the economic and environmental evaluation methods that can be adapted in renewable energy projects and establish a full evaluation index system. Normalize the existing cost accounting methods in line with the international norm.

Strengthen the capacity building in service system including designing, training, quality supervision and monitoring, technology service.

Enhance the input and capacity building in key industry and products and provide more training opportunities to foster pioneers and administrators in new/renewable energy industry.

3.2 Impel the industrialization and localization of the technologies

In the light of the development strategy of new/renewable energy in China, we should impel the procedure of technology development and localization by means of independent development combined with technology introduction and localization. During the project construction, we should gradually increase the proportion of local manufacturing in facility supply and establish a comprehensive new/renewable energy industry based on the techonology introduction and digest. We suggest these actions should be taken as follow:

- Explore the key factor that restrict the localization of renewable energy techonology and put forward the settlement scheme.

- Make sure the development target of the key renewable energy technology (including large-size wind generation, PV generation and etc.)
- Support selected enterprises and research institutes based on the open bidding and equal competition to shorten the technology lag and lay a foundation for the local manufacturing with majority of strength and captital.
- Catch up with or even surpass advanced world levels and form manufacturing scale in most renewable energy technologies by means of strengthening R&D and experiment units. For some mature technologies such as solar thermal technology and wind generation, we should boost the formation of commercial manufacturing and R&D system and expand the market scale.
- Develop high-efficient facilities of utilizing biomass energy and new technologies in molding, gasification and liquefaction and speed the update of facilities of biomass energy in rural areas.
- Enhance the development of solar energy and especially focus on solar buildings (including energy-saving solar buildings, solar water-heater and buildings that utilize solar energy comprehensively) and PV generation system.
- Enhance the reliability of power supply and the utilization percentage of small hydropower and substitute small hydropower for the firewood in the area with abundant hydropower.
- Increase the investment in R&D of hydrogen production, stock and utilization technology. We expect that the hydrogen production system using solar, wind and biomass energy and hydrogen production sample facility using coal bed gas will come into use in 2010 and realize large-size commercial manufacturing in 2020.
- Combined with the develop-the-west strategy and local potential of exploituring renewable energy, we should increase the investment in the western provinces and impel the construction of renewable energy industry in western regions.
- Propel the technology cooperation with international organizations and relevant countries, encourage foreign corporations to invest in China under the prerequisites of reciprocity and mutual benefit and introduce and assimilate advanced technologies, technics and key equipments from foreign countries.

3.3 Improve the industry standard and service system

It is necessary in the development of new/renewable energy industry to establish and improve the technology standards and service system. Our suggestions are as follow:

- Set up test centers of product quality both in state and province level step by step
- Establish product standards and improve the quality process and certificate standard institutes.
- Strengthen the market administration and establish project bidding institute, project quality supervision and evaluation, quality guarantee and control, as well as power purchase contract institutes.
- Supplement and mend the existing tecnonology standards on solar water-heater, PV battery and wind generation. Investigate and make the techonology standards on biomass gasification, large- and mid-size biogas projects and geothermal development. Set about to establish technology standards system of turing city wastes into energy as soon as possible. Supplement and modify the existing technology standards based on the comprehensive investigation of the experience of waste disposal in other countries.
- Carry out the procurement policy of the new/renewable energy and cultivate and simulate the formation of the market by means of procurement.
- Consummate the technology service system. Strengthen the construction of technology service network, especially in rural areas where example projects are located. Equip these service centers with modern office facilities as well as experiment and monitoring equipments. Enhance the management and service capability of the personnels in these service centers.
- Establish some nationwide and reginal information websites on new/renewable energy and industry information communication centers.

4. Strengthen the policy intensity to establish the economic incentive mechanism based on market

The new policy should meet the following requirements: firstly, it should adapt to the laws of market economy and can motivate the technology amelioration and cost reduction; secondly, it should have continuous economic feasibility and be good for mitigating the financial pressure and extending the fincancing channels; lastly, it should can coordinate and government function and market mechanism. In a word, we should strengthen the intensity of government support and set up economic incentive mechanism based on market. The objective of the favorable policies in finance, credit, tax and pricing is to encourage enterprises to take part in the construction of new/renewable energy, to reduce the production cost of new/renewable energy

products, to enhance the competition ability in energy market and to create an equal environment for the competition in new/renewable energy industry.

4.1 Meliorate the economic policies to create an environment for equal competition

Value added tax: implement full taxation relief in the value added tax of wind generation. This can help reduce both the wind power price before taxing and the into-grid price before taxing, which will benefit both wind generation enterprises and power grid. (2) Import and export tax: implement full import and export taxation relief for wind generation components that can't be producec in China. (3)Income tax: China has included the new/renewable energy industry into high-tech industries, which will help new/renewable energy industry to win favourable tax policy. If the value added tax system changes from current production type into consumption type, this problem can be solved by deducting the value added tax of renewable energy generation facilities in the stage of electricity sale. This policy has been implemented in foreign companies. In order to maintain an environment of equal competition, China should apply this policy into domestic companies. Moreover, favorable income policy has been implemented in wind generation in several provinces, but the policy guideline in state level hasn't come on. The consistent income tax policy nationwide is necessary, especially for the wind concession projects. We suggest relieving all the income tax of renewable energy generation enterprises in the first 5 years and levying the income tax according to a uniform percentage in the whole operation cycle (20 years provisionally), or 15%, from the 6th year on.

4.2 Boarden the channels of credit loan and investment/financing

The state encourages enterprises to finance from multichannels, participate the new/renewable energy development and to pioneer in international financing market.

1) Try to win the specific loans and discount loans for the development of new/renewable energy and list the projects related with new/renewable energy development into the scope of policy-related loans.
2) Establish PBF to support the development of new/renewable energy. The fund will arise from multi-channels: first of all, we should incorporate the existing funds including loan-repayment fund in rural grid renewal converted from electricity construction fund and three-gorge fund. This kind of incorporation with public benefit target can meet the public policy target of financing the

projects of renewable energy and energy saving; secondly, we should extract a certain percentage of defile fees to support the development of clean energy and clean electricity. Thirdly, we should increase the electricity price a little to appeal the consumers to undertake the obligation of protecting environment and supporting the development of clean energy. The fund will be used in the large-size or key projects involved in new/renewable energy listed into the state plan, as well as the development of key new/renewable energy industries. The primary research has shown that the foundation of PBF will have no significant impact on the current electricity price.

3) Study the incentive mechanism to stimulate the private investment and extend the financing channels of renewable energy. Encourage the private capital to invest the new/renewable energy industry. Investigate the feasibility and Implementing Measures of leading the private capital into this field. Set up some experimental units in private companies to invest wind generation projects and enact a series support policies and administration codes. Take account of multi-channel financing including encouraging the outstanding companies in renewable energy industry to financing from the stock market.

4.3 Pricing mechanism

In order to encourage the development of large-scale generation of new/renewable energy into the power grid, the government should set down the pricing policy of generation into grid and sound pricing method of new/renewable energy generation into grid. The difference of electricity prices between coal generation and renewable energy should be shared within a larger grid scope. And with the structure adjustment of national grid and the development of reform, we can solve the problem in term of standard power purchase contract in some proper opportunity. Other products related with new/renewable energy such as hot water and flammable gas should be sold in a certain market, pricing with reference to the market prices of similar energy products.

4.4 Subsidy policy

In order to solve the problem of living enery supply in povety areas, the central and local governments should consider the subsidy policy for the development of new/renewable energy in these areas. The subsidy can be paid to the farmers in povety areas who purchase the dispersive generation facilities (PV, wind power and PV/wind hybrid) in order to meet the basic power need or the farmers that take part in the

grain-for-green project. The subsidy can be paid from national poverty reduction fund and electricity common prosperity project fund.

4.5 Shape the institution of market competition step by step

With development of renewable energy and economy and electricity system reform, simply using economic incentive has been outdated. In making the policy to encourage the development of renewable energy, the new theme will be how to introduce competition and reduce cost in renewable energy generation industry. Thus, the policy about cultivating market mechanism should be paid enough attention.

Based on the summary of international development policies of renewable energy, we suggest that some market activation policies such as wind concession and green certificate exchange mechanism be carried out in some experitmental units. Considering the long-time interest and development, we should investgate the feasibility and necessity of establishing our own green certificate market as well as the implement stage.

5. Found the consistent administration institution

National Development and Reform Commission and relevant ministries should establish expedite information communication channel and strengthen the coordination and cooperation in the form of guidance or coordination committee. The government should take renewable energy as strategic energy, establish an efficient administration institution with distinct function, set up administration mechanism based on the strategic management and adapt to the development of market economy. Firm is the main body of market economy and the function of government is to supply service, coordination, administration and supervision. The content of administration includes making the policies, plans and strategies related with new/renewable energy, strengthening the macro adjustment and regulation, encourage the enterprises engaged in renewable energy to take part in market competition and realize the sustainable development of energy.

The contents of administration mechanism are as follow:

- Coordinate the relevant government departments to put forward development strategy and plan on new/renewable energy as well as development target in each stage and policy/legislation suggestions
- Carry out the specific measures of development strategy and plan and supervise

and inspect the effect of execution

- Strengthen the communication with provincial energy administration institutions as well as information collection, investigate the new problems in the development of new/renewable energy and deal with these problems with the help of relevant departments
- Make the administration codes and assist the legislature to promulgate the laws related with energy and supervise the exection of these laws
- Simplize the approval procedure
- Make the investment plan of renewable energy and encourage the technology R&D and industry construction step by step
- Set the acceptable energy price and take favorable tax policy.
- Strengthen the coordination with construction, environment pretecion and energy saving departments and impel the development of renewable energy in terms of environment protection and energy saving.

6. Enhance the propagandism aiming at all the citizen

Make good use of all kinds of media to introduce the critical role the new/renewable energy plays in improving the ecologic environments and living quality as well as the sustainable development of national economy. More and more people will support the development of new/renewable energy and use this kind of clean, nonpolluting and sustainable energy. Moreover, we should report the newest development of technology and related information in this field by means of newspapers and websites. By this way more and more decision-makers and investors may support or invest in this field. Also we should make training for the enterprisers who are engaged in the manufacuturing, marketing and service of new/renewable energy and help them advance the service and management level as well as innovation consciessness and product development. These training may impel the development of new/renewable energy industry and increase the level of development. In a word, only if more and more people know about the advantage of renewable enegy, the development of new/renewable energy would possibly be in the right path. The suggestions on propagnsism are as follow:

- Pay attention to the information service and consult the foreign experience in pulic relation, energy statistics, information network, techonology consulting, energy audit and energy efficiency ID.

- Pay attention to the basic research of information service and found a national-wide MIS and GIS on new/renewable energy which can compare and analyse the resource reserve and distribution, provide market information service and supply information support in make the development plan of new/renewable energy.
- Establish the training bases for professionals in new/renewable energy and encourage the technology cooperation and information communication with other countries.

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